

Traffic_Sign_Segmentation_and_Classification

Project I : Traffic Sign Segmentation and Classification using YOLOv8

This dataset from Kaggle (<https://www.kaggle.com/datasets/andrewmvd/road-sign-detection>) contains 877 images of four distinct classes: Traffic Light, Stop, Speed Limit, and Crosswalk. The annotations are provided in the PASCAL VOC format.

Traffic Sign Recognition (TSR) is a crucial part of advanced driver-assistance systems (ADAS). It involves both object detection and classification, which makes it a complex task due to the variety of traffic sign types, different environmental conditions, and potential occlusions.

The project consists of three main stages. First, I conducted an initial evaluation to assess the performance of the YOLOv8n pre-trained model on our dataset. Then, I conducted a second evaluation after implementing some fine-tuning and data augmentation. Finally, I performed additional data augmentation, re-trained the model, and re-evaluated it before running some inferences.

```
[ ]: # Install YOLOv8 and other dependencies
!pip install ultralytics
!pip install opencv-python-headless
!pip install seaborn tqdm
!pip install torch torchvision torchaudio
!pip install -U albumentations
!pip install git+https://github.com/facebookresearch/segment-anything.git
!pip install kaggle
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Collecting ultralytics
  Downloading ultralytics-8.2.71-py3-none-any.whl.metadata (41 kB)
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Requirement already satisfied: opencv-python-headless>=4.9.0.80 in
/usr/local/lib/python3.10/dist-packages (from albumentations) (4.10.0.84)
Requirement already satisfied: tomli>=2.0.1 in /usr/local/lib/python3.10/dist-
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Requirement already satisfied: imageio>=2.33 in /usr/local/lib/python3.10/dist-
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Requirement already satisfied: tifffile>=2022.8.12 in
/usr/local/lib/python3.10/dist-packages (from scikit-
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Requirement already satisfied: lazy-loader>=0.4 in
/usr/local/lib/python3.10/dist-packages (from scikit-
image>=0.21.0->albumentations) (0.4)
Collecting git+https://github.com/facebookresearch/segment-anything.git
  Cloning https://github.com/facebookresearch/segment-anything.git to /tmp/pip-
req-build-iqau_1tr
    Running command git clone --filter=blob:none --quiet
https://github.com/facebookresearch/segment-anything.git /tmp/pip-req-build-
iqau_1tr
      Resolved https://github.com/facebookresearch/segment-anything.git to commit
6fdee8f2727f4506cfbbe553e23b895e27956588
      Preparing metadata (setup.py) ... done
Building wheels for collected packages: segment Anything
  Building wheel for segment Anything (setup.py) ... done
  Created wheel for segment Anything: filename=segment Anything-1.0-py3-none-
any.whl size=36591
sha256=aafaa8751a1a5591908838e54243ea15c8b30d9be3fcc3e0f6e3cd9c5d37e6ee2
  Stored in directory: /tmp/pip-ephem-wheel-cache-
actcmo_q/wheels/10/cf/59/9ccb2f0a1bcc81d4fb0e501680b5d088d690c6cfbc02dc99d
Successfully built segment Anything
Installing collected packages: segment Anything
Successfully installed segment Anything-1.0
Requirement already satisfied: kaggle in /usr/local/lib/python3.10/dist-packages
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/usr/local/lib/python3.10/dist-packages (from kaggle) (2.8.2)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-
packages (from kaggle) (2.31.0)
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages
(from kaggle) (4.66.4)
Requirement already satisfied: python-slugify in /usr/local/lib/python3.10/dist-
packages (from kaggle) (8.0.4)
Requirement already satisfied: urllib3 in /usr/local/lib/python3.10/dist-
packages (from kaggle) (2.0.7)
Requirement already satisfied: bleach in /usr/local/lib/python3.10/dist-packages
(from kaggle) (6.1.0)
Requirement already satisfied: webencodings in /usr/local/lib/python3.10/dist-
packages (from bleach->kaggle) (0.5.1)
Requirement already satisfied: text-unidecode>=1.3 in
/usr/local/lib/python3.10/dist-packages (from python-slugify->kaggle) (1.3)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.10/dist-packages (from requests->kaggle) (3.3.2)
```

```
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->kaggle) (3.7)
```

```
[ ]: from google.colab import files  
files.upload()
```

```
[ ]: import os  
import xml.etree.ElementTree as ET  
import shutil  
import zipfile  
import matplotlib.pyplot as plt  
import matplotlib.image as mpimg  
import cv2  
from ultralytics import YOLO  
import torch  
import requests  
import random  
import albumentations as A
```

```
[ ]: # Make .kaggle directory  
os.makedirs('/root/.kaggle', exist_ok=True)  
  
# Move the kaggle.json file to the correct location  
shutil.move('kaggle.json', '/root/.kaggle/kaggle.json')  
  
# Set permissions  
os.chmod('/root/.kaggle/kaggle.json', 600)
```

```
[ ]: # Download the dataset  
!kaggle datasets download -d andrewmvd/road-sign-detection -p  
↳ road_sign_detection  
  
# Extract the dataset  
  
dataset_zip = 'road_sign_detection/road-sign-detection.zip'  
with zipfile.ZipFile(dataset_zip, 'r') as zip_ref:  
    zip_ref.extractall('road_sign_detection')
```

```
Dataset URL: https://www.kaggle.com/datasets/andrewmvd/road-sign-detection  
License(s): CC0-1.0  
Downloading road-sign-detection.zip to road_sign_detection  
99% 217M/218M [00:10<00:00, 24.2MB/s]  
100% 218M/218M [00:10<00:00, 21.0MB/s]
```

```
[ ]: # Paths to the images and annotations  
images_path = 'road_sign_detection/images'  
annotations_path = 'road_sign_detection/annotations'
```

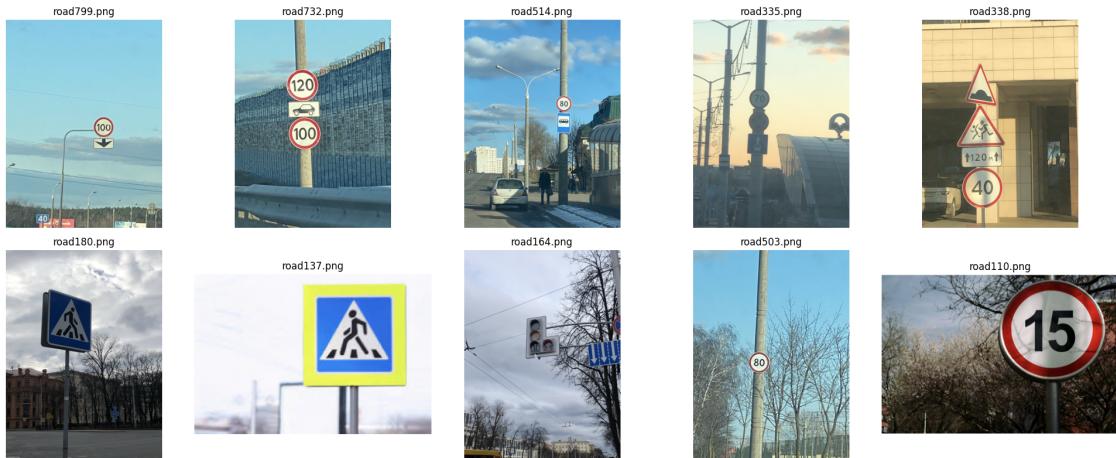
```
[ ]: # Get list of image files
images = [f for f in os.listdir(images_path) if f.endswith('.png')]
random.shuffle(images)

#for image in images:
#    print(image)
```

```
[ ]: # Select ten random images to display
sample_images = random.sample(os.listdir(images_path), 10)

# Display the images
fig, axs = plt.subplots(2, 5, figsize=(20, 8))
for ax, img_file in zip(axs.flatten(), sample_images):
    img_path = os.path.join(images_path, img_file)
    img = mpimg.imread(img_path)
    ax.imshow(img)
    ax.set_title(img_file)
    ax.axis('off')

plt.tight_layout()
plt.show()
```



```
[ ]: # Define the class mapping
class_mapping = {
    'trafficlight': 0,
    'stop': 1,
    'speedlimit': 2,
    'crosswalk': 3
}

# Function to convert XML to YOLO format
```

```

def convert_xml_to_yolo(xml_file, output_dir):
    tree = ET.parse(xml_file)
    root = tree.getroot()

    image_width = int(root.find('size/width').text)
    image_height = int(root.find('size/height').text)

    yolo_annotations = []
    for obj in root.findall('object'):
        class_name = obj.find('name').text
        if class_name not in class_mapping:
            continue

        class_id = class_mapping[class_name]

        bndbox = obj.find('bndbox')
        xmin = int(bndbox.find('xmin').text)
        ymin = int(bndbox.find('ymin').text)
        xmax = int(bndbox.find('xmax').text)
        ymax = int(bndbox.find('ymax').text)

        x_center = (xmin + xmax) / 2.0 / image_width
        y_center = (ymin + ymax) / 2.0 / image_height
        width = (xmax - xmin) / image_width
        height = (ymax - ymin) / image_height

        yolo_annotations.append(f"{class_id} {x_center} {y_center} {width}\n{height}")

    output_file = os.path.join(output_dir, root.find('filename').text.replace('.png', '.txt'))
    with open(output_file, 'w') as f:
        f.write('\n'.join(yolo_annotations))

# Paths to the directories
xml_dir = '/content/road_sign_detection/annotations'
output_dir = '/content/road_sign_detection/labels'

os.makedirs(output_dir, exist_ok=True)

# Convert all XML files in the directory
for xml_file in os.listdir(xml_dir):
    if xml_file.endswith('.xml'):
        convert_xml_to_yolo(os.path.join(xml_dir, xml_file), output_dir)

print("Conversion to YOLO format completed.")

```

Conversion to YOLO format completed.

```
[ ]: # Create directories for training and validation sets
os.makedirs('road_sign_detection/train/images', exist_ok=True)
os.makedirs('road_sign_detection/train/labels', exist_ok=True)
os.makedirs('road_sign_detection/val/images', exist_ok=True)
os.makedirs('road_sign_detection/val/labels', exist_ok=True)

[ ]: # Split into training and validation sets (80-20 split)
split_idx = int(0.8 * len(images))
train_images = images[:split_idx]
val_images = images[split_idx:]

# Copy files to corresponding directories
for img in train_images:
    shutil.copy(os.path.join(images_path, img), os.path.
    ↪join('road_sign_detection/train/images', img))
    shutil.copy(os.path.join(output_dir, img.replace('.png', '.txt')), os.path.
    ↪join('road_sign_detection/train/labels', img.replace('.png', '.txt')))

for img in val_images:
    shutil.copy(os.path.join(images_path, img), os.path.
    ↪join('road_sign_detection/val/images', img))
    shutil.copy(os.path.join(output_dir, img.replace('.png', '.txt')), os.path.
    ↪join('road_sign_detection/val/labels', img.replace('.png', '.txt')))

print("Splitting into training and validation sets completed.")
```

Splitting into training and validation sets completed.

```
[ ]: # Create and save the YAML configuration file
yaml_content = """
train: road_sign_detection/train/images
val: road_sign_detection/val/images

# Number of classes
nc: 4

# Class names
names: ['trafficlight', 'stop', 'speedlimit', 'crosswalk']
"""

with open('/content/road_sign_detection.yaml', 'w') as file:
    file.write(yaml_content)

print("road_sign_detection.yaml has been created and saved.")
```

```
road_sign_detection.yaml has been created and saved.
```

```
[ ]: # List files in the current working directory to verify  
!ls -l
```

```
total 12  
drwxr-xr-x 7 root root 4096 Aug  2 23:29 road_sign_detection  
-rw-r--r-- 1 root root 179 Aug  2 23:29 road_sign_detection.yaml  
drwxr-xr-x 1 root root 4096 Aug  1 13:24 sample_data
```

```
[ ]: # Get the current working directory  
current_directory = os.getcwd()  
  
# Construct the path to the YAML file  
yaml_path = os.path.join(current_directory, 'road_sign_detection.yaml')  
  
print(f"Path to road_sign_detection.yaml: {yaml_path}")
```

```
Path to road_sign_detection.yaml: /content/road_sign_detection.yaml  
#Initial Evaluation (Before Fine-Tuning)
```

```
[ ]: # Load the YOLO model  
model = YOLO('yolov8n.yaml') # Using YOLOv8 nano for speed
```

```
[ ]: # Evaluate the model on the validation set before fine-tuning  
results = model.val(data='/content/road_sign_detection.yaml', split='val')  
print("Evaluation before fine-tuning:", results.results_dict)
```

```
Ultralytics YOLOv8.2.71 Python-3.10.12 torch-2.3.1+cu121 CUDA:0 (Tesla T4,  
15102MiB)  
YOLOv8n summary (fused): 168 layers, 3,151,904 parameters, 31,920 gradients, 8.7  
GFLOPs  
Downloading https://ultralytics.com/assets/Arial.ttf to  
'/root/.config/Ultralytics/Arial.ttf'...  
100% | 755k/755k [00:00<00:00, 105MB/s]  
val: Scanning /content/road_sign_detection/val/labels... 176  
images, 0 backgrounds, 0 corrupt: 100% | 176/176 [00:00<00:00,  
777.56it/s]  
  
val: New cache created:  
/content/road_sign_detection/val/labels.cache
```

	Class	Images	Instances	Box(P	R	mAP50
mAP50-95): 100%	11/11	[00:05<00:00,	1.98it/s]			
	all	176	265	0	0	0
0						

```

Speed: 6.4ms preprocess, 12.6ms inference, 0.0ms loss, 1.2ms postprocess per
image
Results saved to runs/detect/val
Evaluation before fine-tuning: {'metrics/precision(B)': 0.0,
'metrics/recall(B)': 0.0, 'metrics/mAP50(B)': 0.0, 'metrics/mAP50-95(B)': 0.0,
'fitness': 0.0}

#Fine-Tuning the YOLOv8n
```

```
[ ]: # Fine-tune the YOLOv8 model on the training dataset
model.train(data='/content/road_sign_detection.yaml', epochs=50, imgsz=640)
```

```

Ultralytics YOLOv8.2.71 Python-3.10.12 torch-2.3.1+cu121 CUDA:0 (Tesla T4,
15102MiB)
engine/trainer: task=detect, mode=train, model=yolov8n.yaml,
data=/content/road_sign_detection.yaml, epochs=50, time=None, patience=100,
batch=16, imgsz=640, save=True, save_period=-1, cache=False, device=None,
workers=8, project=None, name=train, exist_ok=False, pretrained=True,
optimizer=auto, verbose=True, seed=0, deterministic=True, single_cls=False,
rect=False, cos_lr=False, close_mosaic=10, resume=False, amp=True, fraction=1.0,
profile=False, freeze=None, multi_scale=False, overlap_mask=True, mask_ratio=4,
dropout=0.0, val=True, split=val, save_json=False, save_hybrid=False, conf=None,
iou=0.7, max_det=300, half=False, dnn=False, plots=True, source=None,
vid_stride=1, stream_buffer=False, visualize=False, augment=False,
agnostic_nms=False, classes=None, retina_masks=False, embed=None, show=False,
save_frames=False, save_txt=False, save_conf=False, save_crop=False,
show_labels=True, show_conf=True, show_boxes=True, line_width=None,
format=torchscript, keras=False, optimize=False, int8=False, dynamic=False,
simplify=False, opset=None, workspace=4, nms=False, lr0=0.01, lrf=0.01,
momentum=0.937, weight_decay=0.0005, warmup_epochs=3.0, warmup_momentum=0.8,
warmup_bias_lr=0.1, box=7.5, cls=0.5, df1=1.5, pose=12.0, kobj=1.0,
label_smoothing=0.0, nbs=64, hsv_h=0.015, hsv_s=0.7, hsv_v=0.4, degrees=0.0,
translate=0.1, scale=0.5, shear=0.0, perspective=0.0, flipud=0.0, fliplr=0.5,
bgr=0.0, mosaic=1.0, mixup=0.0, copy_paste=0.0, auto_augment=randaugment,
erasing=0.4, crop_fraction=1.0, cfg=None, tracker=botsort.yaml,
save_dir=runs/detect/train
Overriding model.yaml nc=80 with nc=4
```

	from	n	params	module
arguments				
0	-1	1	464	ultralytics.nn.modules.conv.Conv
[3, 16, 3, 2]				
1	-1	1	4672	ultralytics.nn.modules.conv.Conv
[16, 32, 3, 2]				
2	-1	1	7360	ultralytics.nn.modules.block.C2f
[32, 32, 1, True]				
3	-1	1	18560	ultralytics.nn.modules.conv.Conv
[32, 64, 3, 2]				
4	-1	2	49664	ultralytics.nn.modules.block.C2f

```

[64, 64, 2, True]
 5           -1 1    73984 ultralytics.nn.modules.conv.Conv
[64, 128, 3, 2]
 6           -1 2   197632 ultralytics.nn.modules.block.C2f
[128, 128, 2, True]
 7           -1 1   295424 ultralytics.nn.modules.conv.Conv
[128, 256, 3, 2]
 8           -1 1   460288 ultralytics.nn.modules.block.C2f
[256, 256, 1, True]
 9           -1 1   164608 ultralytics.nn.modules.block.SPPF
[256, 256, 5]
10          -1 1      0 torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']
11          [-1, 6] 1      0 ultralytics.nn.modules.conv.Concat
[1]
12          -1 1   148224 ultralytics.nn.modules.block.C2f
[384, 128, 1]
13          -1 1      0 torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']
14          [-1, 4] 1      0 ultralytics.nn.modules.conv.Concat
[1]
15          -1 1   37248 ultralytics.nn.modules.block.C2f
[192, 64, 1]
16          -1 1   36992 ultralytics.nn.modules.conv.Conv
[64, 64, 3, 2]
17          [-1, 12] 1      0 ultralytics.nn.modules.conv.Concat
[1]
18          -1 1   123648 ultralytics.nn.modules.block.C2f
[192, 128, 1]
19          -1 1   147712 ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]
20          [-1, 9] 1      0 ultralytics.nn.modules.conv.Concat
[1]
21          -1 1   493056 ultralytics.nn.modules.block.C2f
[384, 256, 1]
22          [15, 18, 21] 1   752092 ultralytics.nn.modules.head.Detect
[4, [64, 128, 256]]
YOLOv8n summary: 225 layers, 3,011,628 parameters, 3,011,612 gradients, 8.2
GFLOPs

```

TensorBoard: Start with 'tensorboard --logdir runs/detect/train',
view at <http://localhost:6006/>

Freezing layer 'model.22.dfl.conv.weight'

AMP: running Automatic Mixed Precision (AMP) checks with YOLOv8n...

Downloading

<https://github.com/ultralytics/assets/releases/download/v8.2.0/yolov8n.pt> to
'yolov8n.pt'...

```

100%|       | 6.25M/6.25M [00:00<00:00, 247MB/s]

AMP: checks passed

train: Scanning /content/road_sign_detection/train/labels... 701
images, 0 backgrounds, 0 corrupt: 100%|       | 701/701 [00:00<00:00,
999.03it/s]

train: New cache created:
/content/road_sign_detection/train/labels.cache
albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01,
blur_limit=(3, 7)), ToGray(p=0.01), CLAHE(p=0.01, clip_limit=(1, 4.0),
tile_grid_size=(8, 8))

/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning: os.fork()
was called. os.fork() is incompatible with multithreaded code, and JAX is
multithreaded, so this will likely lead to a deadlock.

    self.pid = os.fork()

val: Scanning /content/road_sign_detection/val/labels.cache... 176
images, 0 backgrounds, 0 corrupt: 100%|       | 176/176 [00:00<?, ?it/s]

Plotting labels to runs/detect/train/labels.jpg...
optimizer: 'optimizer=auto' found, ignoring 'lr0=0.01' and
'momentum=0.937' and determining best 'optimizer', 'lr0' and 'momentum'
automatically...
optimizer: AdamW(lr=0.00125, momentum=0.9) with parameter groups 57
weight(decay=0.0), 64 weight(decay=0.0005), 63 bias(decay=0.0)
TensorBoard: model graph visualization added
Image sizes 640 train, 640 val
Using 2 dataloader workers
Logging results to runs/detect/train
Starting training for 50 epochs...

```

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
1/50	2.27G	3.616	5.416	4.33	29	640:
100%	44/44 [00:30<00:00, 1.47it/s]					
	Class	Images	Instances	Box(P	R	mAP50
mAP50-95): 100%	6/6 [00:07<00:00, 1.22s/it]					
	all	176	265	0.00023	0.1	0.000182
6.06e-05						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
2/50	2.25G	3.263	4.7	3.789	36	640:
100%	44/44 [00:20<00:00, 2.11it/s]					
	Class	Images	Instances	Box(P	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.20it/s]					

	all	176	265	0.000234	0.1	0.0002
6.34e-05						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
3/50	2.25G	2.815	4.034	3.183	41	640:
100%	44/44 [00:19<00:00, 2.23it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.38it/s]					
	all	176	265	0.508	0.0211	0.0132
0.00574						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
4/50	2.25G	2.345	3.329	2.644	25	640:
100%	44/44 [00:19<00:00, 2.26it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.30it/s]					
	all	176	265	0.374	0.212	0.119
0.0632						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
5/50	2.27G	2.021	2.655	2.304	39	640:
100%	44/44 [00:28<00:00, 1.52it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:05<00:00, 1.18it/s]					
	all	176	265	0.786	0.251	0.314
0.193						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
6/50	2.25G	1.779	2.239	2.103	26	640:
100%	44/44 [00:18<00:00, 2.41it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.34it/s]					
	all	176	265	0.606	0.386	0.445
0.266						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
-------	---------	----------	----------	----------	-----------	------

	7/50	2.25G	1.622	1.885	1.889	27	640:
100%	44/44 [00:20<00:00, 2.19it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.65it/s]						
	all	176	265	0.874	0.419	0.48	
0.323							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
	8/50	2.25G	1.411	1.602	1.71	48	640:
100%	44/44 [00:20<00:00, 2.15it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.49it/s]						
	all	176	265	0.942	0.448	0.565	
0.397							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
	9/50	2.25G	1.327	1.488	1.634	31	640:
100%	44/44 [00:23<00:00, 1.88it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.26it/s]						
	all	176	265	0.597	0.497	0.556	
0.384							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
	10/50	2.25G	1.275	1.413	1.584	24	640:
100%	44/44 [00:19<00:00, 2.23it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.34it/s]						
	all	176	265	0.798	0.564	0.612	
0.428							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
	11/50	2.27G	1.235	1.327	1.524	30	640:
100%	44/44 [00:20<00:00, 2.16it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.67it/s]						

	all	176	265	0.802	0.498	0.567
0.382						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
12/50	2.29G	1.153	1.227	1.447	27	640:
100%	44/44 [00:24<00:00, 1.78it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:04<00:00, 1.42it/s]					mAP50
	all	176	265	0.938	0.544	0.647
0.461						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
13/50	2.25G	1.107	1.12	1.411	21	640:
100%	44/44 [00:19<00:00, 2.27it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:04<00:00, 1.31it/s]					mAP50
	all	176	265	0.609	0.575	0.573
0.401						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
14/50	2.25G	1.076	1.091	1.399	33	640:
100%	44/44 [00:19<00:00, 2.27it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:02<00:00, 2.49it/s]					mAP50
	all	176	265	0.918	0.645	0.719
0.51						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
15/50	2.25G	1.035	1.019	1.335	30	640:
100%	44/44 [00:18<00:00, 2.34it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:02<00:00, 2.78it/s]					mAP50
	all	176	265	0.944	0.601	0.702
0.505						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
16/50	2.25G	1.082	1.072	1.364	41	640:
100%	44/44 [00:25<00:00, 1.73it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.41it/s]					
	all	176	265	0.698	0.665	0.686
0.514						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
17/50	2.28G	1.004	0.9819	1.327	31	640:
100%	44/44 [00:19<00:00, 2.27it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.32it/s]					
	all	176	265	0.777	0.696	0.709
0.503						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
18/50	2.26G	1.032	0.9934	1.327	28	640:
100%	44/44 [00:19<00:00, 2.29it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.94it/s]					
	all	176	265	0.759	0.647	0.7
0.514						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
19/50	2.25G	1.017	0.9601	1.314	24	640:
100%	44/44 [00:19<00:00, 2.22it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.72it/s]					
	all	176	265	0.663	0.66	0.725
0.519						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
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	20/50	2.25G	1.029	0.9447	1.316	43	640:
100%	44/44 [00:24<00:00, 1.80it/s]					R	mAP50
	Class	Images	Instances	Box(P)			
mAP50-95): 100%	6/6 [00:02<00:00, 2.47it/s]						
	all	176	265	0.741	0.673	0.722	
0.55							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
21/50	2.25G	0.982	0.9041	1.264	27	640:	
100%	44/44 [00:19<00:00, 2.30it/s]						
	Class	Images	Instances	Box(P)	R	mAP50	
mAP50-95): 100%	6/6 [00:03<00:00, 1.58it/s]						
	all	176	265	0.804	0.648	0.73	
0.544							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
22/50	2.25G	0.9383	0.8647	1.248	31	640:	
100%	44/44 [00:18<00:00, 2.33it/s]						
	Class	Images	Instances	Box(P)	R	mAP50	
mAP50-95): 100%	6/6 [00:04<00:00, 1.20it/s]						
	all	176	265	0.913	0.602	0.707	
0.52							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
23/50	2.25G	0.9362	0.8466	1.249	39	640:	
100%	44/44 [00:20<00:00, 2.12it/s]						
	Class	Images	Instances	Box(P)	R	mAP50	
mAP50-95): 100%	6/6 [00:04<00:00, 1.48it/s]						
	all	176	265	0.884	0.692	0.771	
0.592							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
24/50	2.25G	0.9442	0.8465	1.242	38	640:	
100%	44/44 [00:23<00:00, 1.85it/s]						
	Class	Images	Instances	Box(P)	R	mAP50	
mAP50-95): 100%	6/6 [00:02<00:00, 2.24it/s]						

	all	176	265	0.545	0.706	0.634
0.479						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
25/50	2.25G	0.9153	0.832	1.23	49	640:
100%	44/44 [00:19<00:00, 2.31it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:04<00:00, 1.37it/s]					mAP50
	all	176	265	0.784	0.687	0.765
0.585						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
26/50	2.27G	0.9113	0.8155	1.243	31	640:
100%	44/44 [00:19<00:00, 2.21it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:03<00:00, 1.55it/s]					mAP50
	all	176	265	0.836	0.737	0.797
0.598						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
27/50	2.25G	0.8977	0.7996	1.206	31	640:
100%	44/44 [00:24<00:00, 1.79it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:04<00:00, 1.29it/s]					mAP50
	all	176	265	0.783	0.719	0.766
0.576						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
28/50	2.25G	0.8961	0.7758	1.198	29	640:
100%	44/44 [00:28<00:00, 1.56it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:04<00:00, 1.25it/s]					mAP50
	all	176	265	0.754	0.733	0.782
0.578						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
29/50	2.25G	0.8749	0.7668	1.19	22	640:
100%	44/44 [00:22<00:00, 1.94it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.93it/s]					
	all	176	265	0.847	0.771	0.814
0.619						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
30/50	2.25G	0.8625	0.7337	1.177	28	640:
100%	44/44 [00:32<00:00, 1.35it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.71it/s]					
	all	176	265	0.784	0.749	0.798
0.62						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
31/50	2.25G	0.8458	0.7226	1.168	36	640:
100%	44/44 [00:19<00:00, 2.28it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.43it/s]					
	all	176	265	0.839	0.746	0.816
0.63						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
32/50	2.25G	0.8511	0.7249	1.162	40	640:
100%	44/44 [00:20<00:00, 2.19it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.02it/s]					
	all	176	265	0.798	0.757	0.793
0.601						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
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33/50	2.25G	0.8741	0.7248	1.195	42	640:
100%	44/44 [00:23<00:00, 1.85it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.25it/s]					
	all	176	265	0.849	0.742	0.801
0.612						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
34/50	2.25G	0.8411	0.7041	1.162	27	640:
100%	44/44 [00:23<00:00, 1.88it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.47it/s]					
	all	176	265	0.734	0.831	0.838
0.641						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
35/50	2.25G	0.814	0.6958	1.156	39	640:
100%	44/44 [00:20<00:00, 2.20it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.15it/s]					
	all	176	265	0.726	0.83	0.841
0.632						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
36/50	2.25G	0.8435	0.7179	1.175	42	640:
100%	44/44 [00:19<00:00, 2.25it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.22it/s]					
	all	176	265	0.847	0.785	0.826
0.65						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
37/50	2.25G	0.837	0.6933	1.153	34	640:
100%	44/44 [00:26<00:00, 1.65it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.77it/s]					

	all	176	265	0.87	0.791	0.832
0.64						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
38/50	2.25G	0.7987	0.6532	1.13	30	640:
100%	44/44 [00:19<00:00, 2.21it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.93it/s]					
	all	176	265	0.768	0.805	0.841
0.658						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
39/50	2.27G	0.7961	0.6667	1.139	36	640:
100%	44/44 [00:19<00:00, 2.31it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.47it/s]					
	all	176	265	0.819	0.806	0.83
0.645						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
40/50	2.27G	0.7866	0.6442	1.112	41	640:
100%	44/44 [00:19<00:00, 2.31it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.43it/s]					
	all	176	265	0.791	0.783	0.808
0.624						

Closing dataloader mosaic

```
albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01,
blur_limit=(3, 7)), ToGray(p=0.01), CLAHE(p=0.01, clip_limit=(1, 4.0),
tile_grid_size=(8, 8))
```

```
/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning: os.fork()
was called. os.fork() is incompatible with multithreaded code, and JAX is
multithreaded, so this will likely lead to a deadlock.
```

```
    self.pid = os.fork()
```

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
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41/50	2.39G	0.7233	0.5982	1.068	17	640:
100%	44/44 [00:30<00:00, 1.46it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.46it/s]					
	all	176	265	0.776	0.84	0.843
0.656						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
42/50	2.27G	0.7036	0.5704	1.06	18	640:
100%	44/44 [00:19<00:00, 2.30it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.58it/s]					
	all	176	265	0.791	0.859	0.847
0.661						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
43/50	2.25G	0.7026	0.5492	1.059	19	640:
100%	44/44 [00:19<00:00, 2.28it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.43it/s]					
	all	176	265	0.829	0.829	0.856
0.681						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
44/50	2.25G	0.6841	0.5365	1.06	14	640:
100%	44/44 [00:24<00:00, 1.81it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.40it/s]					
	all	176	265	0.915	0.808	0.87
0.692						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
45/50	2.25G	0.6715	0.5323	1.038	19	640:
100%	44/44 [00:20<00:00, 2.12it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.74it/s]					

	all	176	265	0.896	0.812	0.866
0.691						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
46/50	2.25G	0.6769	0.525	1.046	14	640:
100%	44/44 [00:19<00:00, 2.23it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.60it/s]					
	all	176	265	0.881	0.799	0.856
0.69						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
47/50	2.25G	0.6821	0.507	1.032	20	640:
100%	44/44 [00:19<00:00, 2.28it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.62it/s]					
	all	176	265	0.828	0.847	0.867
0.696						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
48/50	2.25G	0.6618	0.5028	1.038	19	640:
100%	44/44 [00:25<00:00, 1.69it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.77it/s]					
	all	176	265	0.851	0.855	0.87
0.7						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
49/50	2.25G	0.6605	0.5132	1.02	15	640:
100%	44/44 [00:18<00:00, 2.36it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.48it/s]					
	all	176	265	0.854	0.843	0.872
0.699						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
50/50	2.25G	0.6619	0.4921	1.03	16	640:
100%	44/44 [00:17<00:00, 2.47it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.46it/s]					
	all	176	265	0.879	0.835	0.868
0.703						

50 epochs completed in 0.373 hours.

Optimizer stripped from runs/detect/train/weights/last.pt, 6.2MB
 Optimizer stripped from runs/detect/train/weights/best.pt, 6.2MB

Validating runs/detect/train/weights/best.pt...

Ultralytics YOLOv8.2.71 Python-3.10.12 torch-2.3.1+cu121 CUDA:0 (Tesla T4, 15102MiB)

YOLOv8n summary (fused): 168 layers, 3,006,428 parameters, 0 gradients, 8.1 GFLOPs

	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:04<00:00, 1.27it/s]					
	all	176	265	0.879	0.835	0.869
0.704	trafficlight	24	43	0.711	0.535	0.598
0.362	stop	20	20	0.921	1	0.995
0.872	speedlimit	134	154	0.974	0.991	0.995
0.901	crosswalk	38	48	0.909	0.812	0.887
0.68						

Speed: 0.3ms preprocess, 2.4ms inference, 0.0ms loss, 6.8ms postprocess per image

Results saved to runs/detect/train

[]: ultralytics.utils.metrics.DetMetrics object with attributes:

```

ap_class_index: array([0, 1, 2, 3])
box: ultralytics.utils.metrics.Metric object
confusion_matrix: <ultralytics.utils.metrics.ConfusionMatrix object at
0x78d7b3a8c3a0>
curves: ['Precision-Recall(B)', 'F1-Confidence(B)', 'Precision-Confidence(B)', 'Recall-Confidence(B)']
curves_results: [[array([
0,      0.001001,   0.002002,   0.003003,

```

0.004004,	0.005005,	0.006006,	0.007007,	0.008008,	0.009009,
0.01001,	0.011011,	0.012012,	0.013013,	0.014014,	0.015015,
0.016016,	0.017017,	0.018018,	0.019019,	0.02002,	0.021021,
0.022022,	0.023023,	0.024024,	0.025025,	0.026026,	0.027027,
					0.028028,
0.029029,	0.03003,	0.031031,	0.032032,	0.033033,	0.034034,
0.035035,	0.036036,	0.037037,	0.038038,	0.039039,	0.04004,
0.041041,	0.042042,	0.043043,	0.044044,	0.045045,	0.046046,
0.047047,		0.048048,	0.049049,	0.05005,	0.051051,
					0.052052,
0.053053,	0.054054,	0.055055,	0.056056,	0.057057,	0.058058,
0.059059,	0.06006,	0.061061,	0.062062,	0.063063,	0.064064,
0.065065,	0.066066,	0.067067,	0.068068,	0.069069,	0.07007,
0.071071,		0.072072,	0.073073,	0.074074,	0.075075,
					0.076076,
0.077077,	0.078078,	0.079079,	0.08008,	0.081081,	0.082082,
0.083083,	0.084084,	0.085085,	0.086086,	0.087087,	0.088088,
0.089089,	0.09009,	0.091091,	0.092092,	0.093093,	0.094094,
0.095095,		0.096096,	0.097097,	0.098098,	0.099099,
					0.1001,
0.1011,	0.1021,	0.1031,	0.1041,	0.10511,	0.10611,
0.10711,	0.10811,	0.10911,	0.11011,	0.11111,	0.11211,
0.11311,	0.11411,	0.11512,	0.11612,	0.11712,	0.11812,
0.11912,		0.12012,	0.12112,	0.12212,	0.12312,
					0.12412,
0.12513,	0.12613,	0.12713,	0.12813,	0.12913,	0.13013,
0.13113,	0.13213,	0.13313,	0.13413,	0.13514,	0.13614,
0.13714,	0.13814,	0.13914,	0.14014,	0.14114,	0.14214,
0.14314,		0.14414,	0.14515,	0.14615,	0.14715,
					0.14815,
0.14915,	0.15015,	0.15115,	0.15215,	0.15315,	0.15415,
0.15516,	0.15616,	0.15716,	0.15816,	0.15916,	0.16016,
0.16116,	0.16216,	0.16316,	0.16416,	0.16517,	0.16617,
0.16717,		0.16817,	0.16917,	0.17017,	0.17117,
					0.17217,
0.17317,	0.17417,	0.17518,	0.17618,	0.17718,	0.17818,
0.17918,	0.18018,	0.18118,	0.18218,	0.18318,	0.18418,
0.18519,	0.18619,	0.18719,	0.18819,	0.18919,	0.19019,
0.19119,		0.19219,	0.19319,	0.19419,	0.1952,
					0.1962,
0.1972,	0.1982,	0.1992,	0.2002,	0.2012,	0.2022,
0.2032,	0.2042,	0.20521,	0.20621,	0.20721,	0.20821,
0.20921,	0.21021,	0.21121,	0.21221,	0.21321,	0.21421,
0.21522,		0.21622,	0.21722,	0.21822,	0.21922,
					0.22022,
0.22122,	0.22222,	0.22322,	0.22422,	0.22523,	0.22623,
0.22723,	0.22823,	0.22923,	0.23023,	0.23123,	0.23223,

0.23323,	0.23423,	0.23524,	0.23624,	0.23724,	0.23824,
0.23924,	0.24024,	0.24124,	0.24224,	0.24324,	0.24424,
0.24525,	0.24625,	0.24725,	0.24825,	0.24925,	0.25025,
0.25125,	0.25225,	0.25325,	0.25425,	0.25526,	0.25626,
0.25726,	0.25826,	0.25926,	0.26026,	0.26126,	0.26226,
0.26326,	0.26426,	0.26527,	0.26627,	0.26727,	0.26827,
0.26927,	0.27027,	0.27127,	0.27227,	0.27327,	0.27427,
0.27528,	0.27628,	0.27728,	0.27828,	0.27928,	0.28028,
0.28128,	0.28228,	0.28328,	0.28428,	0.28529,	0.28629,
0.28729,	0.28829,	0.28929,	0.29029,	0.29129,	0.29229,
0.29329,	0.29429,	0.2953,	0.2963,	0.2973,	0.2983,
0.2993,	0.3003,	0.3013,	0.3023,	0.3033,	0.3043,
0.30531,	0.30631,	0.30731,	0.30831,	0.30931,	0.31031,
0.31131,	0.31231,	0.31331,	0.31431,	0.31532,	0.31632,
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0.23924,					
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0.25726,	0.25826,	0.25926,	0.26026,	0.26126,	0.26226,
0.26326,					
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0.35936,					
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0.86386,	0.86486,	0.86587,	0.86687,	0.86787,	0.86887,
0.86987,	0.87087,	0.87187,	0.87287,	0.87387,	0.87487,
0.87588,	0.87688,	0.87788,	0.87888,	0.87988,	0.88088,
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0.98398,					

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0]], 'Confidence', 'Recall')])
fitness: 0.720204131610512
keys: ['metrics/precision(B)', 'metrics/recall(B)', 'metrics/mAP50(B)', 'metrics/mAP50-95(B)']
maps: array([ 0.36165,    0.87203,    0.90149,    0.67969])
names: {0: 'trafficlight', 1: 'stop', 2: 'speedlimit', 3: 'crosswalk'}
plot: True
results_dict: {'metrics/precision(B)': 0.8788612712371682, 'metrics/recall(B)': 0.834583013647391, 'metrics/mAP50(B)': 0.8686089509430354, 'metrics/mAP50-95(B)': 0.7037147072402317, 'fitness': 0.720204131610512}
save_dir: PosixPath('runs/detect/train')
speed: {'preprocess': 0.25587732141668146, 'inference': 2.434286204251376, 'loss': 0.0008493661880493164, 'postprocess': 6.791800260543823}
task: 'detect'

```

```
[ ]: # Evaluate the fine-tuned model on the validation set
results = model.val(data='/content/road_sign_detection.yaml', split='val')
print("Evaluation after fine-tuning:", results)
```

Ultralytics YOLOv8.2.66 Python-3.10.12 torch-2.3.1+cu121 CUDA:0 (Tesla T4, 15102MiB)

YOLOv8n summary (fused): 168 layers, 3,006,428 parameters, 0 gradients, 8.1 GFLOPs

```

val: Scanning /content/road_sign_detection/val/labels.cache... 176
images, 0 backgrounds, 0 corrupt: 100%| 176/176 [00:00<?, ?it/s]
/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning: os.fork()
was called. os.fork() is incompatible with multithreaded code, and JAX is
multithreaded, so this will likely lead to a deadlock.
    self.pid = os.fork()

          Class     Images Instances      Box(P)       R      mAP50
mAP50-95): 100%| 11/11 [00:05<00:00,  2.06it/s]

          all      176      256      0.913      0.775      0.83
0.658      trafficlight      24      47      0.884      0.323      0.524
0.282      stop      22      22      0.804      0.932      0.92
0.786      speedlimit      131     147      0.992      0.993      0.988

```

```

0.874
        crosswalk      33       40      0.973      0.85      0.887
0.688
Speed: 0.4ms preprocess, 8.4ms inference, 0.0ms loss, 3.9ms postprocess per
image
Results saved to runs/detect/train2
Evaluation after fine-tuning: ultralytics.utils.metrics.DetMetrics object with
attributes:

ap_class_index: array([0, 1, 2, 3])
box: ultralytics.utils.metrics.Metric object
confusion_matrix: <ultralytics.utils.metrics.ConfusionMatrix object at
0x7be3d4060790>
curves: ['Precision-Recall(B)', 'F1-Confidence(B)', 'Precision-Confidence(B)', 'Recall-Confidence(B)']
curves_results: [[array([
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    0.01001,      0.011011,      0.012012,      0.013013,      0.014014,      0.015015,
    0.016016,      0.017017,      0.018018,      0.019019,      0.02002,      0.021021,
    0.022022,      0.023023,
    0.024024,      0.025025,      0.026026,      0.027027,      0.028028,
    0.029029,      0.03003,      0.031031,      0.032032,      0.033033,      0.034034,
    0.035035,      0.036036,      0.037037,      0.038038,      0.039039,      0.04004,
    0.041041,      0.042042,      0.043043,      0.044044,      0.045045,      0.046046,
    0.047047,
    0.048048,      0.049049,      0.05005,      0.051051,      0.052052,
    0.053053,      0.054054,      0.055055,      0.056056,      0.057057,      0.058058,
    0.059059,      0.06006,      0.061061,      0.062062,      0.063063,      0.064064,
    0.065065,      0.066066,      0.067067,      0.068068,      0.069069,      0.07007,
    0.071071,
    0.072072,      0.073073,      0.074074,      0.075075,      0.076076,
    0.077077,      0.078078,      0.079079,      0.08008,      0.081081,      0.082082,
    0.083083,      0.084084,      0.085085,      0.086086,      0.087087,      0.088088,
    0.089089,      0.09009,      0.091091,      0.092092,      0.093093,      0.094094,
    0.095095,
    0.096096,      0.097097,      0.098098,      0.099099,      0.1001,
    0.1011,      0.1021,      0.1031,      0.1041,      0.10511,      0.10611,
    0.10711,      0.10811,      0.10911,      0.11011,      0.11111,      0.11211,
    0.11311,      0.11411,      0.11512,      0.11612,      0.11712,      0.11812,
    0.11912,
    0.12012,      0.12112,      0.12212,      0.12312,      0.12412,
    0.12513,      0.12613,      0.12713,      0.12813,      0.12913,      0.13013,
    0.13113,      0.13213,      0.13313,      0.13413,      0.13514,      0.13614,
    0.13714,      0.13814,      0.13914,      0.14014,      0.14114,      0.14214,
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    0.14414,      0.14515,      0.14615,      0.14715,      0.14815,
    0.14915,      0.15015,      0.15115,      0.15215,      0.15315,      0.15415,
    0.15516,      0.15616,      0.15716,      0.15816,      0.15916,      0.16016,
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0.17317,	0.17417,	0.17518,	0.17618,	0.17718,	0.17818,
0.17918,	0.18018,	0.18118,	0.18218,	0.18318,	0.18418,
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0.20921,	0.21021,	0.21121,	0.21221,	0.21321,	0.21421,
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0.23323,	0.23423,	0.23524,	0.23624,	0.23724,	0.23824,
0.23924,	0.24024,	0.24124,	0.24224,	0.24324,	0.24424,
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0.76176,	0.76276,	0.76376,	0.76476,	0.76577,	0.76677,
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0.93594,					
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0.015015,	0.016016,	0.017017,	0.018018,	0.019019,	0.02002,
0.021021,	0.022022,	0.023023,			
	0.024024,	0.025025,	0.026026,	0.027027,	0.028028,
0.029029,	0.03003,	0.031031,	0.032032,	0.033033,	0.034034,
0.035035,	0.036036,	0.037037,	0.038038,	0.039039,	0.04004,
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0.047047,					
	0.048048,	0.049049,	0.05005,	0.051051,	0.052052,

0.053053,	0.054054,	0.055055,	0.056056,	0.057057,	0.058058,
0.059059,	0.06006,	0.061061,	0.062062,	0.063063,	0.064064,
0.065065,	0.066066,	0.067067,	0.068068,	0.069069,	0.07007,
0.071071,	0.072072,	0.073073,	0.074074,	0.075075,	0.076076,
0.077077,	0.078078,	0.079079,	0.08008,	0.081081,	0.082082,
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0.10711,	0.10811,	0.10911,	0.11011,	0.11111,	0.11211,
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0.1972,	0.1982,	0.1992,	0.2002,	0.2012,	0.2022,
0.2032,	0.2042,	0.20521,	0.20621,	0.20721,	0.20821,
0.20921,	0.21021,	0.21121,	0.21221,	0.21321,	0.21421,
0.21522,	0.21622,	0.21722,	0.21822,	0.21922,	0.22022,
0.22122,	0.22222,	0.22322,	0.22422,	0.22523,	0.22623,
0.22723,	0.22823,	0.22923,	0.23023,	0.23123,	0.23223,
0.23323,	0.23423,	0.23524,	0.23624,	0.23724,	0.23824,
0.23924,	0.24024,	0.24124,	0.24224,	0.24324,	0.24424,
0.24525,	0.24625,	0.24725,	0.24825,	0.24925,	0.25025,
0.25125,	0.25225,	0.25325,	0.25425,	0.25526,	0.25626,
0.25726,	0.25826,	0.25926,	0.26026,	0.26126,	0.26226,
0.26326,	0.26426,	0.26527,	0.26627,	0.26727,	0.26827,
0.26927,	0.27027,	0.27127,	0.27227,	0.27327,	0.27427,
0.27528,	0.27628,	0.27728,	0.27828,	0.27928,	0.28028,
0.28128,	0.28228,	0.28328,	0.28428,	0.28529,	0.28629,

0.28729,	0.28829,	0.28929,	0.29029,	0.29129,	0.29229,
0.29329,	0.29429,	0.2953,	0.2963,	0.2973,	0.2983,
0.2993,	0.3003,	0.3013,	0.3023,	0.3033,	0.3043,
0.30531,	0.30631,	0.30731,	0.30831,	0.30931,	0.31031,
0.31131,	0.31231,	0.31331,	0.31431,	0.31532,	0.31632,
0.31732,	0.31832,	0.31932,	0.32032,	0.32132,	0.32232,
0.32332,	0.32432,	0.32533,	0.32633,	0.32733,	0.32833,
0.32933,	0.33033,	0.33133,	0.33233,	0.33333,	0.33433,
0.33534,	0.33634,	0.33734,	0.33834,	0.33934,	0.34034,
0.34134,	0.34234,	0.34334,	0.34434,	0.34535,	0.34635,
0.34735,	0.34835,	0.34935,	0.35035,	0.35135,	0.35235,
0.35335,	0.35435,	0.35536,	0.35636,	0.35736,	0.35836,
0.35936,	0.36036,	0.36136,	0.36236,	0.36336,	0.36436,
0.36537,	0.36637,	0.36737,	0.36837,	0.36937,	0.37037,
0.37137,	0.37237,	0.37337,	0.37437,	0.37538,	0.37638,
0.37738,	0.37838,	0.37938,	0.38038,	0.38138,	0.38238,
0.38338,	0.38438,	0.38539,	0.38639,	0.38739,	0.38839,
0.38939,	0.39039,	0.39139,	0.39239,	0.39339,	0.39439,
0.3954,	0.3964,	0.3974,	0.3984,	0.3994,	0.4004,
0.4014,	0.4024,	0.4034,	0.4044,	0.40541,	0.40641,
0.40741,	0.40841,	0.40941,	0.41041,	0.41141,	0.41241,
0.41341,	0.41441,	0.41542,	0.41642,	0.41742,	0.41842,
0.41942,	0.42042,	0.42142,	0.42242,	0.42342,	0.42442,
0.42543,	0.42643,	0.42743,	0.42843,	0.42943,	0.43043,
0.43143,	0.43243,	0.43343,	0.43443,	0.43544,	0.43644,
0.43744,	0.43844,	0.43944,	0.44044,	0.44144,	0.44244,
0.44344,	0.44444,	0.44545,	0.44645,	0.44745,	0.44845,
0.44945,	0.45045,	0.45145,	0.45245,	0.45345,	0.45445,
0.45546,	0.45646,	0.45746,	0.45846,	0.45946,	0.46046,
0.46146,	0.46246,	0.46346,	0.46446,	0.46547,	0.46647,
0.46747,	0.46847,	0.46947,	0.47047,	0.47147,	0.47247,
0.47347,	0.47447,	0.47548,	0.47648,	0.47748,	0.47848,
0.47948,	0.48048,	0.48148,	0.48248,	0.48348,	0.48448,
0.48549,	0.48649,	0.48749,	0.48849,	0.48949,	0.49049,
0.49149,	0.49249,	0.49349,	0.49449,	0.4955,	0.4965,
0.4975,	0.4985,	0.4995,	0.5005,	0.5015,	0.5025,
0.5035,	0.5045,	0.50551,	0.50651,	0.50751,	0.50851,
0.50951,	0.51051,	0.51151,	0.51251,	0.51351,	0.51451,

0.51552,	0.51652,	0.51752,	0.51852,	0.51952,	0.52052,
0.52152,	0.52252,	0.52352,	0.52452,	0.52553,	0.52653,
0.52753,					
	0.52853,	0.52953,	0.53053,	0.53153,	0.53253,
0.53353,	0.53453,	0.53554,	0.53654,	0.53754,	0.53854,
0.53954,	0.54054,	0.54154,	0.54254,	0.54354,	0.54454,
0.54555,	0.54655,	0.54755,	0.54855,	0.54955,	0.55055,
0.55155,					
	0.55255,	0.55355,	0.55455,	0.55556,	0.55656,
0.55756,	0.55856,	0.55956,	0.56056,	0.56156,	0.56256,
0.56356,	0.56456,	0.56557,	0.56657,	0.56757,	0.56857,
0.56957,	0.57057,	0.57157,	0.57257,	0.57357,	0.57457,
0.57558,					
	0.57658,	0.57758,	0.57858,	0.57958,	0.58058,
0.58158,	0.58258,	0.58358,	0.58458,	0.58559,	0.58659,
0.58759,	0.58859,	0.58959,	0.59059,	0.59159,	0.59259,
0.59359,	0.59459,	0.5956,	0.5966,	0.5976,	0.5986,
0.5996,					
	0.6006,	0.6016,	0.6026,	0.6036,	0.6046,
0.60561,	0.60661,	0.60761,	0.60861,	0.60961,	0.61061,
0.61161,	0.61261,	0.61361,	0.61461,	0.61562,	0.61662,
0.61762,	0.61862,	0.61962,	0.62062,	0.62162,	0.62262,
0.62362,					
	0.62462,	0.62563,	0.62663,	0.62763,	0.62863,
0.62963,	0.63063,	0.63163,	0.63263,	0.63363,	0.63463,
0.63564,	0.63664,	0.63764,	0.63864,	0.63964,	0.64064,
0.64164,	0.64264,	0.64364,	0.64464,	0.64565,	0.64665,
0.64765,					
	0.64865,	0.64965,	0.65065,	0.65165,	0.65265,
0.65365,	0.65465,	0.65566,	0.65666,	0.65766,	0.65866,
0.65966,	0.66066,	0.66166,	0.66266,	0.66366,	0.66466,
0.66567,	0.66667,	0.66767,	0.66867,	0.66967,	0.67067,
0.67167,					
	0.67267,	0.67367,	0.67467,	0.67568,	0.67668,
0.67768,	0.67868,	0.67968,	0.68068,	0.68168,	0.68268,
0.68368,	0.68468,	0.68569,	0.68669,	0.68769,	0.68869,
0.68969,	0.69069,	0.69169,	0.69269,	0.69369,	0.69469,
0.6957,					
	0.6967,	0.6977,	0.6987,	0.6997,	0.7007,
0.7017,	0.7027,	0.7037,	0.7047,	0.70571,	0.70671,
0.70771,	0.70871,	0.70971,	0.71071,	0.71171,	0.71271,
0.71371,	0.71471,	0.71572,	0.71672,	0.71772,	0.71872,
0.71972,					
	0.72072,	0.72172,	0.72272,	0.72372,	0.72472,
0.72573,	0.72673,	0.72773,	0.72873,	0.72973,	0.73073,
0.73173,	0.73273,	0.73373,	0.73473,	0.73574,	0.73674,
0.73774,	0.73874,	0.73974,	0.74074,	0.74174,	0.74274,
0.74374,					

	0.74474,	0.74575,	0.74675,	0.74775,	0.74875,
0.74975,	0.75075,	0.75175,	0.75275,	0.75375,	0.75475,
0.75576,	0.75676,	0.75776,	0.75876,	0.75976,	0.76076,
0.76176,	0.76276,	0.76376,	0.76476,	0.76577,	0.76677,
0.76777,					
	0.76877,	0.76977,	0.77077,	0.77177,	0.77277,
0.77377,	0.77477,	0.77578,	0.77678,	0.77778,	0.77878,
0.77978,	0.78078,	0.78178,	0.78278,	0.78378,	0.78478,
0.78579,	0.78679,	0.78779,	0.78879,	0.78979,	0.79079,
0.79179,					
	0.79279,	0.79379,	0.79479,	0.7958,	0.7968,
0.7978,	0.7988,	0.7998,	0.8008,	0.8018,	0.8028,
0.8038,	0.8048,	0.80581,	0.80681,	0.80781,	0.80881,
0.80981,	0.81081,	0.81181,	0.81281,	0.81381,	0.81481,
0.81582,					
	0.81682,	0.81782,	0.81882,	0.81982,	0.82082,
0.82182,	0.82282,	0.82382,	0.82482,	0.82583,	0.82683,
0.82783,	0.82883,	0.82983,	0.83083,	0.83183,	0.83283,
0.83383,	0.83483,	0.83584,	0.83684,	0.83784,	0.83884,
0.83984,					
	0.84084,	0.84184,	0.84284,	0.84384,	0.84484,
0.84585,	0.84685,	0.84785,	0.84885,	0.84985,	0.85085,
0.85185,	0.85285,	0.85385,	0.85485,	0.85586,	0.85686,
0.85786,	0.85886,	0.85986,	0.86086,	0.86186,	0.86286,
0.86386,					
	0.86486,	0.86587,	0.86687,	0.86787,	0.86887,
0.86987,	0.87087,	0.87187,	0.87287,	0.87387,	0.87487,
0.87588,	0.87688,	0.87788,	0.87888,	0.87988,	0.88088,
0.88188,	0.88288,	0.88388,	0.88488,	0.88589,	0.88689,
0.88789,					
	0.88889,	0.88989,	0.89089,	0.89189,	0.89289,
0.89389,	0.89489,	0.8959,	0.8969,	0.8979,	0.8989,
0.8999,	0.9009,	0.9019,	0.9029,	0.9039,	0.9049,
0.90591,	0.90691,	0.90791,	0.90891,	0.90991,	0.91091,
0.91191,					
	0.91291,	0.91391,	0.91491,	0.91592,	0.91692,
0.91792,	0.91892,	0.91992,	0.92092,	0.92192,	0.92292,
0.92392,	0.92492,	0.92593,	0.92693,	0.92793,	0.92893,
0.92993,	0.93093,	0.93193,	0.93293,	0.93393,	0.93493,
0.93594,					
	0.93694,	0.93794,	0.93894,	0.93994,	0.94094,
0.94194,	0.94294,	0.94394,	0.94494,	0.94595,	0.94695,
0.94795,	0.94895,	0.94995,	0.95095,	0.95195,	0.95295,
0.95395,	0.95495,	0.95596,	0.95696,	0.95796,	0.95896,
0.95996,					
	0.96096,	0.96196,	0.96296,	0.96396,	0.96496,
0.96597,	0.96697,	0.96797,	0.96897,	0.96997,	0.97097,
0.97197,	0.97297,	0.97397,	0.97497,	0.97598,	0.97698,

0.97798,	0.97898,	0.97998,	0.98098,	0.98198,	0.98298,
0.98398,					
	0.98498,	0.98599,	0.98699,	0.98799,	0.98899,
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0.015015,	0.016016,	0.017017,	0.018018,	0.019019,	0.02002,
0.021021,	0.022022,	0.023023,			
	0.024024,	0.025025,	0.026026,	0.027027,	0.028028,
0.029029,	0.03003,	0.031031,	0.032032,	0.033033,	0.034034,
0.035035,	0.036036,	0.037037,	0.038038,	0.039039,	0.04004,
0.041041,	0.042042,	0.043043,	0.044044,	0.045045,	0.046046,
0.047047,					
	0.048048,	0.049049,	0.05005,	0.051051,	0.052052,
0.053053,	0.054054,	0.055055,	0.056056,	0.057057,	0.058058,
0.059059,	0.06006,	0.061061,	0.062062,	0.063063,	0.064064,
0.065065,	0.066066,	0.067067,	0.068068,	0.069069,	0.07007,
0.071071,					
	0.072072,	0.073073,	0.074074,	0.075075,	0.076076,
0.077077,	0.078078,	0.079079,	0.08008,	0.081081,	0.082082,
0.083083,	0.084084,	0.085085,	0.086086,	0.087087,	0.088088,
0.089089,	0.09009,	0.091091,	0.092092,	0.093093,	0.094094,
0.095095,					
	0.096096,	0.097097,	0.098098,	0.099099,	0.1001,
0.1011,	0.1021,	0.1031,	0.1041,	0.10511,	0.10611,
0.10711,	0.10811,	0.10911,	0.11011,	0.11111,	0.11211,
0.11311,	0.11411,	0.11512,	0.11612,	0.11712,	0.11812,
0.11912,					
	0.12012,	0.12112,	0.12212,	0.12312,	0.12412,
0.12513,	0.12613,	0.12713,	0.12813,	0.12913,	0.13013,
0.13113,	0.13213,	0.13313,	0.13413,	0.13514,	0.13614,
0.13714,	0.13814,	0.13914,	0.14014,	0.14114,	0.14214,
0.14314,					
	0.14414,	0.14515,	0.14615,	0.14715,	0.14815,
0.14915,	0.15015,	0.15115,	0.15215,	0.15315,	0.15415,
0.15516,	0.15616,	0.15716,	0.15816,	0.15916,	0.16016,
0.16116,	0.16216,	0.16316,	0.16416,	0.16517,	0.16617,
0.16717,					
	0.16817,	0.16917,	0.17017,	0.17117,	0.17217,
0.17317,	0.17417,	0.17518,	0.17618,	0.17718,	0.17818,

0.17918,	0.18018,	0.18118,	0.18218,	0.18318,	0.18418,
0.18519,	0.18619,	0.18719,	0.18819,	0.18919,	0.19019,
0.19119,					
	0.19219,	0.19319,	0.19419,	0.1952,	0.1962,
0.1972,	0.1982,	0.1992,	0.2002,	0.2012,	0.2022,
0.2032,	0.2042,	0.20521,	0.20621,	0.20721,	0.20821,
0.20921,	0.21021,	0.21121,	0.21221,	0.21321,	0.21421,
0.21522,					
	0.21622,	0.21722,	0.21822,	0.21922,	0.22022,
0.22122,	0.22222,	0.22322,	0.22422,	0.22523,	0.22623,
0.22723,	0.22823,	0.22923,	0.23023,	0.23123,	0.23223,
0.23323,	0.23423,	0.23524,	0.23624,	0.23724,	0.23824,
0.23924,					
	0.24024,	0.24124,	0.24224,	0.24324,	0.24424,
0.24525,	0.24625,	0.24725,	0.24825,	0.24925,	0.25025,
0.25125,	0.25225,	0.25325,	0.25425,	0.25526,	0.25626,
0.25726,	0.25826,	0.25926,	0.26026,	0.26126,	0.26226,
0.26326,					
	0.26426,	0.26527,	0.26627,	0.26727,	0.26827,
0.26927,	0.27027,	0.27127,	0.27227,	0.27327,	0.27427,
0.27528,	0.27628,	0.27728,	0.27828,	0.27928,	0.28028,
0.28128,	0.28228,	0.28328,	0.28428,	0.28529,	0.28629,
0.28729,					
	0.28829,	0.28929,	0.29029,	0.29129,	0.29229,
0.29329,	0.29429,	0.2953,	0.2963,	0.2973,	0.2983,
0.2993,	0.3003,	0.3013,	0.3023,	0.3033,	0.3043,
0.30531,	0.30631,	0.30731,	0.30831,	0.30931,	0.31031,
0.31131,					
	0.31231,	0.31331,	0.31431,	0.31532,	0.31632,
0.31732,	0.31832,	0.31932,	0.32032,	0.32132,	0.32232,
0.32332,	0.32432,	0.32533,	0.32633,	0.32733,	0.32833,
0.32933,	0.33033,	0.33133,	0.33233,	0.33333,	0.33433,
0.33534,					
	0.33634,	0.33734,	0.33834,	0.33934,	0.34034,
0.34134,	0.34234,	0.34334,	0.34434,	0.34535,	0.34635,
0.34735,	0.34835,	0.34935,	0.35035,	0.35135,	0.35235,
0.35335,	0.35435,	0.35536,	0.35636,	0.35736,	0.35836,
0.35936,					
	0.36036,	0.36136,	0.36236,	0.36336,	0.36436,
0.36537,	0.36637,	0.36737,	0.36837,	0.36937,	0.37037,
0.37137,	0.37237,	0.37337,	0.37437,	0.37538,	0.37638,
0.37738,	0.37838,	0.37938,	0.38038,	0.38138,	0.38238,
0.38338,					
	0.38438,	0.38539,	0.38639,	0.38739,	0.38839,
0.38939,	0.39039,	0.39139,	0.39239,	0.39339,	0.39439,
0.3954,	0.3964,	0.3974,	0.3984,	0.3994,	0.4004,
0.4014,	0.4024,	0.4034,	0.4044,	0.40541,	0.40641,
0.40741,					

	0.40841,	0.40941,	0.41041,	0.41141,	0.41241,
0.41341,	0.41441,	0.41542,	0.41642,	0.41742,	0.41842,
0.41942,	0.42042,	0.42142,	0.42242,	0.42342,	0.42442,
0.42543,	0.42643,	0.42743,	0.42843,	0.42943,	0.43043,
0.43143,					
	0.43243,	0.43343,	0.43443,	0.43544,	0.43644,
0.43744,	0.43844,	0.43944,	0.44044,	0.44144,	0.44244,
0.44344,	0.44444,	0.44545,	0.44645,	0.44745,	0.44845,
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0.71972,	0.72072,	0.72172,	0.72272,	0.72372,	0.72472,
0.72573,	0.72673,	0.72773,	0.72873,	0.72973,	0.73073,
0.73173,	0.73273,	0.73373,	0.73473,	0.73574,	0.73674,
0.73774,	0.73874,	0.73974,	0.74074,	0.74174,	0.74274,
0.74374,	0.74474,	0.74575,	0.74675,	0.74775,	0.74875,
0.74975,	0.75075,	0.75175,	0.75275,	0.75375,	0.75475,
0.75576,	0.75676,	0.75776,	0.75876,	0.75976,	0.76076,
0.76176,	0.76276,	0.76376,	0.76476,	0.76577,	0.76677,

0.76777,	0.76877,	0.76977,	0.77077,	0.77177,	0.77277,
0.77377,	0.77477,	0.77578,	0.77678,	0.77778,	0.77878,
0.77978,	0.78078,	0.78178,	0.78278,	0.78378,	0.78478,
0.78579,	0.78679,	0.78779,	0.78879,	0.78979,	0.79079,
0.79179,	0.79279,	0.79379,	0.79479,	0.7958,	0.7968,
0.7978,	0.7988,	0.7998,	0.8008,	0.8018,	0.8028,
0.8038,	0.8048,	0.80581,	0.80681,	0.80781,	0.80881,
0.80981,	0.81081,	0.81181,	0.81281,	0.81381,	0.81481,
0.81582,	0.81682,	0.81782,	0.81882,	0.81982,	0.82082,
0.82182,	0.82282,	0.82382,	0.82482,	0.82583,	0.82683,
0.82783,	0.82883,	0.82983,	0.83083,	0.83183,	0.83283,
0.83383,	0.83483,	0.83584,	0.83684,	0.83784,	0.83884,
0.83984,	0.84084,	0.84184,	0.84284,	0.84384,	0.84484,
0.84585,	0.84685,	0.84785,	0.84885,	0.84985,	0.85085,
0.85185,	0.85285,	0.85385,	0.85485,	0.85586,	0.85686,
0.85786,	0.85886,	0.85986,	0.86086,	0.86186,	0.86286,
0.86386,	0.86486,	0.86587,	0.86687,	0.86787,	0.86887,
0.86987,	0.87087,	0.87187,	0.87287,	0.87387,	0.87487,
0.87588,	0.87688,	0.87788,	0.87888,	0.87988,	0.88088,
0.88188,	0.88288,	0.88388,	0.88488,	0.88589,	0.88689,
0.88789,	0.88889,	0.88989,	0.89089,	0.89189,	0.89289,
0.89389,	0.89489,	0.8959,	0.8969,	0.8979,	0.8989,
0.8999,	0.9009,	0.9019,	0.9029,	0.9039,	0.9049,
0.90591,	0.90691,	0.90791,	0.90891,	0.90991,	0.91091,
0.91191,	0.91291,	0.91391,	0.91491,	0.91592,	0.91692,
0.91792,	0.91892,	0.91992,	0.92092,	0.92192,	0.92292,
0.92392,	0.92492,	0.92593,	0.92693,	0.92793,	0.92893,
0.92993,	0.93093,	0.93193,	0.93293,	0.93393,	0.93493,
0.93594,	0.93694,	0.93794,	0.93894,	0.93994,	0.94094,
0.94194,	0.94294,	0.94394,	0.94494,	0.94595,	0.94695,
0.94795,	0.94895,	0.94995,	0.95095,	0.95195,	0.95295,
0.95395,	0.95495,	0.95596,	0.95696,	0.95796,	0.95896,
0.95996,	0.96096,	0.96196,	0.96296,	0.96396,	0.96496,
0.96597,	0.96697,	0.96797,	0.96897,	0.96997,	0.97097,
0.97197,	0.97297,	0.97397,	0.97497,	0.97598,	0.97698,
0.97798,	0.97898,	0.97998,	0.98098,	0.98198,	0.98298,
0.98398,	0.98498,	0.98599,	0.98699,	0.98799,	0.98899,
0.98999,	0.99099,	0.99199,	0.99299,	0.99399,	0.99499,

```
0.996,          0.997,          0.998,          0.999,          1]), array([[  
0.76596,      0.76596,      0.76596, ..., 0, 0, 0],  
     [1, 1, 1, ..., 0, 0, 0],  
0], [1, 1, 1, ..., 0, 0, 0], [0.925, 0.925, 0.925, ..., 0, 0, 0]]), 'Confidence', 'Recall'])]  
fitness: 0.6748724067301968  
keys: ['metrics/precision(B)', 'metrics/recall(B)', 'metrics/mAP50(B)',  
'metrics/mAP50-95(B)']  
maps: array([ 0.28212,  0.78572,  0.87449,  0.68829])  
names: {0: 'trafficlight', 1: 'stop', 2: 'speedlimit', 3: 'crosswalk'}  
plot: True  
results_dict: {'metrics/precision(B)': 0.9130081839259967, 'metrics/recall(B)':  
0.7746007385804506, 'metrics/mAP50(B)': 0.829820433542062,  
'metrics/mAP50-95(B)': 0.6576559593066561, 'fitness': 0.6748724067301968}  
save_dir: PosixPath('runs/detect/train2')  
speed: {'preprocess': 0.3608600659803911, 'inference': 8.431901985948736,  
'loss': 0.0009428371082652699, 'postprocess': 3.917137330228632}  
task: 'detect'
```

```
#Normalized Confusion Matrix

import seaborn as sns
from sklearn.metrics import confusion_matrix, precision_recall_curve, average_precision_score

# Perform inference on validation images
val_images_path = 'road_sign_detection/val/images'
val_labels_path = 'road_sign_detection/val/labels'

true_labels = []
pred_labels = []
all_scores = []

for img_file in os.listdir(val_images_path):
    if img_file.endswith('.png'):
        img_path = os.path.join(val_images_path, img_file)
        label_path = os.path.join(val_labels_path, img_file.replace('.png', '.txt'))
        # Read true labels
        with open(label_path, 'r') as f:
            true_label = [line.split() for line in f.read().splitlines()]

        # Perform inference
        results = model(img_path)
```

```

    for result in results:
        for box in result.boxes.data:
            x_center, y_center, width, height, score, class_id = box.cpu().numpy()
            pred_labels.append(class_id)
            all_scores.append(score)

    for label in true_label:
        true_labels.append(int(label[0]))

# Ensure the lengths of true_labels and pred_labels match
min_len = min(len(true_labels), len(pred_labels))
true_labels = true_labels[:min_len]
pred_labels = pred_labels[:min_len]

# Confusion Matrix
cm = confusion_matrix(true_labels, pred_labels, labels=[0, 1, 2, 3])
plt.figure(figsize=(10, 8))
sns.heatmap(cm, annot=True, fmt="d", cmap="Blues", xticklabels=class_mapping.keys(), yticklabels=class_mapping.keys())
plt.xlabel("Predicted Labels")
plt.ylabel("True Labels")
plt.title("Confusion Matrix")
plt.show()

# Precision-Recall Curve
precision = dict()
recall = dict()
average_precision = dict()

for i in range(4):
    precision[i], recall[i], _ = precision_recall_curve([1 if label == i else 0 for label in true_labels],
                                                       [1 if label == i else 0 for label in pred_labels])
    average_precision[i] = average_precision_score([1 if label == i else 0 for label in true_labels],
                                                   [1 if label == i else 0 for label in pred_labels])

```

image 1/1 /content/road_sign_detection/val/images/road587.png: 640x480 1
speedlimit, 71.5ms
Speed: 18.5ms preprocess, 71.5ms inference, 16.3ms postprocess per image at
shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road360.png: 640x480 1

speedlimit, 37.2ms
Speed: 28.8ms preprocess, 37.2ms inference, 11.9ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road487.png: 640x480 1
speedlimit, 34.6ms
Speed: 3.1ms preprocess, 34.6ms inference, 2.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road227.png: 640x480 2
speedlimits, 32.8ms
Speed: 3.0ms preprocess, 32.8ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road251.png: 640x480 1
speedlimit, 23.4ms
Speed: 8.0ms preprocess, 23.4ms inference, 1.9ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road94.png: 512x640 2 stops, 31.1ms
Speed: 12.2ms preprocess, 31.1ms inference, 2.1ms postprocess per image at shape (1, 3, 512, 640)

image 1/1 /content/road_sign_detection/val/images/road663.png: 640x480 1
speedlimit, 36.4ms
Speed: 21.5ms preprocess, 36.4ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road235.png: 640x480 2
speedlimits, 24.6ms
Speed: 7.5ms preprocess, 24.6ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road579.png: 640x480 1
crosswalk, 25.1ms
Speed: 3.0ms preprocess, 25.1ms inference, 9.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road378.png: 640x480 1
speedlimit, 18.7ms
Speed: 12.1ms preprocess, 18.7ms inference, 9.7ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road729.png: 640x480 2
speedlimits, 22.9ms
Speed: 3.0ms preprocess, 22.9ms inference, 9.2ms postprocess per image at shape (1, 3, 640, 480)

```
image 1/1 /content/road_sign_detection/val/images/road725.png: 640x480 1
speedlimit, 17.9ms
Speed: 9.1ms preprocess, 17.9ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road246.png: 640x480 1
speedlimit, 24.9ms
Speed: 2.9ms preprocess, 24.9ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road537.png: 640x480 1
speedlimit, 1 crosswalk, 29.1ms
Speed: 3.1ms preprocess, 29.1ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road657.png: 640x480 2
speedlimits, 1 crosswalk, 20.5ms
Speed: 10.5ms preprocess, 20.5ms inference, 2.1ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road400.png: 640x480 1
speedlimit, 25.7ms
Speed: 5.5ms preprocess, 25.7ms inference, 6.7ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road311.png: 640x480 1
speedlimit, 1 crosswalk, 38.1ms
Speed: 6.2ms preprocess, 38.1ms inference, 5.6ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road504.png: 640x480 1
speedlimit, 31.9ms
Speed: 10.8ms preprocess, 31.9ms inference, 8.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road386.png: 640x480 1
speedlimit, 27.8ms
Speed: 6.6ms preprocess, 27.8ms inference, 2.4ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road742.png: 640x480 2
speedlimits, 31.1ms
Speed: 7.3ms preprocess, 31.1ms inference, 8.5ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road290.png: 640x480 1
speedlimit, 37.6ms
```

Speed: 8.7ms preprocess, 37.6ms inference, 5.3ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road765.png: 640x480 1 speedlimit, 16.8ms Speed: 9.3ms preprocess, 16.8ms inference, 5.2ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road580.png: 640x480 1 crosswalk, 13.0ms Speed: 5.4ms preprocess, 13.0ms inference, 2.2ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road461.png: 640x480 1 trafficlight, 1 speedlimit, 1 crosswalk, 27.0ms Speed: 3.0ms preprocess, 27.0ms inference, 2.4ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road92.png: 448x640 1 stop, 36.1ms Speed: 13.5ms preprocess, 36.1ms inference, 2.2ms postprocess per image at shape (1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road773.png: 640x480 1 speedlimit, 36.3ms Speed: 11.2ms preprocess, 36.3ms inference, 2.3ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road567.png: 640x480 2 speedlimits, 11.3ms Speed: 3.3ms preprocess, 11.3ms inference, 2.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road385.png: 640x480 1 speedlimit, 11.5ms Speed: 3.1ms preprocess, 11.5ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road210.png: 640x480 1 speedlimit, 11.3ms Speed: 3.1ms preprocess, 11.3ms inference, 1.9ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road84.png: 640x448 1 stop, 17.5ms Speed: 3.6ms preprocess, 17.5ms inference, 2.8ms postprocess per image at shape (1, 3, 640, 448)

```
image 1/1 /content/road_sign_detection/val/images/road98.png: 448x640 2 stops,  
28.3ms  
Speed: 7.0ms preprocess, 28.3ms inference, 5.2ms postprocess per image at shape  
(1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road95.png: 640x480 1 stop,  
24.1ms  
Speed: 6.4ms preprocess, 24.1ms inference, 2.0ms postprocess per image at shape  
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road72.png: 448x640 1 stop,  
25.5ms  
Speed: 5.0ms preprocess, 25.5ms inference, 2.5ms postprocess per image at shape  
(1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road364.png: 640x480 1  
speedlimit, 24.4ms  
Speed: 3.2ms preprocess, 24.4ms inference, 2.0ms postprocess per image at shape  
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road93.png: 448x640 1 stop,  
32.6ms  
Speed: 6.5ms preprocess, 32.6ms inference, 2.0ms postprocess per image at shape  
(1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road45.png: 640x448 1  
speedlimit, 34.4ms  
Speed: 3.0ms preprocess, 34.4ms inference, 2.0ms postprocess per image at shape  
(1, 3, 640, 448)

image 1/1 /content/road_sign_detection/val/images/road568.png: 640x480 1  
speedlimit, 25.9ms  
Speed: 5.1ms preprocess, 25.9ms inference, 5.2ms postprocess per image at shape  
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road534.png: 640x480 1  
speedlimit, 2 crosswalks, 25.6ms  
Speed: 2.9ms preprocess, 25.6ms inference, 2.0ms postprocess per image at shape  
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road774.png: 640x480 1  
speedlimit, 24.3ms  
Speed: 3.1ms preprocess, 24.3ms inference, 2.1ms postprocess per image at shape  
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road298.png: 640x480 1  
speedlimit, 20.8ms  
Speed: 3.0ms preprocess, 20.8ms inference, 5.9ms postprocess per image at shape
```

(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road566.png: 640x480 1
speedlimit, 24.1ms
Speed: 3.1ms preprocess, 24.1ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road715.png: 640x480 2
speedlimits, 25.3ms
Speed: 10.1ms preprocess, 25.3ms inference, 2.1ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road621.png: 640x480 1
speedlimit, 29.5ms
Speed: 13.1ms preprocess, 29.5ms inference, 4.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road240.png: 640x480 2
speedlimits, 29.8ms
Speed: 5.0ms preprocess, 29.8ms inference, 2.1ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road304.png: 640x480 1
speedlimit, 42.2ms
Speed: 7.2ms preprocess, 42.2ms inference, 11.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road670.png: 640x480 1
speedlimit, 25.2ms
Speed: 5.1ms preprocess, 25.2ms inference, 2.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road452.png: 640x480 2
speedlimits, 34.7ms
Speed: 5.2ms preprocess, 34.7ms inference, 9.8ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road16.png: 416x640 2
trafficlights, 30.1ms
Speed: 3.1ms preprocess, 30.1ms inference, 3.3ms postprocess per image at shape
(1, 3, 416, 640)

image 1/1 /content/road_sign_detection/val/images/road132.png: 480x640 1
trafficlight, 1 crosswalk, 30.5ms
Speed: 3.2ms preprocess, 30.5ms inference, 2.3ms postprocess per image at shape
(1, 3, 480, 640)

image 1/1 /content/road_sign_detection/val/images/road167.png: 640x480 1

trafficlight, 1 stop, 1 crosswalk, 22.6ms
Speed: 5.2ms preprocess, 22.6ms inference, 3.7ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road29.png: 448x640 (no detections), 21.9ms
Speed: 4.4ms preprocess, 21.9ms inference, 1.0ms postprocess per image at shape (1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road584.png: 640x480 1 speedlimit, 13.7ms
Speed: 3.3ms preprocess, 13.7ms inference, 2.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road824.png: 640x480 2 trafficlights, 1 stop, 3 crosswalks, 25.2ms
Speed: 3.2ms preprocess, 25.2ms inference, 6.7ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road182.png: 640x480 1 speedlimit, 34.1ms
Speed: 6.2ms preprocess, 34.1ms inference, 2.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road187.png: 640x480 1 crosswalk, 18.6ms
Speed: 6.0ms preprocess, 18.6ms inference, 5.5ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road223.png: 640x480 1 speedlimit, 25.1ms
Speed: 3.0ms preprocess, 25.1ms inference, 4.3ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road823.png: 640x480 1 trafficlight, 1 stop, 1 crosswalk, 29.4ms
Speed: 4.7ms preprocess, 29.4ms inference, 6.8ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road690.png: 640x480 2 speedlimits, 38.1ms
Speed: 10.5ms preprocess, 38.1ms inference, 6.3ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road650.png: 640x480 1 speedlimit, 39.3ms
Speed: 8.3ms preprocess, 39.3ms inference, 11.2ms postprocess per image at shape (1, 3, 640, 480)

```
image 1/1 /content/road_sign_detection/val/images/road21.png: 640x480 3
trafficlights, 35.6ms
Speed: 5.0ms preprocess, 35.6ms inference, 3.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road818.png: 640x480 1
speedlimit, 22.0ms
Speed: 2.9ms preprocess, 22.0ms inference, 1.8ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road532.png: 640x480 1
speedlimit, 3 crosswalks, 25.8ms
Speed: 3.2ms preprocess, 25.8ms inference, 3.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road688.png: 640x480 2
speedlimits, 22.1ms
Speed: 5.0ms preprocess, 22.1ms inference, 7.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road422.png: 640x480 1
speedlimit, 25.5ms
Speed: 3.9ms preprocess, 25.5ms inference, 3.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road738.png: 640x480 2
speedlimits, 23.1ms
Speed: 11.3ms preprocess, 23.1ms inference, 8.5ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road471.png: 640x480 1
speedlimit, 23.1ms
Speed: 5.0ms preprocess, 23.1ms inference, 7.5ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road817.png: 640x480 1
speedlimit, 25.4ms
Speed: 3.0ms preprocess, 25.4ms inference, 6.6ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road519.png: 640x480 1
speedlimit, 16.5ms
Speed: 3.5ms preprocess, 16.5ms inference, 12.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road134.png: 448x640 1
crosswalk, 25.0ms
```

Speed: 7.8ms preprocess, 25.0ms inference, 2.0ms postprocess per image at shape (1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road516.png: 640x480 1 speedlimit, 30.2ms Speed: 9.3ms preprocess, 30.2ms inference, 2.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road381.png: 640x480 1 speedlimit, 38.2ms Speed: 6.6ms preprocess, 38.2ms inference, 3.4ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road463.png: 640x480 1 trafficlight, 1 speedlimit, 1 crosswalk, 26.4ms Speed: 10.3ms preprocess, 26.4ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road146.png: 288x640 1 crosswalk, 29.8ms Speed: 2.2ms preprocess, 29.8ms inference, 2.1ms postprocess per image at shape (1, 3, 288, 640)

image 1/1 /content/road_sign_detection/val/images/road376.png: 640x480 1 speedlimit, 26.6ms Speed: 9.4ms preprocess, 26.6ms inference, 1.9ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road611.png: 640x480 1 speedlimit, 46.7ms Speed: 13.9ms preprocess, 46.7ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road33.png: 640x448 2 trafficlights, 31.2ms Speed: 3.2ms preprocess, 31.2ms inference, 5.1ms postprocess per image at shape (1, 3, 640, 448)

image 1/1 /content/road_sign_detection/val/images/road345.png: 640x480 1 speedlimit, 31.6ms Speed: 9.2ms preprocess, 31.6ms inference, 2.4ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road148.png: 480x640 1 crosswalk, 22.1ms Speed: 8.2ms preprocess, 22.1ms inference, 5.4ms postprocess per image at shape (1, 3, 480, 640)

```
image 1/1 /content/road_sign_detection/val/images/road847.png: 640x480 1
trafficlight, 1 speedlimit, 32.0ms
Speed: 3.1ms preprocess, 32.0ms inference, 2.5ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road18.png: 640x512 3
trafficlights, 21.8ms
Speed: 3.6ms preprocess, 21.8ms inference, 8.3ms postprocess per image at shape
(1, 3, 640, 512)

image 1/1 /content/road_sign_detection/val/images/road308.png: 640x480 1
speedlimit, 1 crosswalk, 22.0ms
Speed: 9.2ms preprocess, 22.0ms inference, 2.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road449.png: 640x480 2
speedlimits, 22.2ms
Speed: 5.3ms preprocess, 22.2ms inference, 5.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road53.png: 480x640 2
trafficlights, 1 stop, 13.4ms
Speed: 3.2ms preprocess, 13.4ms inference, 2.1ms postprocess per image at shape
(1, 3, 480, 640)

image 1/1 /content/road_sign_detection/val/images/road728.png: 640x480 2
speedlimits, 21.0ms
Speed: 6.8ms preprocess, 21.0ms inference, 3.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road171.png: 640x480 1
trafficlight, 1 crosswalk, 38.9ms
Speed: 4.0ms preprocess, 38.9ms inference, 7.8ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road807.png: 640x480 1
speedlimit, 25.6ms
Speed: 9.4ms preprocess, 25.6ms inference, 3.6ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road569.png: 640x480 1
speedlimit, 39.7ms
Speed: 14.8ms preprocess, 39.7ms inference, 6.1ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road4.png: 640x448 4
trafficlights, 28.8ms
Speed: 5.6ms preprocess, 28.8ms inference, 4.0ms postprocess per image at shape
```

(1, 3, 640, 448)

image 1/1 /content/road_sign_detection/val/images/road787.png: 640x480 1
speedlimit, 23.6ms
Speed: 11.3ms preprocess, 23.6ms inference, 2.4ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road837.png: 640x480 1
speedlimit, 24.5ms
Speed: 6.0ms preprocess, 24.5ms inference, 8.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road845.png: 640x480 1
trafficlight, 1 speedlimit, 1 crosswalk, 30.6ms
Speed: 3.0ms preprocess, 30.6ms inference, 1.8ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road518.png: 640x480 1
speedlimit, 20.6ms
Speed: 3.0ms preprocess, 20.6ms inference, 1.9ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road628.png: 640x480 1
speedlimit, 20.7ms
Speed: 7.9ms preprocess, 20.7ms inference, 9.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road564.png: 640x480 1
speedlimit, 1 crosswalk, 28.5ms
Speed: 8.0ms preprocess, 28.5ms inference, 2.1ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road830.png: 640x480 1
speedlimit, 17.8ms
Speed: 3.1ms preprocess, 17.8ms inference, 13.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road262.png: 640x480 1
speedlimit, 25.3ms
Speed: 11.6ms preprocess, 25.3ms inference, 3.8ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road359.png: 640x480 2
speedlimits, 21.5ms
Speed: 13.4ms preprocess, 21.5ms inference, 2.7ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road437.png: 640x480 1

speedlimit, 27.9ms
Speed: 3.3ms preprocess, 27.9ms inference, 2.4ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road865.png: 640x480 1
speedlimit, 29.8ms
Speed: 3.1ms preprocess, 29.8ms inference, 5.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road541.png: 640x480 1
speedlimit, 33.5ms
Speed: 3.0ms preprocess, 33.5ms inference, 2.4ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road126.png: 640x448 1
crosswalk, 26.4ms
Speed: 3.7ms preprocess, 26.4ms inference, 4.1ms postprocess per image at shape (1, 3, 640, 448)

image 1/1 /content/road_sign_detection/val/images/road338.png: 640x480 1
speedlimit, 32.6ms
Speed: 2.9ms preprocess, 32.6ms inference, 2.7ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road479.png: 640x480 1
speedlimit, 26.6ms
Speed: 3.0ms preprocess, 26.6ms inference, 9.7ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road12.png: 640x512 3
trafficlights, 21.7ms
Speed: 7.7ms preprocess, 21.7ms inference, 9.2ms postprocess per image at shape (1, 3, 640, 512)

image 1/1 /content/road_sign_detection/val/images/road358.png: 640x480 1
speedlimit, 25.2ms
Speed: 8.8ms preprocess, 25.2ms inference, 2.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road383.png: 640x480 1
speedlimit, 11.6ms
Speed: 5.0ms preprocess, 11.6ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road735.png: 640x480 2
speedlimits, 30.9ms
Speed: 9.7ms preprocess, 30.9ms inference, 5.2ms postprocess per image at shape (1, 3, 640, 480)

```
image 1/1 /content/road_sign_detection/val/images/road199.png: 640x480 1
speedlimit, 33.4ms
Speed: 7.7ms preprocess, 33.4ms inference, 2.4ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road825.png: 640x480 1
trafficlight, 1 stop, 1 crosswalk, 53.5ms
Speed: 7.5ms preprocess, 53.5ms inference, 5.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road626.png: 640x480 1
speedlimit, 17.4ms
Speed: 9.1ms preprocess, 17.4ms inference, 3.5ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road822.png: 640x480 5
trafficlights, 1 stop, 2 crosswalks, 24.6ms
Speed: 8.1ms preprocess, 24.6ms inference, 4.8ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road555.png: 640x480 1
speedlimit, 24.0ms
Speed: 8.4ms preprocess, 24.0ms inference, 1.9ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road741.png: 640x480 2
speedlimits, 23.0ms
Speed: 7.8ms preprocess, 23.0ms inference, 2.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road384.png: 640x480 1
speedlimit, 19.3ms
Speed: 3.1ms preprocess, 19.3ms inference, 5.1ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road318.png: 640x480 1
speedlimit, 1 crosswalk, 18.8ms
Speed: 3.1ms preprocess, 18.8ms inference, 2.5ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road551.png: 640x480 1
speedlimit, 23.4ms
Speed: 10.3ms preprocess, 23.4ms inference, 2.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road425.png: 640x480 1
speedlimit, 25.3ms
```

Speed: 3.3ms preprocess, 25.3ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road327.png: 640x480 1 trafficlight, 1 speedlimit, 1 crosswalk, 22.3ms Speed: 3.2ms preprocess, 22.3ms inference, 8.2ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road333.png: 640x480 1 speedlimit, 13.3ms Speed: 3.5ms preprocess, 13.3ms inference, 5.5ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road162.png: 640x480 1 speedlimit, 14.1ms Speed: 3.0ms preprocess, 14.1ms inference, 4.3ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road287.png: 640x480 2 speedlimits, 12.1ms Speed: 3.1ms preprocess, 12.1ms inference, 2.5ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road815.png: 640x480 1 speedlimit, 11.2ms Speed: 3.0ms preprocess, 11.2ms inference, 2.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road252.png: 640x480 1 speedlimit, 12.5ms Speed: 3.2ms preprocess, 12.5ms inference, 2.2ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road310.png: 640x480 1 speedlimit, 11.0ms Speed: 3.1ms preprocess, 11.0ms inference, 2.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road179.png: 640x480 1 trafficlight, 10.7ms Speed: 3.1ms preprocess, 10.7ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road464.png: 640x480 3 trafficlights, 1 speedlimit, 1 crosswalk, 15.5ms Speed: 5.0ms preprocess, 15.5ms inference, 4.0ms postprocess per image at shape (1, 3, 640, 480)

```
image 1/1 /content/road_sign_detection/val/images/road536.png: 640x480 1
speedlimit, 18.1ms
Speed: 7.7ms preprocess, 18.1ms inference, 2.2ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road604.png: 640x480 1
speedlimit, 19.5ms
Speed: 3.4ms preprocess, 19.5ms inference, 2.4ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road163.png: 640x480 1 stop, 1
speedlimit, 13.2ms
Speed: 3.1ms preprocess, 13.2ms inference, 2.1ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road139.png: 416x640 1
crosswalk, 27.2ms
Speed: 2.8ms preprocess, 27.2ms inference, 2.4ms postprocess per image at shape
(1, 3, 416, 640)

image 1/1 /content/road_sign_detection/val/images/road382.png: 640x480 1
speedlimit, 27.2ms
Speed: 5.2ms preprocess, 27.2ms inference, 2.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road356.png: 640x480 1 stop,
19.2ms
Speed: 3.1ms preprocess, 19.2ms inference, 4.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road831.png: 640x480 1
speedlimit, 11.2ms
Speed: 5.9ms preprocess, 11.2ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road181.png: 640x480 1
speedlimit, 1 crosswalk, 10.5ms
Speed: 2.9ms preprocess, 10.5ms inference, 2.1ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road253.png: 640x480 1
speedlimit, 10.3ms
Speed: 3.3ms preprocess, 10.3ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road770.png: 640x480 1
speedlimit, 10.3ms
Speed: 2.8ms preprocess, 10.3ms inference, 2.0ms postprocess per image at shape
```

(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road702.png: 640x480 2 speedlimits, 10.0ms
Speed: 2.9ms preprocess, 10.0ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road99.png: 640x448 1 stop, 11.3ms
Speed: 2.9ms preprocess, 11.3ms inference, 1.9ms postprocess per image at shape (1, 3, 640, 448)

image 1/1 /content/road_sign_detection/val/images/road679.png: 640x480 1 speedlimit, 11.5ms
Speed: 3.4ms preprocess, 11.5ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road284.png: 640x480 1 speedlimit, 10.5ms
Speed: 3.1ms preprocess, 10.5ms inference, 1.8ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road746.png: 640x480 2 speedlimits, 10.6ms
Speed: 3.4ms preprocess, 10.6ms inference, 1.9ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road431.png: 640x480 1 speedlimit, 13.7ms
Speed: 5.0ms preprocess, 13.7ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road805.png: 640x480 1 speedlimit, 11.8ms
Speed: 3.5ms preprocess, 11.8ms inference, 2.2ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road118.png: 448x640 1 speedlimit, 13.6ms
Speed: 3.0ms preprocess, 13.6ms inference, 2.1ms postprocess per image at shape (1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road701.png: 640x480 2 speedlimits, 12.6ms
Speed: 2.9ms preprocess, 12.6ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road515.png: 640x480 1

```
speedlimit, 10.9ms
Speed: 2.9ms preprocess, 10.9ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road673.png: 640x480 1 stop,
10.4ms
Speed: 2.9ms preprocess, 10.4ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road129.png: 448x640 1
trafficlight, 1 crosswalk, 15.2ms
Speed: 2.9ms preprocess, 15.2ms inference, 2.0ms postprocess per image at shape
(1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road361.png: 640x480 1
speedlimit, 1 crosswalk, 12.8ms
Speed: 7.1ms preprocess, 12.8ms inference, 3.4ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road854.png: 640x480 1
speedlimit, 15.2ms
Speed: 3.0ms preprocess, 15.2ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road27.png: 640x448 1
trafficlight, 22.6ms
Speed: 3.0ms preprocess, 22.6ms inference, 4.4ms postprocess per image at shape
(1, 3, 640, 448)

image 1/1 /content/road_sign_detection/val/images/road675.png: 640x480 1 stop,
17.3ms
Speed: 6.3ms preprocess, 17.3ms inference, 3.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road69.png: 512x640 2 stops,
19.3ms
Speed: 3.3ms preprocess, 19.3ms inference, 2.5ms postprocess per image at shape
(1, 3, 512, 640)

image 1/1 /content/road_sign_detection/val/images/road365.png: 640x480 1
speedlimit, 17.3ms
Speed: 4.5ms preprocess, 17.3ms inference, 2.8ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road362.png: 640x480 1
speedlimit, 12.9ms
Speed: 2.9ms preprocess, 12.9ms inference, 2.3ms postprocess per image at shape
(1, 3, 640, 480)
```

```
image 1/1 /content/road_sign_detection/val/images/road810.png: 640x480 1
speedlimit, 21.2ms
Speed: 5.8ms preprocess, 21.2ms inference, 4.9ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road708.png: 640x480 2
speedlimits, 12.3ms
Speed: 3.7ms preprocess, 12.3ms inference, 3.3ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road722.png: 640x480 1
speedlimit, 17.4ms
Speed: 4.0ms preprocess, 17.4ms inference, 2.8ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road781.png: 640x480 1
speedlimit, 1 crosswalk, 15.1ms
Speed: 8.0ms preprocess, 15.1ms inference, 3.4ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road189.png: 640x480 1
trafficlight, 2 crosswalks, 10.7ms
Speed: 3.0ms preprocess, 10.7ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road372.png: 640x480 1
speedlimit, 10.7ms
Speed: 3.1ms preprocess, 10.7ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road771.png: 640x480 1
speedlimit, 10.7ms
Speed: 3.1ms preprocess, 10.7ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road131.png: 448x640 2
crosswalks, 11.7ms
Speed: 2.8ms preprocess, 11.7ms inference, 2.1ms postprocess per image at shape
(1, 3, 448, 640)

image 1/1 /content/road_sign_detection/val/images/road413.png: 640x480 1
speedlimit, 11.2ms
Speed: 2.9ms preprocess, 11.2ms inference, 2.0ms postprocess per image at shape
(1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road367.png: 640x480 1
speedlimit, 12.5ms
```

Speed: 3.0ms preprocess, 12.5ms inference, 3.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road523.png: 640x480 1 speedlimit, 11.1ms

Speed: 3.3ms preprocess, 11.1ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road115.png: 384x640 1 speedlimit, 11.5ms

Speed: 2.8ms preprocess, 11.5ms inference, 2.0ms postprocess per image at shape (1, 3, 384, 640)

image 1/1 /content/road_sign_detection/val/images/road272.png: 640x480 1 trafficlight, 1 stop, 2 crosswalks, 14.9ms

Speed: 3.0ms preprocess, 14.9ms inference, 2.0ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road561.png: 640x480 1 speedlimit, 1 crosswalk, 12.1ms

Speed: 3.0ms preprocess, 12.1ms inference, 4.1ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road842.png: 640x480 1 speedlimit, 1 crosswalk, 10.4ms

Speed: 3.3ms preprocess, 10.4ms inference, 1.9ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road710.png: 640x480 2 speedlimits, 10.2ms

Speed: 3.1ms preprocess, 10.2ms inference, 1.9ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road159.png: 640x480 1 speedlimit, 14.4ms

Speed: 3.7ms preprocess, 14.4ms inference, 1.9ms postprocess per image at shape (1, 3, 640, 480)

image 1/1 /content/road_sign_detection/val/images/road540.png: 640x480 1 speedlimit, 17.4ms

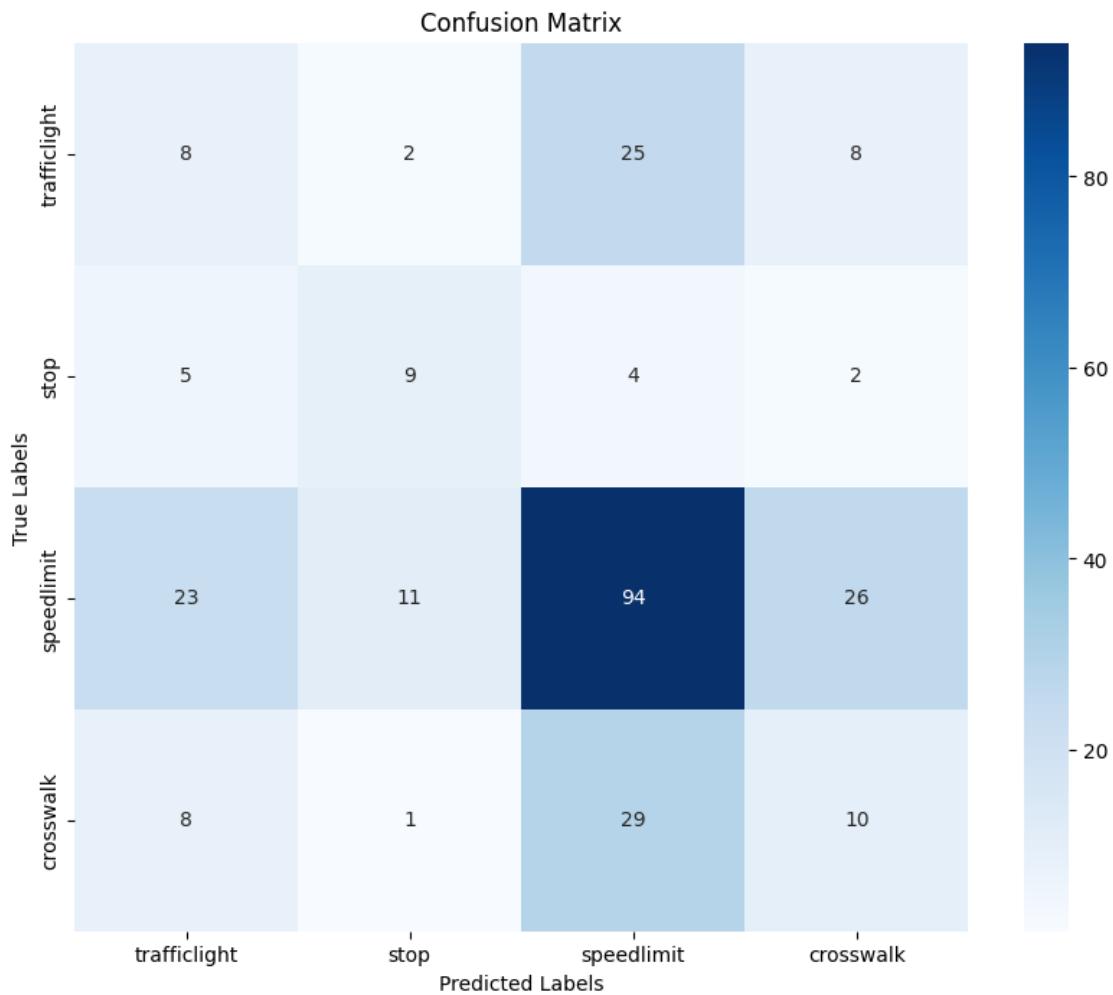
Speed: 3.7ms preprocess, 17.4ms inference, 3.5ms postprocess per image at shape (1, 3, 640, 480)

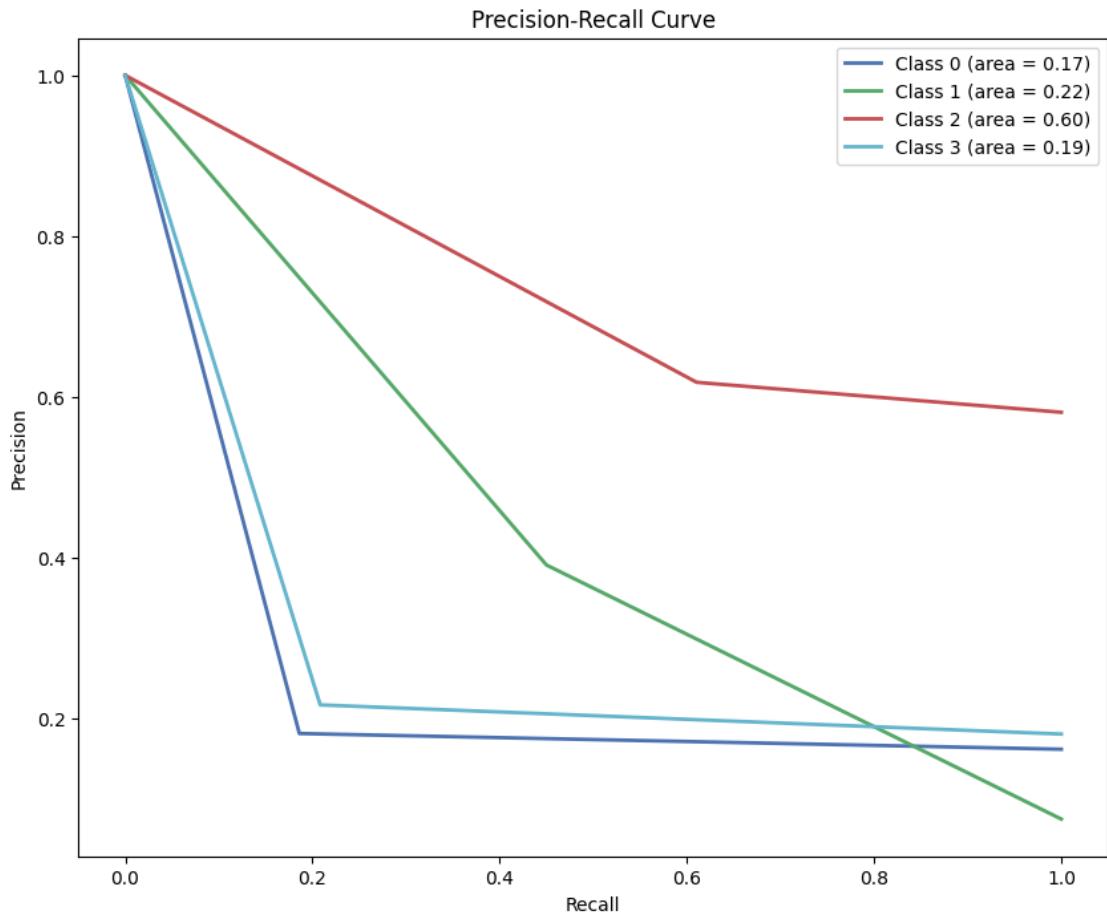
image 1/1 /content/road_sign_detection/val/images/road236.png: 640x480 3 speedlimits, 18.2ms

Speed: 3.7ms preprocess, 18.2ms inference, 2.4ms postprocess per image at shape (1, 3, 640, 480)

```
image 1/1 /content/road_sign_detection/val/images/road83.png: 640x448 1 stop,  
11.6ms  
Speed: 3.3ms preprocess, 11.6ms inference, 2.0ms postprocess per image at shape  
(1, 3, 640, 448)
```

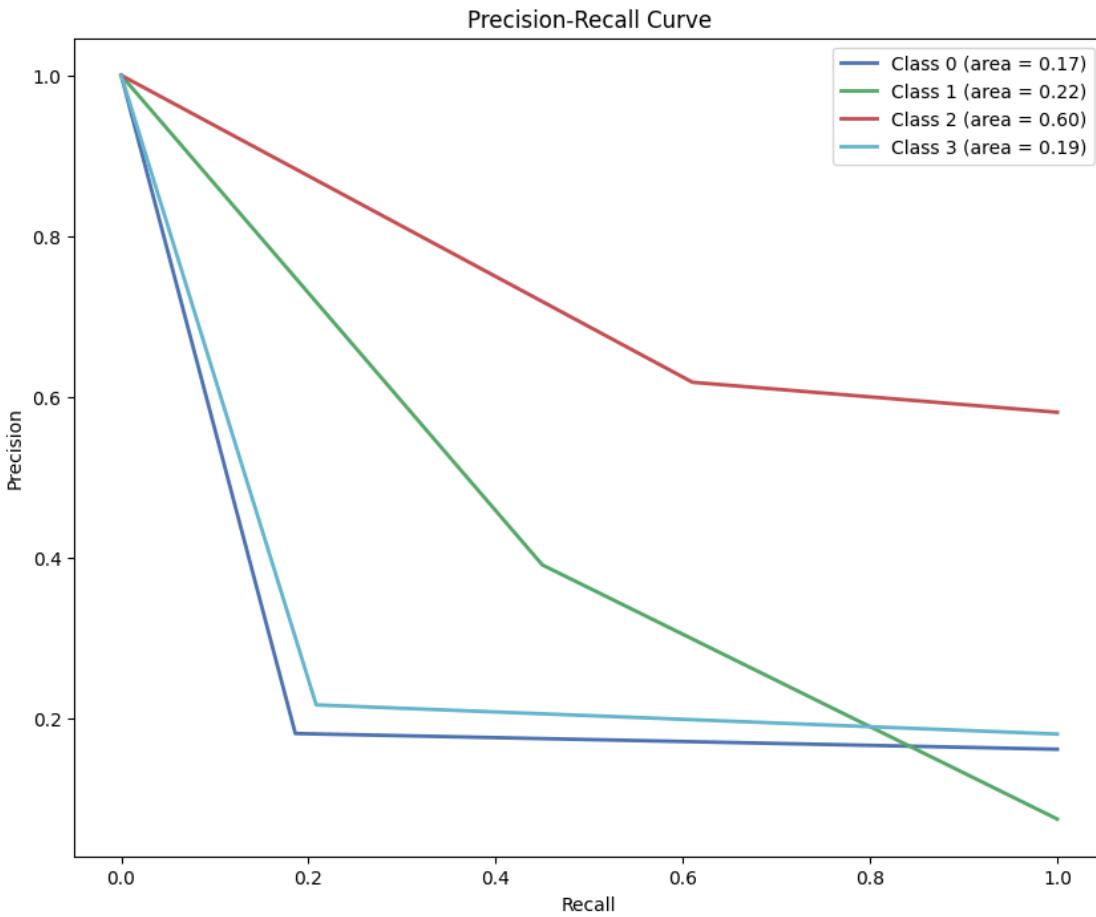
```
image 1/1 /content/road_sign_detection/val/images/road539.png: 640x480 1  
speedlimit, 17.0ms  
Speed: 7.0ms preprocess, 17.0ms inference, 2.1ms postprocess per image at shape  
(1, 3, 640, 480)
```





#Precision-Recall Curve

```
[ ]: # Plot Precision-Recall curve for each class
plt.figure(figsize=(10, 8))
colors = ['b', 'g', 'r', 'c']
for i, color in zip(range(4), colors):
    plt.plot(recall[i], precision[i], color=color, lw=2, label=f'Class {i} \u2192 (area = {average_precision[i]:0.2f})')
plt.xlabel('Recall')
plt.ylabel('Precision')
plt.title('Precision-Recall Curve')
plt.legend(loc="best")
plt.show()
```



```
[ ]: # Mount Google Drive
from google.colab import drive
drive.mount('/content/drive')
```

Mounted at /content/drive

```
[ ]: # Create directory in Google Drive to save models using os module
model_dir = '/content/drive/My Drive/Colab Notebooks/YOLOv8_Models'
os.makedirs(model_dir, exist_ok=True)
```

```
[ ]: # Save the model's state dictionary with .pt suffix
fine_tuned_model_path = os.path.join(model_dir, 'yolov8n_finetuned.pt')
torch.save(model.model.state_dict(), fine_tuned_model_path)
print(f"Fine-tuned model saved as {fine_tuned_model_path}")
```

Fine-tuned model saved as /content/drive/My Drive/Colab Notebooks/YOLOv8_Models/yolov8n_finetuned.pt

#Let's train the model with more data augmentation

```
[ ]: # Define data augmentation pipeline
augmentation_pipeline = A.Compose([
    A.RandomCrop(width=450, height=450),
    A.HorizontalFlip(p=0.5),
    A.RandomBrightnessContrast(p=0.2),
    A.HueSaturationValue(p=0.2),
    A.Rotate(limit=15),
    A.Resize(height=640, width=640)
])

[ ]: # Function to apply augmentations to an image
def apply_augmentation(image_path):
    image = cv2.imread(image_path)
    image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
    h, w, _ = image.shape

    if h >= 450 and w >= 450:
        crop = A.RandomCrop(width=450, height=450)
        augmented = crop(image=image)
        image = augmented['image']

    augmented = augmentation_pipeline(image=image)
    return augmented['image']

# Apply augmentations and save augmented images
augmented_images_path = 'road_sign_detection/train/augmented_images'
os.makedirs(augmented_images_path, exist_ok=True)

train_images = [f for f in os.listdir('/content/road_sign_detection/train/images') if f.endswith('.jpg')]
for img in train_images:
    img_path = os.path.join('/content/road_sign_detection/train/images', img)
    augmented_image = apply_augmentation(img_path)
    augmented_img_path = os.path.join(augmented_images_path, img)
    cv2.imwrite(augmented_img_path, cv2.cvtColor(augmented_image, cv2.COLOR_RGB2BGR))

[ ]: # Train the model with augmented data
model.train(data='/content/road_sign_detection.yaml', epochs=50, imgsz=640, augment=True)
```

Ultralytics YOLOv8.2.66 Python-3.10.12 torch-2.3.1+cu121 CUDA:0 (Tesla T4, 15102MiB)

engine/trainer: task=detect, mode=train, model=yolov8n.yaml, data=/content/road_sign_detection.yaml, epochs=50, time=None, patience=100, batch=16, imgsz=640, save=True, save_period=-1, cache=False, device=None, workers=8, project=None, name=train2, exist_ok=False, pretrained=True, optimizer=auto, verbose=True, seed=0, deterministic=True, single_cls=False,

```

rect=False, cos_lr=False, close_mosaic=10, resume=False, amp=True, fraction=1.0,
profile=False, freeze=None, multi_scale=False, overlap_mask=True, mask_ratio=4,
dropout=0.0, val=True, split=val, save_json=False, save_hybrid=False, conf=None,
iou=0.7, max_det=300, half=False, dnn=False, plots=True, source=None,
vid_stride=1, stream_buffer=False, visualize=False, augment=True,
agnostic_nms=False, classes=None, retina_masks=False, embed=None, show=False,
save_frames=False, save_txt=False, save_conf=False, save_crop=False,
show_labels=True, show_conf=True, show_boxes=True, line_width=None,
format=torchscript, keras=False, optimize=False, int8=False, dynamic=False,
simplify=False, opset=None, workspace=4, nms=False, lr0=0.01, lrf=0.01,
momentum=0.937, weight_decay=0.0005, warmup_epochs=3.0, warmup_momentum=0.8,
warmup_bias_lr=0.0, box=7.5, cls=0.5, df1=1.5, pose=12.0, kobj=1.0,
label_smoothing=0.0, nbs=64, hsv_h=0.015, hsv_s=0.7, hsv_v=0.4, degrees=0.0,
translate=0.1, scale=0.5, shear=0.0, perspective=0.0, flipud=0.0, fliplr=0.5,
bgr=0.0, mosaic=0.0, mixup=0.0, copy_paste=0.0, auto_augment=randaugment,
erasing=0.4, crop_fraction=1.0, cfg=None, tracker=botsort.yaml,
save_dir=runs/detect/train2

```

	from	n	params	module
arguments				
0		-1 1	464	ultralytics.nn.modules.conv.Conv
[3, 16, 3, 2]				
1		-1 1	4672	ultralytics.nn.modules.conv.Conv
[16, 32, 3, 2]				
2		-1 1	7360	ultralytics.nn.modules.block.C2f
[32, 32, 1, True]				
3		-1 1	18560	ultralytics.nn.modules.conv.Conv
[32, 64, 3, 2]				
4		-1 2	49664	ultralytics.nn.modules.block.C2f
[64, 64, 2, True]				
5		-1 1	73984	ultralytics.nn.modules.conv.Conv
[64, 128, 3, 2]				
6		-1 2	197632	ultralytics.nn.modules.block.C2f
[128, 128, 2, True]				
7		-1 1	295424	ultralytics.nn.modules.conv.Conv
[128, 256, 3, 2]				
8		-1 1	460288	ultralytics.nn.modules.block.C2f
[256, 256, 1, True]				
9		-1 1	164608	ultralytics.nn.modules.block.SPPF
[256, 256, 5]				
10		-1 1	0	torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']				
11		[-1, 6] 1	0	ultralytics.nn.modules.conv.Concat
[1]				
12		-1 1	148224	ultralytics.nn.modules.block.C2f
[384, 128, 1]				
13		-1 1	0	torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']				

```

14           [-1, 4]  1          0 ultralytics.nn.modules.conv.Concat
[1]
15           -1  1      37248 ultralytics.nn.modules.block.C2f
[192, 64, 1]
16           -1  1      36992 ultralytics.nn.modules.conv.Conv
[64, 64, 3, 2]
17           [-1, 12]  1          0 ultralytics.nn.modules.conv.Concat
[1]
18           -1  1     123648 ultralytics.nn.modules.block.C2f
[192, 128, 1]
19           -1  1     147712 ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]
20           [-1, 9]  1          0 ultralytics.nn.modules.conv.Concat
[1]
21           -1  1     493056 ultralytics.nn.modules.block.C2f
[384, 256, 1]
22           [15, 18, 21]  1     752092 ultralytics.nn.modules.head.Detect
[4, [64, 128, 256]]
YOLOv8n summary: 225 layers, 3,011,628 parameters, 3,011,612 gradients, 8.2
GFLOPs

```

TensorBoard: Start with 'tensorboard --logdir runs/detect/train2', view at <http://localhost:6006/>

Freezing layer 'model.22.dfl.conv.weight'

AMP: running Automatic Mixed Precision (AMP) checks with YOLOv8n...

AMP: checks passed

train: Scanning /content/road_sign_detection/train/labels.cache...
701 images, 0 backgrounds, 0 corrupt: 100% | 701/701 [00:00<?, ?it/s]

albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01, blur_limit=(3, 7)), ToGray(p=0.01), CLAHE(p=0.01, clip_limit=(1, 4.0), tile_grid_size=(8, 8))

/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning: os.fork() was called. os.fork() is incompatible with multithreaded code, and JAX is multithreaded, so this will likely lead to a deadlock.

```

    self.pid = os.fork()
val: Scanning /content/road_sign_detection/val/labels.cache... 176
images, 0 backgrounds, 0 corrupt: 100% | 176/176 [00:00<?, ?it/s]

Plotting labels to runs/detect/train2/labels.jpg...
optimizer: 'optimizer=auto' found, ignoring 'lr0=0.01' and
'momentum=0.937' and determining best 'optimizer', 'lr0' and 'momentum'
automatically...
optimizer: AdamW(lr=0.00125, momentum=0.9) with parameter groups 57
weight(decay=0.0), 64 weight(decay=0.0005), 63 bias(decay=0.0)
TensorBoard: model graph visualization added
Image sizes 640 train, 640 val

```

Using 2 dataloader workers
 Logging results to runs/detect/train2
 Starting training for 50 epochs...

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
1/50	2.45G	3.298	6.029	4.351	19	640:
100%	44/44 [00:31<00:00, 1.38it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.14it/s]					
	all	176	235	0.000209	0.105	0.000154
		5.43e-05				

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
2/50	2.25G	3.066	5.354	3.819	16	640:
100%	44/44 [00:19<00:00, 2.30it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.97it/s]					
	all	176	235	0.000114	0.0338	9.86e-05
		3.54e-05				

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
3/50	2.24G	2.613	4.642	3.231	21	640:
100%	44/44 [00:24<00:00, 1.80it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.50it/s]					
	all	176	235	0.000831	0.144	0.022
		0.00553				

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
4/50	2.25G	2.184	3.723	2.674	16	640:
100%	44/44 [00:19<00:00, 2.25it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.98it/s]					
	all	176	235	0.446	0.193	0.181
		0.105				

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
5/50	2.25G	1.813	2.88	2.251	15	640:
100%	44/44 [00:18<00:00, 2.35it/s]					

	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95) : 100%	6/6 [00:02<00:00, 2.54it/s]					
	all	176	235	0.867	0.174	0.208
0.142						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
6/50	2.25G	1.497	2.29	2	15	640:
100%	44/44 [00:19<00:00, 2.30it/s]					
mAP50-95) : 100%	6/6 [00:01<00:00, 3.21it/s]					
	all	176	235	0.77	0.32	0.353
0.227						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
7/50	2.26G	1.354	1.847	1.791	13	640:
100%	44/44 [00:18<00:00, 2.41it/s]					
mAP50-95) : 100%	6/6 [00:02<00:00, 2.15it/s]					
	all	176	235	0.869	0.428	0.477
0.332						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
8/50	2.24G	1.253	1.633	1.694	18	640:
100%	44/44 [00:17<00:00, 2.58it/s]					
mAP50-95) : 100%	6/6 [00:03<00:00, 1.74it/s]					
	all	176	235	0.903	0.385	0.455
0.326						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
9/50	2.24G	1.151	1.422	1.576	24	640:
100%	44/44 [00:16<00:00, 2.67it/s]					
mAP50-95) : 100%	6/6 [00:03<00:00, 1.72it/s]					

	all	176	235	0.831	0.422	0.47
0.351						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
10/50	2.26G	1.096	1.319	1.53	18	640:
100%	44/44 [00:15<00:00, 2.86it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:04<00:00, 1.48it/s]					mAP50
	all	176	235	0.825	0.497	0.519
0.383						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
11/50	2.24G	1.055	1.201	1.455	15	640:
100%	44/44 [00:15<00:00, 2.79it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:03<00:00, 1.79it/s]					mAP50
	all	176	235	0.775	0.539	0.619
0.456						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
12/50	2.24G	1.005	1.135	1.4	25	640:
100%	44/44 [00:16<00:00, 2.72it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:02<00:00, 2.37it/s]					mAP50
	all	176	235	0.676	0.545	0.62
0.441						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
13/50	2.24G	1.008	1.053	1.376	19	640:
100%	44/44 [00:17<00:00, 2.49it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:02<00:00, 2.93it/s]					mAP50
	all	176	235	0.868	0.543	0.613
0.457						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
14/50	2.24G	1.004	1.034	1.383	20	640:
100%	44/44 [00:18<00:00, 2.35it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.93it/s]					
	all	176	235	0.899	0.558	0.607
0.454						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
15/50	2.24G	0.9771	0.9825	1.337	16	640:
100%	44/44 [00:18<00:00, 2.40it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.05it/s]					
	all	176	235	0.623	0.633	0.629
0.478						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
16/50	2.24G	0.9304	0.9124	1.319	16	640:
100%	44/44 [00:19<00:00, 2.31it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.13it/s]					
	all	176	235	0.948	0.575	0.685
0.518						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
17/50	2.24G	0.9265	0.9058	1.285	21	640:
100%	44/44 [00:18<00:00, 2.41it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.03it/s]					
	all	176	235	0.866	0.653	0.705
0.524						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
18/50	2.24G	0.8962	0.8477	1.264	17	640:
100%	44/44 [00:19<00:00, 2.30it/s]					

	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95) : 100%	6/6 [00:02<00:00, 2.73it/s]					
	all	176	235	0.87	0.68	0.743
0.563						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
19/50	2.24G	0.9347	0.8962	1.291	18	640:
100%	44/44 [00:18<00:00, 2.37it/s]					
mAP50-95) : 100%	6/6 [00:02<00:00, 2.34it/s]					
	all	176	235	0.845	0.585	0.656
0.474						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
20/50	2.24G	0.8824	0.8269	1.249	16	640:
100%	44/44 [00:17<00:00, 2.52it/s]					
mAP50-95) : 100%	6/6 [00:03<00:00, 1.71it/s]					
	all	176	235	0.681	0.698	0.728
0.542						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
21/50	2.24G	0.9058	0.8354	1.262	19	640:
100%	44/44 [00:16<00:00, 2.66it/s]					
mAP50-95) : 100%	6/6 [00:03<00:00, 1.67it/s]					
	all	176	235	0.794	0.718	0.739
0.58						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
22/50	2.24G	0.9006	0.8031	1.255	19	640:
100%	44/44 [00:15<00:00, 2.84it/s]					
mAP50-95) : 100%	6/6 [00:04<00:00, 1.40it/s]					

	all	176	235	0.883	0.717	0.767
0.581						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
23/50	2.24G	0.8608	0.7709	1.229	24	640:
100%	44/44 [00:15<00:00, 2.87it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:03<00:00, 1.60it/s]					mAP50
	all	176	235	0.704	0.706	0.73
0.558						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
24/50	2.26G	0.8675	0.7377	1.21	18	640:
100%	44/44 [00:15<00:00, 2.82it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:02<00:00, 2.01it/s]					mAP50
	all	176	235	0.812	0.753	0.757
0.584						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
25/50	2.24G	0.8452	0.7173	1.205	19	640:
100%	44/44 [00:16<00:00, 2.65it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:02<00:00, 2.36it/s]					mAP50
	all	176	235	0.812	0.798	0.776
0.592						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
26/50	2.24G	0.8297	0.7024	1.183	22	640:
100%	44/44 [00:17<00:00, 2.51it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:02<00:00, 2.90it/s]					mAP50
	all	176	235	0.808	0.738	0.742
0.562						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
27/50	2.24G	0.8246	0.6982	1.178	17	640:
100%	44/44 [00:17<00:00, 2.50it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.73it/s]					
	all	176	235	0.83	0.731	0.772
0.59						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
28/50	2.24G	0.7911	0.69	1.162	17	640:
100%	44/44 [00:18<00:00, 2.34it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.26it/s]					
	all	176	235	0.724	0.747	0.755
0.592						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
29/50	2.24G	0.8088	0.6768	1.159	22	640:
100%	44/44 [00:18<00:00, 2.41it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.31it/s]					
	all	176	235	0.729	0.758	0.753
0.583						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
30/50	2.24G	0.8069	0.6716	1.165	16	640:
100%	44/44 [00:18<00:00, 2.33it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.40it/s]					
	all	176	235	0.799	0.711	0.759
0.589						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
-------	---------	----------	----------	----------	-----------	------

	31/50	2.24G	0.8212	0.677	1.172	18	640:
100%	44/44 [00:19<00:00, 2.28it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.93it/s]						
	all	176	235	0.78	0.725	0.743	
0.56							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
32/50	2.24G	0.8003	0.6698	1.158		29	640:
100%	44/44 [00:18<00:00, 2.34it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.54it/s]						
	all	176	235	0.833	0.748	0.776	
0.604							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
33/50	2.26G	0.7805	0.6542	1.144		18	640:
100%	44/44 [00:17<00:00, 2.46it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.88it/s]						
	all	176	235	0.814	0.714	0.756	
0.592							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
34/50	2.24G	0.7739	0.6159	1.132		21	640:
100%	44/44 [00:17<00:00, 2.51it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.54it/s]						
	all	176	235	0.91	0.733	0.788	
0.602							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
35/50	2.26G	0.7674	0.5973	1.117		17	640:
100%	44/44 [00:16<00:00, 2.69it/s]						
	Class	Images	Instances	Box(P)		R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.68it/s]						

	all	176	235	0.786	0.751	0.769
0.599						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
36/50	2.24G	0.7813	0.6105	1.132	19	640:
100%	44/44 [00:15<00:00, 2.82it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:04<00:00, 1.47it/s]					mAP50
	all	176	235	0.807	0.782	0.779
0.603						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
37/50	2.24G	0.7658	0.603	1.119	16	640:
100%	44/44 [00:15<00:00, 2.81it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:03<00:00, 1.72it/s]					mAP50
	all	176	235	0.806	0.766	0.787
0.616						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
38/50	2.24G	0.7376	0.5639	1.102	19	640:
100%	44/44 [00:16<00:00, 2.65it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:03<00:00, 1.76it/s]					mAP50
	all	176	235	0.874	0.77	0.793
0.62						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
39/50	2.24G	0.7616	0.5846	1.11	23	640:
100%	44/44 [00:16<00:00, 2.70it/s]	Class	Images	Instances	Box(P)	R
mAP50-95): 100%	6/6 [00:03<00:00, 1.82it/s]					mAP50
	all	176	235	0.825	0.777	0.78
0.592						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
40/50	2.24G	0.7417	0.5801	1.115	18	640:
100%	44/44 [00:16<00:00, 2.63it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.22it/s]					
	all	176	235	0.865	0.732	0.779
0.598						

Closing dataloader mosaic

albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01, blur_limit=(3, 7)), ToGray(p=0.01), CLAHE(p=0.01, clip_limit=(1, 4.0), tile_grid_size=(8, 8))

/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning: os.fork() was called. os.fork() is incompatible with multithreaded code, and JAX is multithreaded, so this will likely lead to a deadlock.

 self.pid = os.fork()

/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning: os.fork() was called. os.fork() is incompatible with multithreaded code, and JAX is multithreaded, so this will likely lead to a deadlock.

 self.pid = os.fork()

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
41/50	2.24G	0.76	0.5721	1.116	20	640:
100%	44/44 [00:20<00:00, 2.14it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.61it/s]					
	all	176	235	0.78	0.79	0.776
0.606						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
42/50	2.24G	0.7259	0.562	1.091	15	640:
100%	44/44 [00:16<00:00, 2.71it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:03<00:00, 1.70it/s]					
	all	176	235	0.804	0.793	0.807
0.629						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
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	43/50	2.26G	0.7397	0.5532	1.092	20	640:
100%	44/44 [00:16<00:00, 2.66it/s]					R	mAP50
	Class	Images	Instances	Box(P)			
mAP50-95): 100%	6/6 [00:03<00:00, 1.89it/s]						
	all	176	235	0.857	0.788	0.793	
0.614							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
44/50	2.24G	0.7335	0.558	1.096	27	640:	
100%	44/44 [00:16<00:00, 2.70it/s]						
	Class	Images	Instances	Box(P)	R	mAP50	
mAP50-95): 100%	6/6 [00:02<00:00, 2.01it/s]						
	all	176	235	0.826	0.791	0.789	
0.617							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
45/50	2.26G	0.7165	0.5463	1.079	16	640:	
100%	44/44 [00:17<00:00, 2.51it/s]						
	Class	Images	Instances	Box(P)	R	mAP50	
mAP50-95): 100%	6/6 [00:02<00:00, 2.44it/s]						
	all	176	235	0.827	0.793	0.818	
0.636							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
46/50	2.24G	0.7214	0.5372	1.085	18	640:	
100%	44/44 [00:18<00:00, 2.35it/s]						
	Class	Images	Instances	Box(P)	R	mAP50	
mAP50-95): 100%	6/6 [00:02<00:00, 2.64it/s]						
	all	176	235	0.845	0.798	0.811	
0.641							

	Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
47/50	2.25G	0.7138	0.5368	1.086	19	640:	
100%	44/44 [00:18<00:00, 2.33it/s]						
	Class	Images	Instances	Box(P)	R	mAP50	
mAP50-95): 100%	6/6 [00:02<00:00, 2.98it/s]						

	all	176	235	0.852	0.769	0.812
0.638						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
48/50	2.24G	0.7082	0.5231	1.075	16	640:
100%	44/44 [00:18<00:00, 2.38it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.03it/s]					
	all	176	235	0.866	0.783	0.818
0.648						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
49/50	2.24G	0.7101	0.5248	1.072	28	640:
100%	44/44 [00:19<00:00, 2.24it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:02<00:00, 2.53it/s]					
	all	176	235	0.911	0.775	0.812
0.647						

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
50/50	2.25G	0.6864	0.5237	1.061	17	640:
100%	44/44 [00:19<00:00, 2.24it/s]					
	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:01<00:00, 3.15it/s]					
	all	176	235	0.901	0.77	0.807
0.639						

50 epochs completed in 0.309 hours.

Optimizer stripped from runs/detect/train2/weights/last.pt, 6.2MB
 Optimizer stripped from runs/detect/train2/weights/best.pt, 6.2MB

Validating runs/detect/train2/weights/best.pt...
 Ultralytics YOLOv8.2.66 Python-3.10.12 torch-2.3.1+cu121 CUDA:0 (Tesla T4, 15102MiB)
 YOLOv8n summary (fused): 168 layers, 3,006,428 parameters, 0 gradients, 8.1 GFLOPs

	Class	Images	Instances	Box(P)	R	mAP50
mAP50-95): 100%	6/6 [00:08<00:00, 1.38s/it]					
0.648	all	176	235	0.87	0.797	0.808
0.239	trafficlight	14	23	0.633	0.478	0.472
0.84	stop	14	14	0.871	0.929	0.928
0.872	speedlimit	144	163	1	0.981	0.995
0.643	crosswalk	31	35	0.974	0.8	0.838
Speed: 0.6ms preprocess, 30.6ms inference, 0.0ms loss, 3.1ms postprocess per image						
Results saved to runs/detect/train2						

[]: ultralytics.utils.metrics.DetMetrics object with attributes:

```

ap_class_index: array([0, 1, 2, 3])
box: ultralytics.utils.metrics.Metric object
confusion_matrix: <ultralytics.utils.metrics.ConfusionMatrix object at
0x7de387f1fa60>
curves: ['Precision-Recall(B)', 'F1-Confidence(B)', 'Precision-Confidence(B)', 'Recall-Confidence(B)']
curves_results: [[array([
0,      0.001001,   0.002002,   0.003003,
0.004004,   0.005005,   0.006006,   0.007007,   0.008008,   0.009009,
0.01001,    0.011011,   0.012012,   0.013013,   0.014014,   0.015015,
0.016016,   0.017017,   0.018018,   0.019019,   0.02002,    0.021021,
0.022022,   0.023023,
0.024024,   0.025025,   0.026026,   0.027027,   0.028028,
0.029029,   0.03003,    0.031031,   0.032032,   0.033033,   0.034034,
0.035035,   0.036036,   0.037037,   0.038038,   0.039039,   0.04004,
0.041041,   0.042042,   0.043043,   0.044044,   0.045045,   0.046046,
0.047047,
0.048048,   0.049049,   0.05005,    0.051051,   0.052052,
0.053053,   0.054054,   0.055055,   0.056056,   0.057057,   0.058058,
0.059059,   0.06006,    0.061061,   0.062062,   0.063063,   0.064064,
0.065065,   0.066066,   0.067067,   0.068068,   0.069069,   0.07007,
0.071071,
0.072072,   0.073073,   0.074074,   0.075075,   0.076076,
0.077077,   0.078078,   0.079079,   0.08008,    0.081081,   0.082082,
0.083083,   0.084084,   0.085085,   0.086086,   0.087087,   0.088088,
0.089089,   0.09009,    0.091091,   0.092092,   0.093093,   0.094094,
0.095095,
0.096096,   0.097097,   0.098098,   0.099099,   0.1001,
0.1011,     0.1021,     0.1031,     0.1041,     0.10511,   0.10611,
0.10711,    0.10811,   0.10911,   0.11011,   0.11111,   0.11211,

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0.11311,	0.11411,	0.11512,	0.11612,	0.11712,	0.11812,
0.11912,	0.12012,	0.12112,	0.12212,	0.12312,	0.12412,
0.12513,	0.12613,	0.12713,	0.12813,	0.12913,	0.13013,
0.13113,	0.13213,	0.13313,	0.13413,	0.13514,	0.13614,
0.13714,	0.13814,	0.13914,	0.14014,	0.14114,	0.14214,
0.14314,	0.14414,	0.14515,	0.14615,	0.14715,	0.14815,
0.14915,	0.15015,	0.15115,	0.15215,	0.15315,	0.15415,
0.15516,	0.15616,	0.15716,	0.15816,	0.15916,	0.16016,
0.16116,	0.16216,	0.16316,	0.16416,	0.16517,	0.16617,
0.16717,	0.16817,	0.16917,	0.17017,	0.17117,	0.17217,
0.17317,	0.17417,	0.17518,	0.17618,	0.17718,	0.17818,
0.17918,	0.18018,	0.18118,	0.18218,	0.18318,	0.18418,
0.18519,	0.18619,	0.18719,	0.18819,	0.18919,	0.19019,
0.19119,	0.19219,	0.19319,	0.19419,	0.1952,	0.1962,
0.1972,	0.1982,	0.1992,	0.2002,	0.2012,	0.2022,
0.2032,	0.2042,	0.20521,	0.20621,	0.20721,	0.20821,
0.20921,	0.21021,	0.21121,	0.21221,	0.21321,	0.21421,
0.21522,	0.21622,	0.21722,	0.21822,	0.21922,	0.22022,
0.22122,	0.22222,	0.22322,	0.22422,	0.22523,	0.22623,
0.22723,	0.22823,	0.22923,	0.23023,	0.23123,	0.23223,
0.23323,	0.23423,	0.23524,	0.23624,	0.23724,	0.23824,
0.23924,	0.24024,	0.24124,	0.24224,	0.24324,	0.24424,
0.24525,	0.24625,	0.24725,	0.24825,	0.24925,	0.25025,
0.25125,	0.25225,	0.25325,	0.25425,	0.25526,	0.25626,
0.25726,	0.25826,	0.25926,	0.26026,	0.26126,	0.26226,
0.26326,	0.26426,	0.26527,	0.26627,	0.26727,	0.26827,
0.26927,	0.27027,	0.27127,	0.27227,	0.27327,	0.27427,
0.27528,	0.27628,	0.27728,	0.27828,	0.27928,	0.28028,
0.28128,	0.28228,	0.28328,	0.28428,	0.28529,	0.28629,
0.28729,	0.28829,	0.28929,	0.29029,	0.29129,	0.29229,
0.29329,	0.29429,	0.2953,	0.2963,	0.2973,	0.2983,
0.2993,	0.3003,	0.3013,	0.3023,	0.3033,	0.3043,
0.30531,	0.30631,	0.30731,	0.30831,	0.30931,	0.31031,
0.31131,	0.31231,	0.31331,	0.31431,	0.31532,	0.31632,
0.31732,	0.31832,	0.31932,	0.32032,	0.32132,	0.32232,
0.32332,	0.32432,	0.32533,	0.32633,	0.32733,	0.32833,
0.32933,	0.33033,	0.33133,	0.33233,	0.33333,	0.33433,
0.33534,					

	0.33634,	0.33734,	0.33834,	0.33934,	0.34034,
0.34134,	0.34234,	0.34334,	0.34434,	0.34535,	0.34635,
0.34735,	0.34835,	0.34935,	0.35035,	0.35135,	0.35235,
0.35335,	0.35435,	0.35536,	0.35636,	0.35736,	0.35836,
0.35936,					
	0.36036,	0.36136,	0.36236,	0.36336,	0.36436,
0.36537,	0.36637,	0.36737,	0.36837,	0.36937,	0.37037,
0.37137,	0.37237,	0.37337,	0.37437,	0.37538,	0.37638,
0.37738,	0.37838,	0.37938,	0.38038,	0.38138,	0.38238,
0.38338,					
	0.38438,	0.38539,	0.38639,	0.38739,	0.38839,
0.38939,	0.39039,	0.39139,	0.39239,	0.39339,	0.39439,
0.3954,	0.3964,	0.3974,	0.3984,	0.3994,	0.4004,
0.4014,	0.4024,	0.4034,	0.4044,	0.40541,	0.40641,
0.40741,					
	0.40841,	0.40941,	0.41041,	0.41141,	0.41241,
0.41341,	0.41441,	0.41542,	0.41642,	0.41742,	0.41842,
0.41942,	0.42042,	0.42142,	0.42242,	0.42342,	0.42442,
0.42543,	0.42643,	0.42743,	0.42843,	0.42943,	0.43043,
0.43143,					
	0.43243,	0.43343,	0.43443,	0.43544,	0.43644,
0.43744,	0.43844,	0.43944,	0.44044,	0.44144,	0.44244,
0.44344,	0.44444,	0.44545,	0.44645,	0.44745,	0.44845,
0.44945,	0.45045,	0.45145,	0.45245,	0.45345,	0.45445,
0.45546,					
	0.45646,	0.45746,	0.45846,	0.45946,	0.46046,
0.46146,	0.46246,	0.46346,	0.46446,	0.46547,	0.46647,
0.46747,	0.46847,	0.46947,	0.47047,	0.47147,	0.47247,
0.47347,	0.47447,	0.47548,	0.47648,	0.47748,	0.47848,
0.47948,					
	0.48048,	0.48148,	0.48248,	0.48348,	0.48448,
0.48549,	0.48649,	0.48749,	0.48849,	0.48949,	0.49049,
0.49149,	0.49249,	0.49349,	0.49449,	0.4955,	0.4965,
0.4975,	0.4985,	0.4995,	0.5005,	0.5015,	0.5025,
0.5035,					
	0.5045,	0.50551,	0.50651,	0.50751,	0.50851,
0.50951,	0.51051,	0.51151,	0.51251,	0.51351,	0.51451,
0.51552,	0.51652,	0.51752,	0.51852,	0.51952,	0.52052,
0.52152,	0.52252,	0.52352,	0.52452,	0.52553,	0.52653,
0.52753,					
	0.52853,	0.52953,	0.53053,	0.53153,	0.53253,
0.53353,	0.53453,	0.53554,	0.53654,	0.53754,	0.53854,
0.53954,	0.54054,	0.54154,	0.54254,	0.54354,	0.54454,
0.54555,	0.54655,	0.54755,	0.54855,	0.54955,	0.55055,
0.55155,					
	0.55255,	0.55355,	0.55455,	0.55556,	0.55656,
0.55756,	0.55856,	0.55956,	0.56056,	0.56156,	0.56256,

0.56356,	0.56456,	0.56557,	0.56657,	0.56757,	0.56857,
0.56957,	0.57057,	0.57157,	0.57257,	0.57357,	0.57457,
0.57558,					
	0.57658,	0.57758,	0.57858,	0.57958,	0.58058,
0.58158,	0.58258,	0.58358,	0.58458,	0.58559,	0.58659,
0.58759,	0.58859,	0.58959,	0.59059,	0.59159,	0.59259,
0.59359,	0.59459,	0.59556,	0.5966,	0.5976,	0.5986,
0.5996,					
	0.6006,	0.6016,	0.6026,	0.6036,	0.6046,
0.60561,	0.60661,	0.60761,	0.60861,	0.60961,	0.61061,
0.61161,	0.61261,	0.61361,	0.61461,	0.61562,	0.61662,
0.61762,	0.61862,	0.61962,	0.62062,	0.62162,	0.62262,
0.62362,					
	0.62462,	0.62563,	0.62663,	0.62763,	0.62863,
0.62963,	0.63063,	0.63163,	0.63263,	0.63363,	0.63463,
0.63564,	0.63664,	0.63764,	0.63864,	0.63964,	0.64064,
0.64164,	0.64264,	0.64364,	0.64464,	0.64565,	0.64665,
0.64765,					
	0.64865,	0.64965,	0.65065,	0.65165,	0.65265,
0.65365,	0.65465,	0.65566,	0.65666,	0.65766,	0.65866,
0.65966,	0.66066,	0.66166,	0.66266,	0.66366,	0.66466,
0.66567,	0.66667,	0.66767,	0.66867,	0.66967,	0.67067,
0.67167,					
	0.67267,	0.67367,	0.67467,	0.67568,	0.67668,
0.67768,	0.67868,	0.67968,	0.68068,	0.68168,	0.68268,
0.68368,	0.68468,	0.68569,	0.68669,	0.68769,	0.68869,
0.68969,	0.69069,	0.69169,	0.69269,	0.69369,	0.69469,
0.6957,					
	0.6967,	0.6977,	0.6987,	0.6997,	0.7007,
0.7017,	0.7027,	0.7037,	0.7047,	0.70571,	0.70671,
0.70771,	0.70871,	0.70971,	0.71071,	0.71171,	0.71271,
0.71371,	0.71471,	0.71572,	0.71672,	0.71772,	0.71872,
0.71972,					
	0.72072,	0.72172,	0.72272,	0.72372,	0.72472,
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0.76777,					
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	0.93694,	0.93794,	0.93894,	0.93994,	0.94094,
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0.95996,					
	0.96096,	0.96196,	0.96296,	0.96396,	0.96496,
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0.26326,					
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0.80981,	0.81081,	0.81181,	0.81281,	0.81381,	0.81481,
0.81582,	0.81682,	0.81782,	0.81882,	0.81982,	0.82082,
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0.16717,					
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0.23924,					
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0.26326,					
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0.31131,					

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0.35936,					
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0.19119,	0.19219,	0.19319,	0.19419,	0.1952,	0.1962,
0.1972,	0.1982,	0.1992,	0.2002,	0.2012,	0.2022,
0.2032,	0.2042,	0.20521,	0.20621,	0.20721,	0.20821,
0.20921,	0.21021,	0.21121,	0.21221,	0.21321,	0.21421,
0.21522,	0.21622,	0.21722,	0.21822,	0.21922,	0.22022,
0.22122,	0.22222,	0.22322,	0.22422,	0.22523,	0.22623,
0.22723,	0.22823,	0.22923,	0.23023,	0.23123,	0.23223,
0.23323,	0.23423,	0.23524,	0.23624,	0.23724,	0.23824,
0.23924,	0.24024,	0.24124,	0.24224,	0.24324,	0.24424,
0.24525,	0.24625,	0.24725,	0.24825,	0.24925,	0.25025,
0.25125,	0.25225,	0.25325,	0.25425,	0.25526,	0.25626,
0.25726,	0.25826,	0.25926,	0.26026,	0.26126,	0.26226,
0.26326,	0.26426,	0.26527,	0.26627,	0.26727,	0.26827,
0.26927,	0.27027,	0.27127,	0.27227,	0.27327,	0.27427,
0.27528,	0.27628,	0.27728,	0.27828,	0.27928,	0.28028,
0.28128,	0.28228,	0.28328,	0.28428,	0.28529,	0.28629,
0.28729,	0.28829,	0.28929,	0.29029,	0.29129,	0.29229,
0.29329,	0.29429,	0.2953,	0.2963,	0.2973,	0.2983,
0.2993,	0.3003,	0.3013,	0.3023,	0.3033,	0.3043,
0.30531,	0.30631,	0.30731,	0.30831,	0.30931,	0.31031,
0.31131,	0.31231,	0.31331,	0.31431,	0.31532,	0.31632,
0.31732,	0.31832,	0.31932,	0.32032,	0.32132,	0.32232,
0.32332,	0.32432,	0.32533,	0.32633,	0.32733,	0.32833,
0.32933,	0.33033,	0.33133,	0.33233,	0.33333,	0.33433,
0.33534,	0.33634,	0.33734,	0.33834,	0.33934,	0.34034,
0.34134,	0.34234,	0.34334,	0.34434,	0.34535,	0.34635,
0.34735,	0.34835,	0.34935,	0.35035,	0.35135,	0.35235,
0.35335,	0.35435,	0.35536,	0.35636,	0.35736,	0.35836,
0.35936,	0.36036,	0.36136,	0.36236,	0.36336,	0.36436,
0.36537,	0.36637,	0.36737,	0.36837,	0.36937,	0.37037,
0.37137,	0.37237,	0.37337,	0.37437,	0.37538,	0.37638,
0.37738,	0.37838,	0.37938,	0.38038,	0.38138,	0.38238,
0.38338,	0.38438,	0.38539,	0.38639,	0.38739,	0.38839,
0.38939,	0.39039,	0.39139,	0.39239,	0.39339,	0.39439,
0.3954,	0.3964,	0.3974,	0.3984,	0.3994,	0.4004,
0.4014,	0.4024,	0.4034,	0.4044,	0.40541,	0.40641,
0.40741,					

	0.40841,	0.40941,	0.41041,	0.41141,	0.41241,
0.41341,	0.41441,	0.41542,	0.41642,	0.41742,	0.41842,
0.41942,	0.42042,	0.42142,	0.42242,	0.42342,	0.42442,
0.42543,	0.42643,	0.42743,	0.42843,	0.42943,	0.43043,
0.43143,					
	0.43243,	0.43343,	0.43443,	0.43544,	0.43644,
0.43744,	0.43844,	0.43944,	0.44044,	0.44144,	0.44244,
0.44344,	0.44444,	0.44545,	0.44645,	0.44745,	0.44845,
0.44945,	0.45045,	0.45145,	0.45245,	0.45345,	0.45445,
0.45546,					
	0.45646,	0.45746,	0.45846,	0.45946,	0.46046,
0.46146,	0.46246,	0.46346,	0.46446,	0.46547,	0.46647,
0.46747,	0.46847,	0.46947,	0.47047,	0.47147,	0.47247,
0.47347,	0.47447,	0.47548,	0.47648,	0.47748,	0.47848,
0.47948,					
	0.48048,	0.48148,	0.48248,	0.48348,	0.48448,
0.48549,	0.48649,	0.48749,	0.48849,	0.48949,	0.49049,
0.49149,	0.49249,	0.49349,	0.49449,	0.4955,	0.4965,
0.4975,	0.4985,	0.4995,	0.5005,	0.5015,	0.5025,
0.5035,					
	0.5045,	0.50551,	0.50651,	0.50751,	0.50851,
0.50951,	0.51051,	0.51151,	0.51251,	0.51351,	0.51451,
0.51552,	0.51652,	0.51752,	0.51852,	0.51952,	0.52052,
0.52152,	0.52252,	0.52352,	0.52452,	0.52553,	0.52653,
0.52753,					
	0.52853,	0.52953,	0.53053,	0.53153,	0.53253,
0.53353,	0.53453,	0.53554,	0.53654,	0.53754,	0.53854,
0.53954,	0.54054,	0.54154,	0.54254,	0.54354,	0.54454,
0.54555,	0.54655,	0.54755,	0.54855,	0.54955,	0.55055,
0.55155,					
	0.55255,	0.55355,	0.55455,	0.55556,	0.55656,
0.55756,	0.55856,	0.55956,	0.56056,	0.56156,	0.56256,
0.56356,	0.56456,	0.56557,	0.56657,	0.56757,	0.56857,
0.56957,	0.57057,	0.57157,	0.57257,	0.57357,	0.57457,
0.57558,					
	0.57658,	0.57758,	0.57858,	0.57958,	0.58058,
0.58158,	0.58258,	0.58358,	0.58458,	0.58559,	0.58659,
0.58759,	0.58859,	0.58959,	0.59059,	0.59159,	0.59259,
0.59359,	0.59459,	0.5956,	0.5966,	0.5976,	0.5986,
0.5996,					
	0.6006,	0.6016,	0.6026,	0.6036,	0.6046,
0.60561,	0.60661,	0.60761,	0.60861,	0.60961,	0.61061,
0.61161,	0.61261,	0.61361,	0.61461,	0.61562,	0.61662,
0.61762,	0.61862,	0.61962,	0.62062,	0.62162,	0.62262,
0.62362,					
	0.62462,	0.62563,	0.62663,	0.62763,	0.62863,
0.62963,	0.63063,	0.63163,	0.63263,	0.63363,	0.63463,

0.63564,	0.63664,	0.63764,	0.63864,	0.63964,	0.64064,
0.64164,	0.64264,	0.64364,	0.64464,	0.64565,	0.64665,
0.64765,					
	0.64865,	0.64965,	0.65065,	0.65165,	0.65265,
0.65365,	0.65465,	0.65566,	0.65666,	0.65766,	0.65866,
0.65966,	0.66066,	0.66166,	0.66266,	0.66366,	0.66466,
0.66567,	0.66667,	0.66767,	0.66867,	0.66967,	0.67067,
0.67167,					
	0.67267,	0.67367,	0.67467,	0.67568,	0.67668,
0.67768,	0.67868,	0.67968,	0.68068,	0.68168,	0.68268,
0.68368,	0.68468,	0.68569,	0.68669,	0.68769,	0.68869,
0.68969,	0.69069,	0.69169,	0.69269,	0.69369,	0.69469,
0.6957,					
	0.6967,	0.6977,	0.6987,	0.6997,	0.7007,
0.7017,	0.7027,	0.7037,	0.7047,	0.70571,	0.70671,
0.70771,	0.70871,	0.70971,	0.71071,	0.71171,	0.71271,
0.71371,	0.71471,	0.71572,	0.71672,	0.71772,	0.71872,
0.71972,					
	0.72072,	0.72172,	0.72272,	0.72372,	0.72472,
0.72573,	0.72673,	0.72773,	0.72873,	0.72973,	0.73073,
0.73173,	0.73273,	0.73373,	0.73473,	0.73574,	0.73674,
0.73774,	0.73874,	0.73974,	0.74074,	0.74174,	0.74274,
0.74374,					
	0.74474,	0.74575,	0.74675,	0.74775,	0.74875,
0.74975,	0.75075,	0.75175,	0.75275,	0.75375,	0.75475,
0.75576,	0.75676,	0.75776,	0.75876,	0.75976,	0.76076,
0.76176,	0.76276,	0.76376,	0.76476,	0.76577,	0.76677,
0.76777,					
	0.76877,	0.76977,	0.77077,	0.77177,	0.77277,
0.77377,	0.77477,	0.77578,	0.77678,	0.77778,	0.77878,
0.77978,	0.78078,	0.78178,	0.78278,	0.78378,	0.78478,
0.78579,	0.78679,	0.78779,	0.78879,	0.78979,	0.79079,
0.79179,					
	0.79279,	0.79379,	0.79479,	0.7958,	0.7968,
0.7978,	0.7988,	0.7998,	0.8008,	0.8018,	0.8028,
0.8038,	0.8048,	0.80581,	0.80681,	0.80781,	0.80881,
0.80981,	0.81081,	0.81181,	0.81281,	0.81381,	0.81481,
0.81582,					
	0.81682,	0.81782,	0.81882,	0.81982,	0.82082,
0.82182,	0.82282,	0.82382,	0.82482,	0.82583,	0.82683,
0.82783,	0.82883,	0.82983,	0.83083,	0.83183,	0.83283,
0.83383,	0.83483,	0.83584,	0.83684,	0.83784,	0.83884,
0.83984,					
	0.84084,	0.84184,	0.84284,	0.84384,	0.84484,
0.84585,	0.84685,	0.84785,	0.84885,	0.84985,	0.85085,
0.85185,	0.85285,	0.85385,	0.85485,	0.85586,	0.85686,
0.85786,	0.85886,	0.85986,	0.86086,	0.86186,	0.86286,

```

0.86386,
        0.86486,    0.86587,    0.86687,    0.86787,    0.86887,
0.86987,    0.87087,    0.87187,    0.87287,    0.87387,    0.87487,
0.87588,    0.87688,    0.87788,    0.87888,    0.87988,    0.88088,
0.88188,    0.88288,    0.88388,    0.88488,    0.88589,    0.88689,
0.88789,
        0.88889,    0.88989,    0.89089,    0.89189,    0.89289,
0.89389,    0.89489,    0.8959,     0.8969,     0.8979,     0.8989,
0.8999,     0.9009,     0.9019,     0.9029,     0.9039,     0.9049,
0.90591,    0.90691,    0.90791,    0.90891,    0.90991,    0.91091,
0.91191,
        0.91291,    0.91391,    0.91491,    0.91592,    0.91692,
0.91792,    0.91892,    0.91992,    0.92092,    0.92192,    0.92292,
0.92392,    0.92492,    0.92593,    0.92693,    0.92793,    0.92893,
0.92993,    0.93093,    0.93193,    0.93293,    0.93393,    0.93493,
0.93594,
        0.93694,    0.93794,    0.93894,    0.93994,    0.94094,
0.94194,    0.94294,    0.94394,    0.94494,    0.94595,    0.94695,
0.94795,    0.94895,    0.94995,    0.95095,    0.95195,    0.95295,
0.95395,    0.95495,    0.95596,    0.95696,    0.95796,    0.95896,
0.95996,
        0.96096,    0.96196,    0.96296,    0.96396,    0.96496,
0.96597,    0.96697,    0.96797,    0.96897,    0.96997,    0.97097,
0.97197,    0.97297,    0.97397,    0.97497,    0.97598,    0.97698,
0.97798,    0.97898,    0.97998,    0.98098,    0.98198,    0.98298,
0.98398,
        0.98498,    0.98599,    0.98699,    0.98799,    0.98899,
0.98999,    0.99099,    0.99199,    0.99299,    0.99399,    0.99499,
0.996,      0.997,      0.998,      0.999,      1], array([[[
0.65217,    0.65217,    0.65217, ..., 0,          0,          0],
[           1,           1,           0.92857, ..., 0.073216, 0,
0],
[           1,           1,           1, ..., 0,          0,          0,
0],
[           0.91429, 0.91429, 0.91429, ..., 0,          0,          0,
0]]), 'Confidence', 'Recall']]
```

fitness: 0.6643370825691431

keys: ['metrics/precision(B)', 'metrics/recall(B)', 'metrics/mAP50(B)', 'metrics/mAP50-95(B)']

maps: array([0.23912, 0.8397, 0.87152, 0.64309])

names: {0: 'trafficlight', 1: 'stop', 2: 'speedlimit', 3: 'crosswalk'}

plot: True

results_dict: {'metrics/precision(B)': 0.8695143368043048, 'metrics/recall(B)': 0.7969557648511543, 'metrics/mAP50(B)': 0.808163102886269, 'metrics/mAP50-95(B)': 0.6483564136450181, 'fitness': 0.6643370825691431}

save_dir: PosixPath('runs/detect/train2')

speed: {'preprocess': 0.6413933905688198, 'inference': 30.595840378241103,

```

'loss': 0.0005283138968727806, 'postprocess': 3.0698491768403486}
task: 'detect'

[ ]: # Evaluate the model on the validation set after training with augmented data
results = model.val(data='/content/road_sign_detection.yaml', split='val')
print("Evaluation after training with augmented data:", results)

Ultralytics YOLOv8.2.66 Python-3.10.12 torch-2.3.1+cu121 CUDA:0 (Tesla T4,
15102MiB)
YOLOv8n summary (fused): 168 layers, 3,006,428 parameters, 0 gradients, 8.1
GFLOPs

val: Scanning /content/road_sign_detection/val/labels.cache... 176
images, 0 backgrounds, 0 corrupt: 100%|      | 176/176 [00:00<?, ?it/s]
/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning: os.fork()
was called. os.fork() is incompatible with multithreaded code, and JAX is
multithreaded, so this will likely lead to a deadlock.

    self.pid = os.fork()
        Class      Images Instances      Box(P)       R      mAP50
mAP50-95): 100%|      | 11/11 [00:08<00:00,  1.22it/s]

          all        176        256      0.888      0.761      0.801
0.64
          trafficlight     24        47      0.676      0.362      0.449
0.222
          stop         22        22      0.932      0.909      0.932
0.817
          speedlimit     131        147      0.993      0.972      0.99
0.882
          crosswalk      33        40      0.951        0.8      0.834
0.637
Speed: 0.8ms preprocess, 26.1ms inference, 0.0ms loss, 5.8ms postprocess per
image
Results saved to runs/detect/train32
Evaluation after training with augmented data:
ultralytics.utils.metrics.DetMetrics object with attributes:

ap_class_index: array([0, 1, 2, 3])
box: ultralytics.utils.metrics.Metric object
confusion_matrix: <ultralytics.utils.metrics.ConfusionMatrix object at
0x7be3d43fd750>
curves: ['Precision-Recall(B)', 'F1-Confidence(B)', 'Precision-Confidence(B)', 'Recall-Confidence(B)']
curves_results: [[array([
0,      0.001001,      0.002002,      0.003003,
0.004004,      0.005005,      0.006006,      0.007007,      0.008008,      0.009009,
0.01001,      0.011011,      0.012012,      0.013013,      0.014014,      0.015015,
0.016016,      0.017017,      0.018018,      0.019019,      0.02002,      0.021021,
0.022022,      0.023023,
0.024024,      0.025025,      0.026026,      0.027027,      0.028028,
0.029029,      0.03003,      0.031031,      0.032032,      0.033033,      0.034034,
0.035035,      0.036036,      0.037037,      0.038038,      0.039039,      0.04004,
0.041041,      0.042042,      0.043043,      0.044044,      0.045045,      0.046046,
0.047047,      0.048048,      0.049049,      0.05005,      0.051051,      0.052052,
0.053053,      0.054054,      0.055055,      0.056056,      0.057057,      0.058058,
0.059059,      0.06006,      0.061061,      0.062062,      0.063063,      0.064064,
0.065065,      0.066066,      0.067067,      0.068068,      0.069069,      0.07007,
0.071071,      0.072072,      0.073073,      0.074074,      0.075075,      0.076076,
0.077077,      0.078078,      0.079079,      0.08008,      0.081081,      0.082082,
0.083083,      0.084084,      0.085085,      0.086086,      0.087087,      0.088088,
0.089089,      0.09009,      0.091091,      0.092092,      0.093093,      0.094094,
0.095095,      0.096096,      0.097097,      0.098098,      0.099099,      0.10001,
0.101011,      0.102012,      0.103013,      0.104014,      0.105015,      0.106016,
0.107017,      0.108018,      0.109019,      0.11002,      0.111021,      0.112022,
0.113023,      0.114024,      0.115025,      0.116026,      0.117027,      0.118028,
0.119029,      0.12003,      0.121031,      0.122032,      0.123033,      0.124034,
0.125035,      0.126036,      0.127037,      0.128038,      0.129039,      0.13004,
0.131041,      0.132042,      0.133043,      0.134044,      0.135045,      0.136046,
0.137047,      0.138048,      0.139049,      0.14005,      0.141051,      0.142052,
0.143053,      0.144054,      0.145055,      0.146056,      0.147057,      0.148058,
0.149059,      0.15006,      0.151061,      0.152062,      0.153063,      0.154064,
0.155065,      0.156066,      0.157067,      0.158068,      0.159069,      0.16007,
0.161071,      0.162072,      0.163073,      0.164074,      0.165075,      0.166076,
0.167077,      0.168078,      0.169079,      0.17008,      0.171081,      0.172082,
0.173083,      0.174084,      0.175085,      0.176086,      0.177087,      0.178088,
0.179089,      0.18009,      0.181091,      0.182092,      0.183093,      0.184094,
0.185095,      0.186096,      0.187097,      0.188098,      0.189099,      0.19001,
0.191011,      0.192012,      0.193013,      0.194014,      0.195015,      0.196016,
0.197017,      0.198018,      0.199019,      0.20002,      0.201021,      0.202022,
0.203023,      0.204024,      0.205025,      0.206026,      0.207027,      0.208028,
0.209029,      0.21003,      0.211031,      0.212032,      0.213033,      0.214034,
0.215035,      0.216036,      0.217037,      0.218038,      0.219039,      0.22004,
0.221041,      0.222042,      0.223043,      0.224044,      0.225045,      0.226046,
0.227047,      0.228048,      0.229049,      0.23005,      0.231051,      0.232052,
0.233053,      0.234054,      0.235055,      0.236056,      0.237057,      0.238058,
0.239059,      0.24006,      0.241061,      0.242062,      0.243063,      0.244064,
0.245065,      0.246066,      0.247067,      0.248068,      0.249069,      0.25007,
0.251071,      0.252072,      0.253073,      0.254074,      0.255075,      0.256076,
0.257077,      0.258078,      0.259079,      0.26008,      0.261081,      0.262082,
0.263083,      0.264084,      0.265085,      0.266086,      0.267087,      0.268088,
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0.51552,	0.51652,	0.51752,	0.51852,	0.51952,	0.52052,
0.52152,	0.52252,	0.52352,	0.52452,	0.52553,	0.52653,
0.52753,					
	0.52853,	0.52953,	0.53053,	0.53153,	0.53253,
0.53353,	0.53453,	0.53554,	0.53654,	0.53754,	0.53854,
0.53954,	0.54054,	0.54154,	0.54254,	0.54354,	0.54454,
0.54555,	0.54655,	0.54755,	0.54855,	0.54955,	0.55055,
0.55155,					
	0.55255,	0.55355,	0.55455,	0.55556,	0.55656,
0.55756,	0.55856,	0.55956,	0.56056,	0.56156,	0.56256,
0.56356,	0.56456,	0.56557,	0.56657,	0.56757,	0.56857,
0.56957,	0.57057,	0.57157,	0.57257,	0.57357,	0.57457,
0.57558,					
	0.57658,	0.57758,	0.57858,	0.57958,	0.58058,
0.58158,	0.58258,	0.58358,	0.58458,	0.58559,	0.58659,
0.58759,	0.58859,	0.58959,	0.59059,	0.59159,	0.59259,
0.59359,	0.59459,	0.5956,	0.5966,	0.5976,	0.5986,
0.5996,					
	0.6006,	0.6016,	0.6026,	0.6036,	0.6046,
0.60561,	0.60661,	0.60761,	0.60861,	0.60961,	0.61061,
0.61161,	0.61261,	0.61361,	0.61461,	0.61562,	0.61662,
0.61762,	0.61862,	0.61962,	0.62062,	0.62162,	0.62262,
0.62362,					
	0.62462,	0.62563,	0.62663,	0.62763,	0.62863,
0.62963,	0.63063,	0.63163,	0.63263,	0.63363,	0.63463,
0.63564,	0.63664,	0.63764,	0.63864,	0.63964,	0.64064,
0.64164,	0.64264,	0.64364,	0.64464,	0.64565,	0.64665,
0.64765,					
	0.64865,	0.64965,	0.65065,	0.65165,	0.65265,
0.65365,	0.65465,	0.65566,	0.65666,	0.65766,	0.65866,
0.65966,	0.66066,	0.66166,	0.66266,	0.66366,	0.66466,
0.66567,	0.66667,	0.66767,	0.66867,	0.66967,	0.67067,
0.67167,					
	0.67267,	0.67367,	0.67467,	0.67568,	0.67668,
0.67768,	0.67868,	0.67968,	0.68068,	0.68168,	0.68268,
0.68368,	0.68468,	0.68569,	0.68669,	0.68769,	0.68869,
0.68969,	0.69069,	0.69169,	0.69269,	0.69369,	0.69469,
0.6957,					
	0.6967,	0.6977,	0.6987,	0.6997,	0.7007,
0.7017,	0.7027,	0.7037,	0.7047,	0.70571,	0.70671,
0.70771,	0.70871,	0.70971,	0.71071,	0.71171,	0.71271,
0.71371,	0.71471,	0.71572,	0.71672,	0.71772,	0.71872,
0.71972,					

	0.72072,	0.72172,	0.72272,	0.72372,	0.72472,
0.72573,	0.72673,	0.72773,	0.72873,	0.72973,	0.73073,
0.73173,	0.73273,	0.73373,	0.73473,	0.73574,	0.73674,
0.73774,	0.73874,	0.73974,	0.74074,	0.74174,	0.74274,
0.74374,					
	0.74474,	0.74575,	0.74675,	0.74775,	0.74875,
0.74975,	0.75075,	0.75175,	0.75275,	0.75375,	0.75475,
0.75576,	0.75676,	0.75776,	0.75876,	0.75976,	0.76076,
0.76176,	0.76276,	0.76376,	0.76476,	0.76577,	0.76677,
0.76777,					
	0.76877,	0.76977,	0.77077,	0.77177,	0.77277,
0.77377,	0.77477,	0.77578,	0.77678,	0.77778,	0.77878,
0.77978,	0.78078,	0.78178,	0.78278,	0.78378,	0.78478,
0.78579,	0.78679,	0.78779,	0.78879,	0.78979,	0.79079,
0.79179,					
	0.79279,	0.79379,	0.79479,	0.7958,	0.7968,
0.7978,	0.7988,	0.7998,	0.8008,	0.8018,	0.8028,
0.8038,	0.8048,	0.80581,	0.80681,	0.80781,	0.80881,
0.80981,	0.81081,	0.81181,	0.81281,	0.81381,	0.81481,
0.81582,					
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0.82783,	0.82883,	0.82983,	0.83083,	0.83183,	0.83283,
0.83383,	0.83483,	0.83584,	0.83684,	0.83784,	0.83884,
0.83984,					
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0.84585,	0.84685,	0.84785,	0.84885,	0.84985,	0.85085,
0.85185,	0.85285,	0.85385,	0.85485,	0.85586,	0.85686,
0.85786,	0.85886,	0.85986,	0.86086,	0.86186,	0.86286,
0.86386,					
	0.86486,	0.86587,	0.86687,	0.86787,	0.86887,
0.86987,	0.87087,	0.87187,	0.87287,	0.87387,	0.87487,
0.87588,	0.87688,	0.87788,	0.87888,	0.87988,	0.88088,
0.88188,	0.88288,	0.88388,	0.88488,	0.88589,	0.88689,
0.88789,					
	0.88889,	0.88989,	0.89089,	0.89189,	0.89289,
0.89389,	0.89489,	0.8959,	0.8969,	0.8979,	0.8989,
0.8999,	0.9009,	0.9019,	0.9029,	0.9039,	0.9049,
0.90591,	0.90691,	0.90791,	0.90891,	0.90991,	0.91091,
0.91191,					
	0.91291,	0.91391,	0.91491,	0.91592,	0.91692,
0.91792,	0.91892,	0.91992,	0.92092,	0.92192,	0.92292,
0.92392,	0.92492,	0.92593,	0.92693,	0.92793,	0.92893,
0.92993,	0.93093,	0.93193,	0.93293,	0.93393,	0.93493,
0.93594,					
	0.93694,	0.93794,	0.93894,	0.93994,	0.94094,
0.94194,	0.94294,	0.94394,	0.94494,	0.94595,	0.94695,
0.94795,	0.94895,	0.94995,	0.95095,	0.95195,	0.95295,

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0.95996,	0.96096,	0.96196,	0.96296,	0.96396,	0.96496,
0.96597,	0.96697,	0.96797,	0.96897,	0.96997,	0.97097,
0.97197,	0.97297,	0.97397,	0.97497,	0.97598,	0.97698,
0.97798,	0.97898,	0.97998,	0.98098,	0.98198,	0.98298,
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0.029029,	0.03003,	0.031031,	0.032032,	0.033033,	0.034034,
0.035035,	0.036036,	0.037037,	0.038038,	0.039039,	0.04004,
0.041041,	0.042042,	0.043043,	0.044044,	0.045045,	0.046046,
0.047047,	0.048048,	0.049049,	0.05005,	0.051051,	0.052052,
0.053053,	0.054054,	0.055055,	0.056056,	0.057057,	0.058058,
0.059059,	0.06006,	0.061061,	0.062062,	0.063063,	0.064064,
0.065065,	0.066066,	0.067067,	0.068068,	0.069069,	0.07007,
0.071071,	0.072072,	0.073073,	0.074074,	0.075075,	0.076076,
0.077077,	0.078078,	0.079079,	0.08008,	0.081081,	0.082082,
0.083083,	0.084084,	0.085085,	0.086086,	0.087087,	0.088088,
0.089089,	0.09009,	0.091091,	0.092092,	0.093093,	0.094094,
0.095095,	0.096096,	0.097097,	0.098098,	0.099099,	0.1001,
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0.10711,	0.10811,	0.10911,	0.11011,	0.11111,	0.11211,
0.11311,	0.11411,	0.11512,	0.11612,	0.11712,	0.11812,
0.11912,	0.12012,	0.12112,	0.12212,	0.12312,	0.12412,
0.12513,	0.12613,	0.12713,	0.12813,	0.12913,	0.13013,
0.13113,	0.13213,	0.13313,	0.13413,	0.13514,	0.13614,
0.13714,	0.13814,	0.13914,	0.14014,	0.14114,	0.14214,
0.14314,	0.14414,	0.14515,	0.14615,	0.14715,	0.14815,
0.14915,	0.15015,	0.15115,	0.15215,	0.15315,	0.15415,

0.15516,	0.15616,	0.15716,	0.15816,	0.15916,	0.16016,
0.16116,	0.16216,	0.16316,	0.16416,	0.16517,	0.16617,
0.16717,					
	0.16817,	0.16917,	0.17017,	0.17117,	0.17217,
0.17317,	0.17417,	0.17518,	0.17618,	0.17718,	0.17818,
0.17918,	0.18018,	0.18118,	0.18218,	0.18318,	0.18418,
0.18519,	0.18619,	0.18719,	0.18819,	0.18919,	0.19019,
0.19119,					
	0.19219,	0.19319,	0.19419,	0.1952,	0.1962,
0.1972,	0.1982,	0.1992,	0.2002,	0.2012,	0.2022,
0.2032,	0.2042,	0.20521,	0.20621,	0.20721,	0.20821,
0.20921,	0.21021,	0.21121,	0.21221,	0.21321,	0.21421,
0.21522,					
	0.21622,	0.21722,	0.21822,	0.21922,	0.22022,
0.22122,	0.22222,	0.22322,	0.22422,	0.22523,	0.22623,
0.22723,	0.22823,	0.22923,	0.23023,	0.23123,	0.23223,
0.23323,	0.23423,	0.23524,	0.23624,	0.23724,	0.23824,
0.23924,					
	0.24024,	0.24124,	0.24224,	0.24324,	0.24424,
0.24525,	0.24625,	0.24725,	0.24825,	0.24925,	0.25025,
0.25125,	0.25225,	0.25325,	0.25425,	0.25526,	0.25626,
0.25726,	0.25826,	0.25926,	0.26026,	0.26126,	0.26226,
0.26326,					
	0.26426,	0.26527,	0.26627,	0.26727,	0.26827,
0.26927,	0.27027,	0.27127,	0.27227,	0.27327,	0.27427,
0.27528,	0.27628,	0.27728,	0.27828,	0.27928,	0.28028,
0.28128,	0.28228,	0.28328,	0.28428,	0.28529,	0.28629,
0.28729,					
	0.28829,	0.28929,	0.29029,	0.29129,	0.29229,
0.29329,	0.29429,	0.2953,	0.2963,	0.2973,	0.2983,
0.2993,	0.3003,	0.3013,	0.3023,	0.3033,	0.3043,
0.30531,	0.30631,	0.30731,	0.30831,	0.30931,	0.31031,
0.31131,					
	0.31231,	0.31331,	0.31431,	0.31532,	0.31632,
0.31732,	0.31832,	0.31932,	0.32032,	0.32132,	0.32232,
0.32332,	0.32432,	0.32533,	0.32633,	0.32733,	0.32833,
0.32933,	0.33033,	0.33133,	0.33233,	0.33333,	0.33433,
0.33534,					
	0.33634,	0.33734,	0.33834,	0.33934,	0.34034,
0.34134,	0.34234,	0.34334,	0.34434,	0.34535,	0.34635,
0.34735,	0.34835,	0.34935,	0.35035,	0.35135,	0.35235,
0.35335,	0.35435,	0.35536,	0.35636,	0.35736,	0.35836,
0.35936,					
	0.36036,	0.36136,	0.36236,	0.36336,	0.36436,
0.36537,	0.36637,	0.36737,	0.36837,	0.36937,	0.37037,
0.37137,	0.37237,	0.37337,	0.37437,	0.37538,	0.37638,
0.37738,	0.37838,	0.37938,	0.38038,	0.38138,	0.38238,
0.38338,					

	0.38438,	0.38539,	0.38639,	0.38739,	0.38839,
0.38939,	0.39039,	0.39139,	0.39239,	0.39339,	0.39439,
0.3954,	0.3964,	0.3974,	0.3984,	0.3994,	0.4004,
0.4014,	0.4024,	0.4034,	0.4044,	0.40541,	0.40641,
0.40741,					
	0.40841,	0.40941,	0.41041,	0.41141,	0.41241,
0.41341,	0.41441,	0.41542,	0.41642,	0.41742,	0.41842,
0.41942,	0.42042,	0.42142,	0.42242,	0.42342,	0.42442,
0.42543,	0.42643,	0.42743,	0.42843,	0.42943,	0.43043,
0.43143,					
	0.43243,	0.43343,	0.43443,	0.43544,	0.43644,
0.43744,	0.43844,	0.43944,	0.44044,	0.44144,	0.44244,
0.44344,	0.44444,	0.44545,	0.44645,	0.44745,	0.44845,
0.44945,	0.45045,	0.45145,	0.45245,	0.45345,	0.45445,
0.45546,					
	0.45646,	0.45746,	0.45846,	0.45946,	0.46046,
0.46146,	0.46246,	0.46346,	0.46446,	0.46547,	0.46647,
0.46747,	0.46847,	0.46947,	0.47047,	0.47147,	0.47247,
0.47347,	0.47447,	0.47548,	0.47648,	0.47748,	0.47848,
0.47948,					
	0.48048,	0.48148,	0.48248,	0.48348,	0.48448,
0.48549,	0.48649,	0.48749,	0.48849,	0.48949,	0.49049,
0.49149,	0.49249,	0.49349,	0.49449,	0.4955,	0.4965,
0.4975,	0.4985,	0.4995,	0.5005,	0.5015,	0.5025,
0.5035,					
	0.5045,	0.50551,	0.50651,	0.50751,	0.50851,
0.50951,	0.51051,	0.51151,	0.51251,	0.51351,	0.51451,
0.51552,	0.51652,	0.51752,	0.51852,	0.51952,	0.52052,
0.52152,	0.52252,	0.52352,	0.52452,	0.52553,	0.52653,
0.52753,					
	0.52853,	0.52953,	0.53053,	0.53153,	0.53253,
0.53353,	0.53453,	0.53554,	0.53654,	0.53754,	0.53854,
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0.54555,	0.54655,	0.54755,	0.54855,	0.54955,	0.55055,
0.55155,					
	0.55255,	0.55355,	0.55455,	0.55556,	0.55656,
0.55756,	0.55856,	0.55956,	0.56056,	0.56156,	0.56256,
0.56356,	0.56456,	0.56557,	0.56657,	0.56757,	0.56857,
0.56957,	0.57057,	0.57157,	0.57257,	0.57357,	0.57457,
0.57558,					
	0.57658,	0.57758,	0.57858,	0.57958,	0.58058,
0.58158,	0.58258,	0.58358,	0.58458,	0.58559,	0.58659,
0.58759,	0.58859,	0.58959,	0.59059,	0.59159,	0.59259,
0.59359,	0.59459,	0.5956,	0.5966,	0.5976,	0.5986,
0.5996,					
	0.6006,	0.6016,	0.6026,	0.6036,	0.6046,
0.60561,	0.60661,	0.60761,	0.60861,	0.60961,	0.61061,
0.61161,	0.61261,	0.61361,	0.61461,	0.61562,	0.61662,

0.61762,	0.61862,	0.61962,	0.62062,	0.62162,	0.62262,
0.62362,	0.62462,	0.62563,	0.62663,	0.62763,	0.62863,
0.62963,	0.63063,	0.63163,	0.63263,	0.63363,	0.63463,
0.63564,	0.63664,	0.63764,	0.63864,	0.63964,	0.64064,
0.64164,	0.64264,	0.64364,	0.64464,	0.64565,	0.64665,
0.64765,	0.64865,	0.64965,	0.65065,	0.65165,	0.65265,
0.65365,	0.65465,	0.65566,	0.65666,	0.65766,	0.65866,
0.65966,	0.66066,	0.66166,	0.66266,	0.66366,	0.66466,
0.66567,	0.66667,	0.66767,	0.66867,	0.66967,	0.67067,
0.67167,	0.67267,	0.67367,	0.67467,	0.67568,	0.67668,
0.67768,	0.67868,	0.67968,	0.68068,	0.68168,	0.68268,
0.68368,	0.68468,	0.68569,	0.68669,	0.68769,	0.68869,
0.68969,	0.69069,	0.69169,	0.69269,	0.69369,	0.69469,
0.6957,	0.6967,	0.6977,	0.6987,	0.6997,	0.7007,
0.7017,	0.7027,	0.7037,	0.7047,	0.70571,	0.70671,
0.70771,	0.70871,	0.70971,	0.71071,	0.71171,	0.71271,
0.71371,	0.71471,	0.71572,	0.71672,	0.71772,	0.71872,
0.71972,	0.72072,	0.72172,	0.72272,	0.72372,	0.72472,
0.72573,	0.72673,	0.72773,	0.72873,	0.72973,	0.73073,
0.73173,	0.73273,	0.73373,	0.73473,	0.73574,	0.73674,
0.73774,	0.73874,	0.73974,	0.74074,	0.74174,	0.74274,
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0.74975,	0.75075,	0.75175,	0.75275,	0.75375,	0.75475,
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0.23924,					
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0]]), 'Confidence', 'Recall'])]
fitness: 0.6556971535619067
keys: ['metrics/precision(B)', 'metrics/recall(B)', 'metrics/mAP50(B)',
'metrics/mAP50-95(B)']
maps: array([ 0.22184, 0.81725, 0.88231, 0.63674])
names: {0: 'trafficlight', 1: 'stop', 2: 'speedlimit', 3: 'crosswalk'}
plot: True
results_dict: {'metrics/precision(B)': 0.8880627145502193, 'metrics/recall(B)': 0.7607796207911461, 'metrics/mAP50(B)': 0.8011726096580328, 'metrics/mAP50-95(B)': 0.6395332139956704, 'fitness': 0.6556971535619067}
save_dir: PosixPath('runs/detect/train32')
speed: {'preprocess': 0.7981156760996038, 'inference': 26.05466138232838, 'loss': 0.0009645115245472302, 'postprocess': 5.772346800023859}

```

```

task: 'detect'

[ ]: # Directory containing inference images
inference_images_path = '/content/drive/My Drive/Colab Notebooks/Data/
↳Inference_images'

# Get list of JPEG images
image_files = [f for f in os.listdir(inference_images_path) if f.endswith('..
↳jpeg')]

[ ]: # Check if any JPEG images are found
assert len(image_files) > 0, "No JPEG images found in the directory.

# Display the list of JPEG images
print(f"Found {len(image_files)} JPEG images in the directory:")
for image_file in image_files:
    print(image_file)

```

Found 30 JPEG images in the directory:

```

image8[1].jpeg
image1.jpeg
image22.jpeg
image12.jpeg
image0.jpeg
image25.jpeg
image5[1].jpeg
image21.jpeg
image28[1].jpeg
image24.jpeg
image28.jpeg
image20.jpeg
image15.jpeg
image11[1].jpeg
image26.jpeg
image23.jpeg
image4.jpeg
image18.jpeg
image10.jpeg
image14[1].jpeg
image7.jpeg
image16.jpeg
image14.jpeg
image3.jpeg
image11.jpeg
image19.jpeg
image8.jpeg
image0[1].jpeg
image26[1].jpeg

```

```
image5.jpeg
```

```
#Let's run inferences on Traffic Signs around George Brown College
```

```
[ ]: # Run inference on each image
for image_file in image_files:
    image_path = os.path.join(inference_images_path, image_file)
    results = model.predict(image_path)

    # Display the image with bounding boxes
    for result in results:
        img = result.plot()
        plt.figure(figsize=(10, 10))
        plt.imshow(img)
        plt.title(image_file)
        plt.axis('off')
        plt.show()# Check if the directory exists and contains images
assert os.path.exists(inference_images_path), f"Directory {inference_images_path} does not exist."
image_files = [f for f in os.listdir(inference_images_path) if f.endswith('.jpg')]
assert len(image_files) > 0, "No JPEG images found in the directory."

print(f"Found {len(image_files)} images in the directory.")

# Run inference on each image
for image_file in image_files:
    image_path = os.path.join(inference_images_path, image_file)
    print(f"Running inference on image: {image_path}")

    results = model.predict(image_path)

    if results:
        # Display the image with bounding boxes
        for result in results:
            img = result.plot()
            plt.figure(figsize=(10, 10))
            plt.imshow(img)
            plt.title(image_file)
            plt.axis('off')
            plt.show()
    else:
        print(f"No results for image: {image_path}")
```

```
image 1/1 /content/drive/My Drive/Colab
```

```
Notebooks/Data/Inference_images/image8[1].jpeg: 384x640 2 traffilights, 351.6ms
Speed: 3.0ms preprocess, 351.6ms inference, 2.1ms postprocess per image at shape
```

(1, 3, 384, 640)

image8[1].jpeg

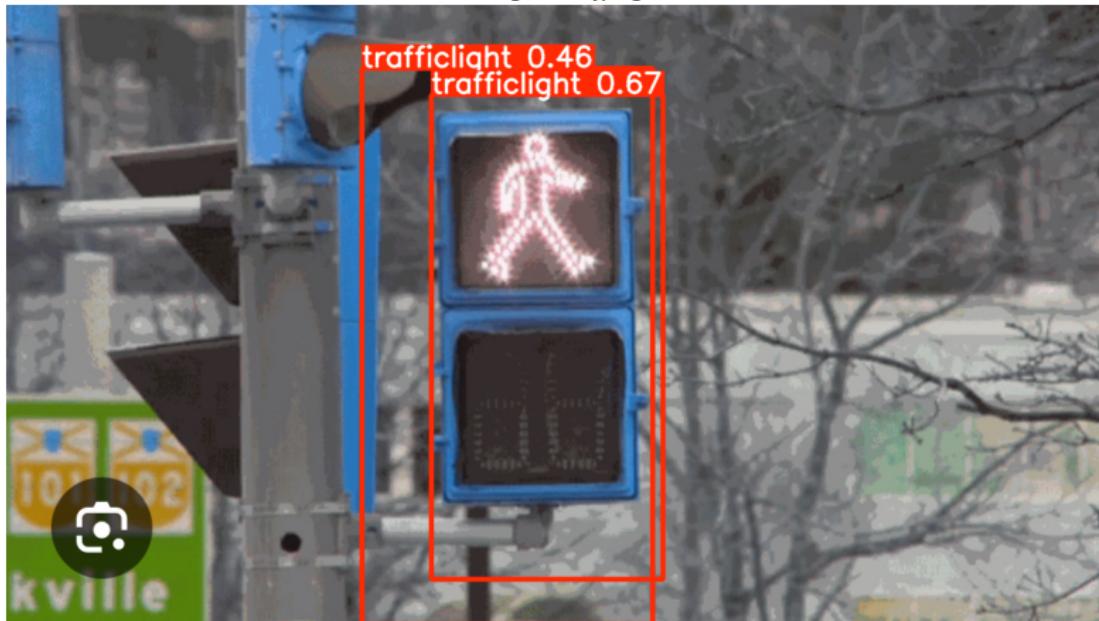


image 1/1 /content/drive/My Drive/Colab

Notebooks/Data/Inference_images/image1.jpeg: 640x512 1 trafficlight, 255.9ms

Speed: 4.2ms preprocess, 255.9ms inference, 1.4ms postprocess per image at shape
(1, 3, 640, 512)

image1.jpeg

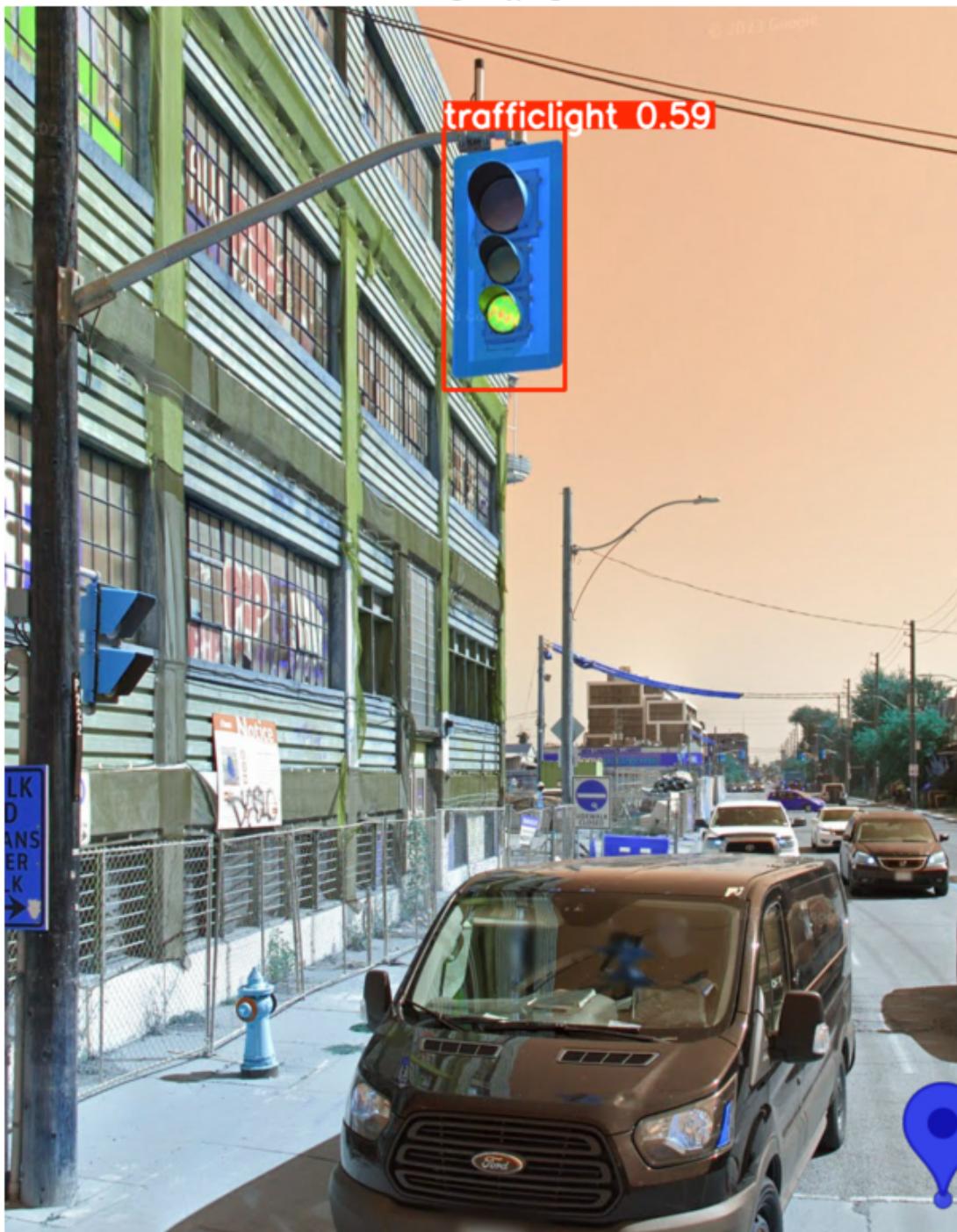


image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image22.jpeg: 640x480 (no detections), 82.3ms
Speed: 2.2ms preprocess, 82.3ms inference, 0.6ms postprocess per image at shape

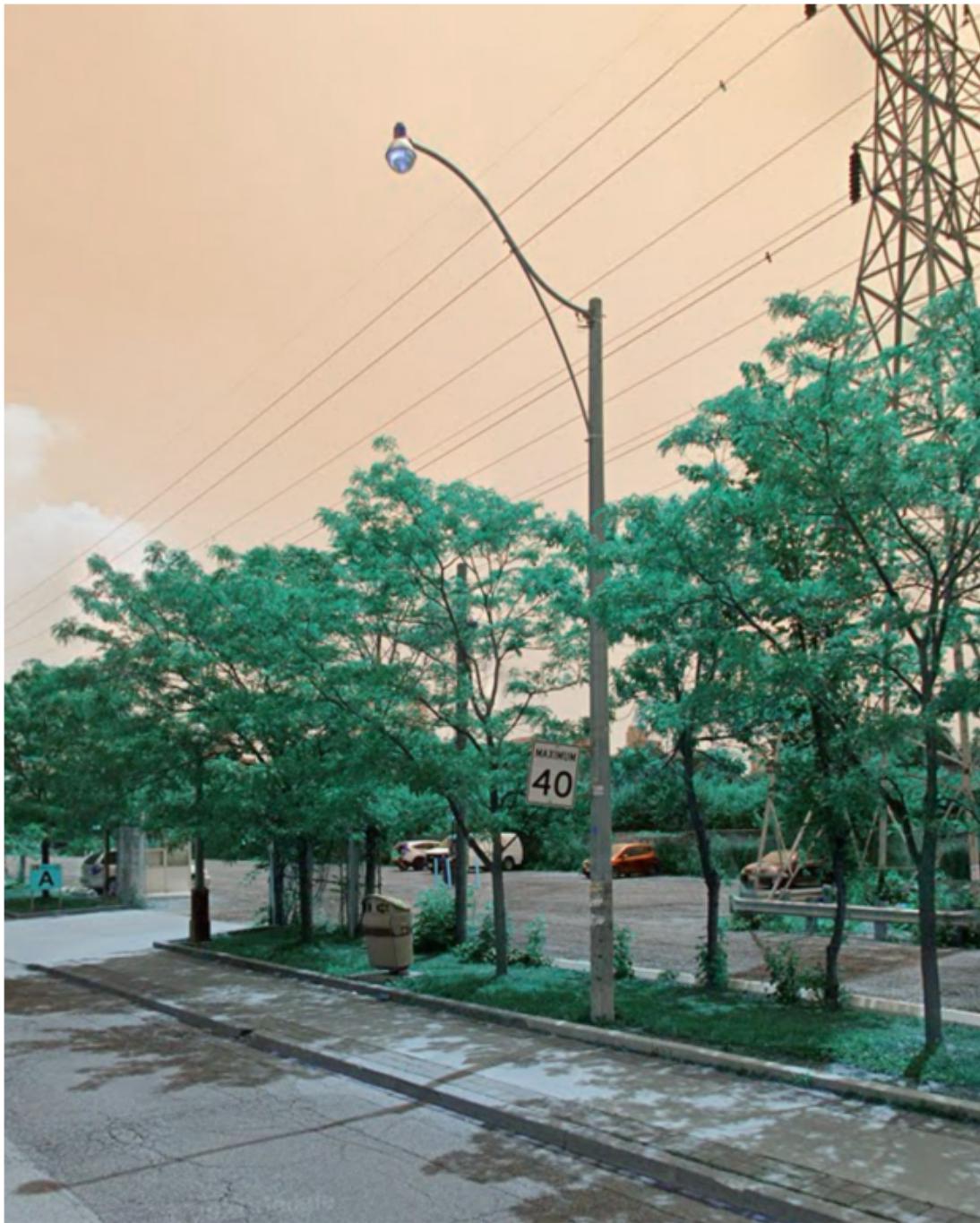
(1, 3, 640, 480)

image22.jpeg



image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image12.jpeg: 640x544 (no detections), 195.9ms
Speed: 2.9ms preprocess, 195.9ms inference, 0.6ms postprocess per image at shape
(1, 3, 640, 544)

image12.jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image0.jpeg: 640x448 (no detections), 179.9ms  
Speed: 1.9ms preprocess, 179.9ms inference, 0.6ms postprocess per image at shape  
(1, 3, 640, 448)
```

image0.jpeg



image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image25.jpeg: 640x512 (no detections), 24.5ms
Speed: 2.1ms preprocess, 24.5ms inference, 0.6ms postprocess per image at shape
(1, 3, 640, 512)

image25.jpeg

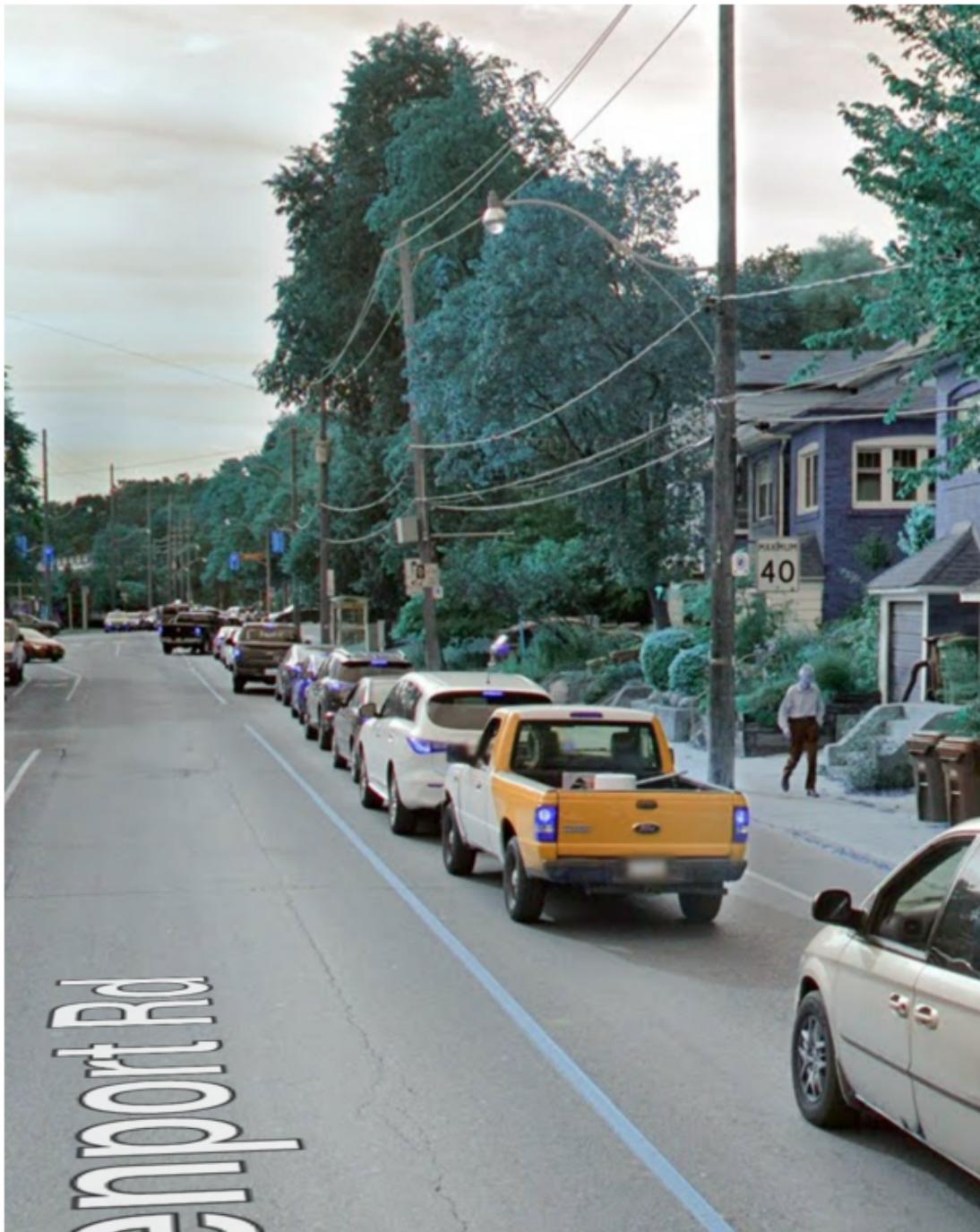


image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image5[1].jpeg: 416x640 (no detections), 180.3ms
Speed: 2.2ms preprocess, 180.3ms inference, 0.8ms postprocess per image at shape
(1, 3, 416, 640)

image5[1].jpeg



image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image21.jpeg: 640x512 1 stop, 36.5ms
Speed: 4.6ms preprocess, 36.5ms inference, 1.5ms postprocess per image at shape
(1, 3, 640, 512)

image21.jpeg



image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image28[1].jpeg: 640x416 3 trafficlights, 1
speedlimit, 290.4ms

Speed: 3.4ms preprocess, 290.4ms inference, 4.8ms postprocess per image at shape (1, 3, 640, 416)

image28[1].jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image24.jpeg: 640x480 (no detections), 50.1ms  
Speed: 2.4ms preprocess, 50.1ms inference, 0.8ms postprocess per image at shape  
(1, 3, 640, 480)
```

image24.jpeg



image 1/1 /content/drive/My Drive/Colab

Notebooks/Data/Inference_images/image28.jpeg: 640x480 3 trafficlights, 24.4ms
Speed: 2.1ms preprocess, 24.4ms inference, 1.3ms postprocess per image at shape
(1, 3, 640, 480)

image28.jpeg

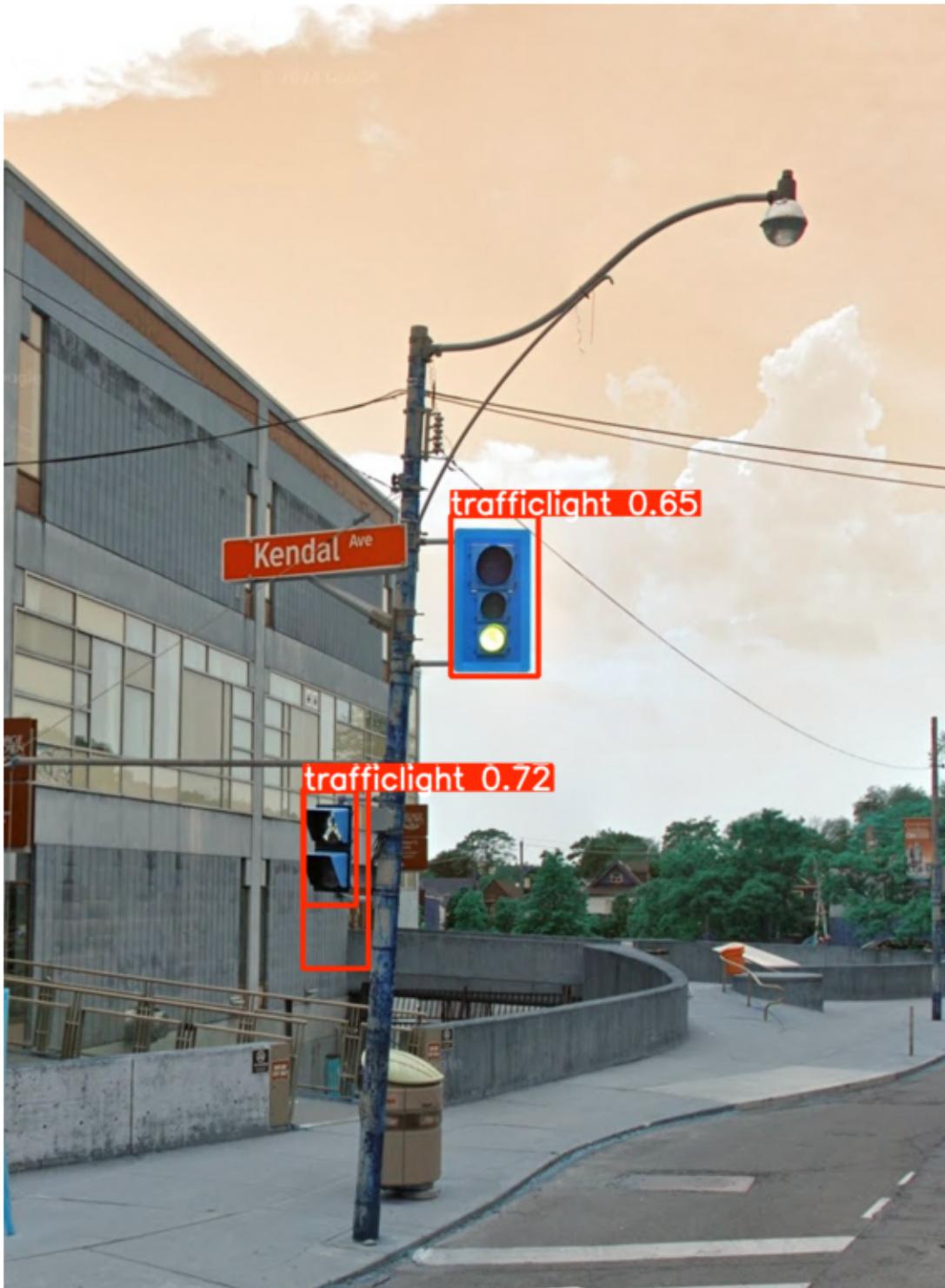
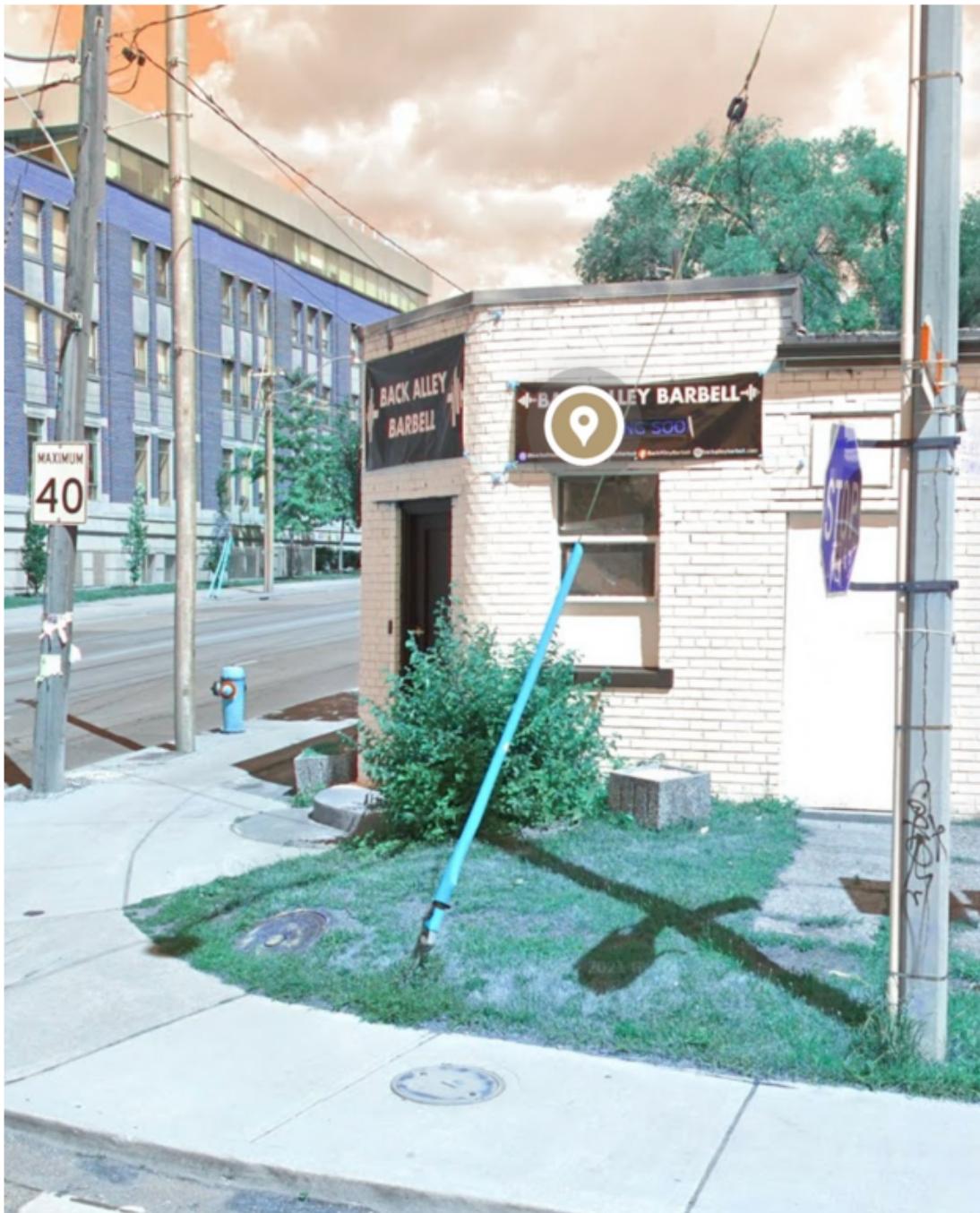


image 1/1 /content/drive/My Drive/Colab

Notebooks/Data/Inference_images/image20.jpeg: 640x544 (no detections), 24.8ms

Speed: 2.3ms preprocess, 24.8ms inference, 0.6ms postprocess per image at shape
(1, 3, 640, 544)

image20.jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image15.jpeg: 640x480 1 trafficlight, 137.7ms  
Speed: 8.8ms preprocess, 137.7ms inference, 3.1ms postprocess per image at shape  
(1, 3, 640, 480)
```

image15.jpeg



image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image11[1].jpeg: 640x544 1 stop, 25.3ms
Speed: 2.9ms preprocess, 25.3ms inference, 1.2ms postprocess per image at shape
(1, 3, 640, 544)

image11[1].jpeg

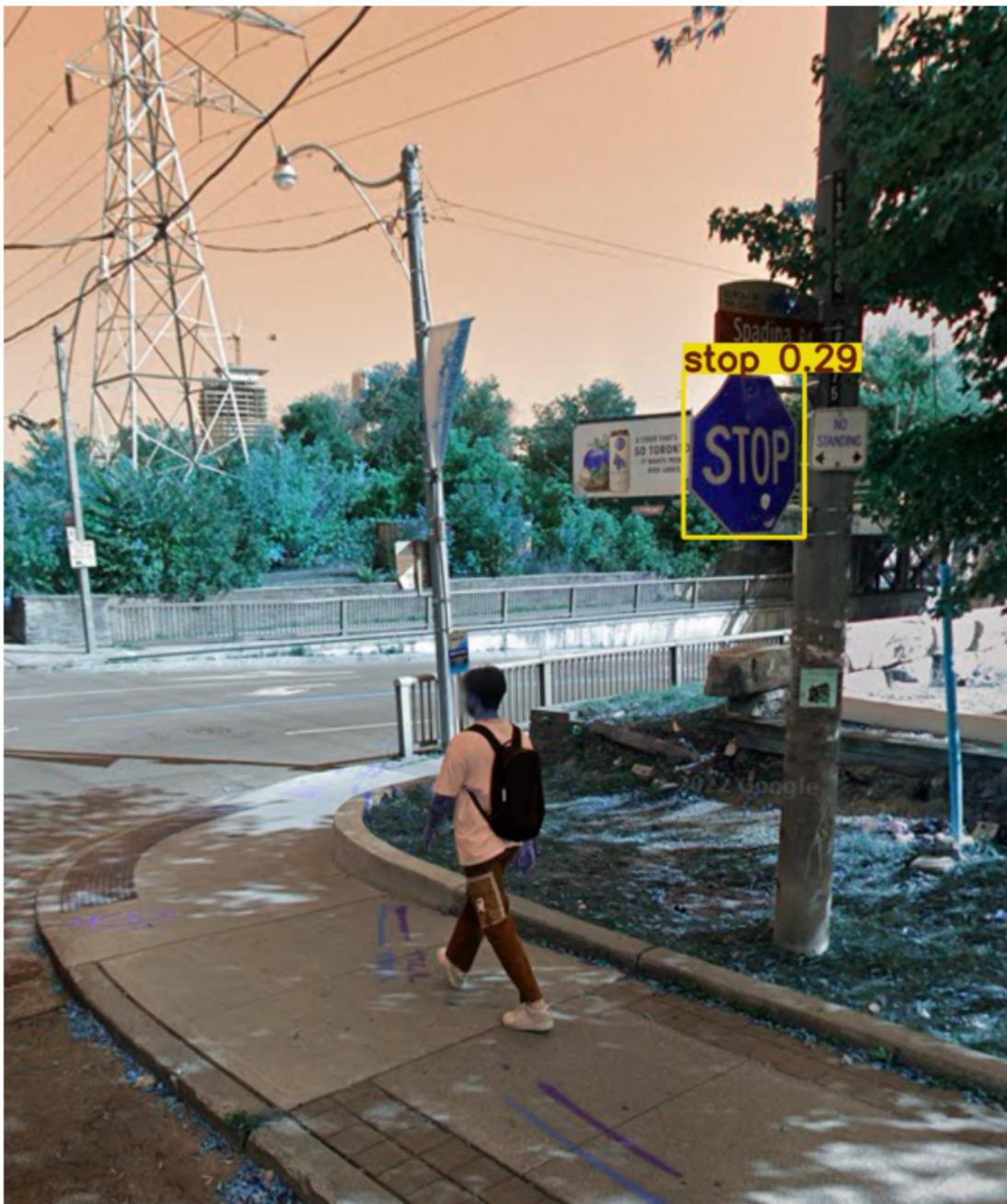


image 1/1 /content/drive/My Drive/Colab

Notebooks/Data/Inference_images/image26.jpeg: 640x480 1 speedlimit, 33.8ms
Speed: 2.5ms preprocess, 33.8ms inference, 1.6ms postprocess per image at shape
(1, 3, 640, 480)

image26.jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image23.jpeg: 640x512 (no detections), 36.9ms  
Speed: 2.6ms preprocess, 36.9ms inference, 0.7ms postprocess per image at shape  
(1, 3, 640, 512)
```

image23.jpeg



image 1/1 /content/drive/My Drive/Colab

Notebooks/Data/Inference_images/image4.jpeg: 512x640 (no detections), 341.9ms

Speed: 5.0ms preprocess, 341.9ms inference, 1.5ms postprocess per image at shape

(1, 3, 512, 640)

image4.jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image18.jpeg: 640x480 1 trafficlight, 1 stop,  
38.0ms  
Speed: 2.5ms preprocess, 38.0ms inference, 1.9ms postprocess per image at shape  
(1, 3, 640, 480)
```

image18.jpeg

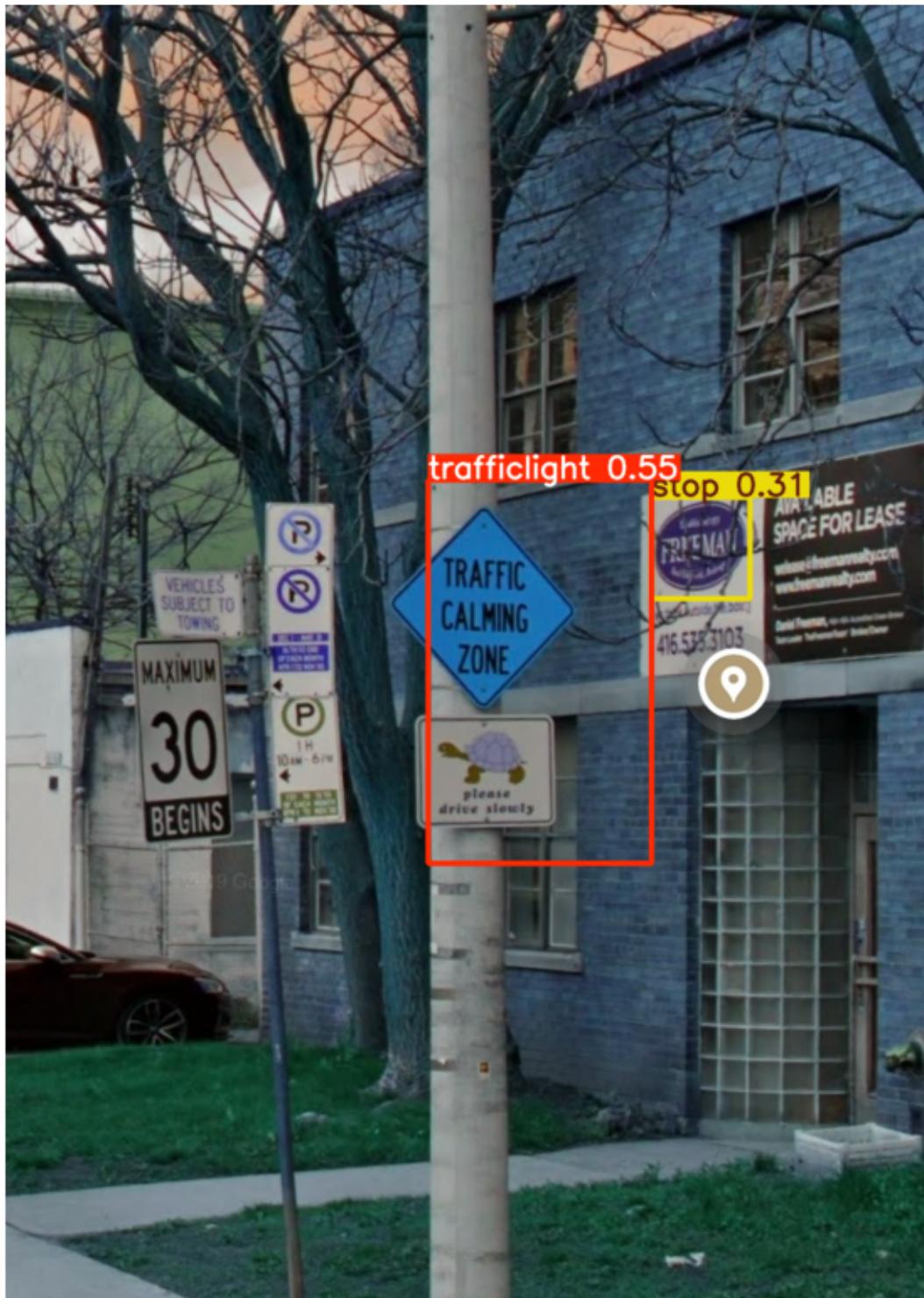


image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image10.jpeg: 640x576 1 speedlimit, 148.7ms
Speed: 2.8ms preprocess, 148.7ms inference, 1.4ms postprocess per image at shape
(1, 3, 640, 576)

image10.jpeg

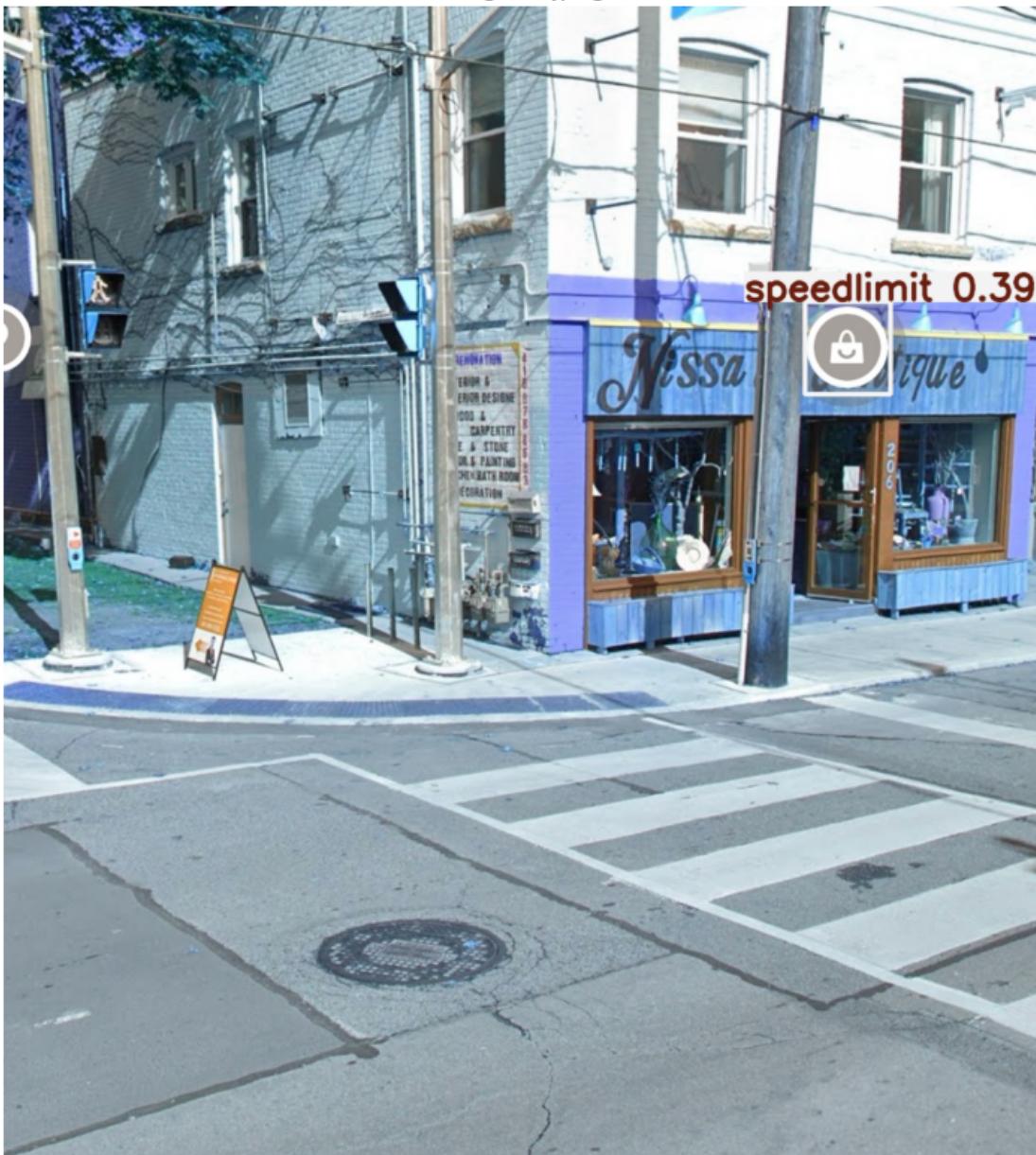
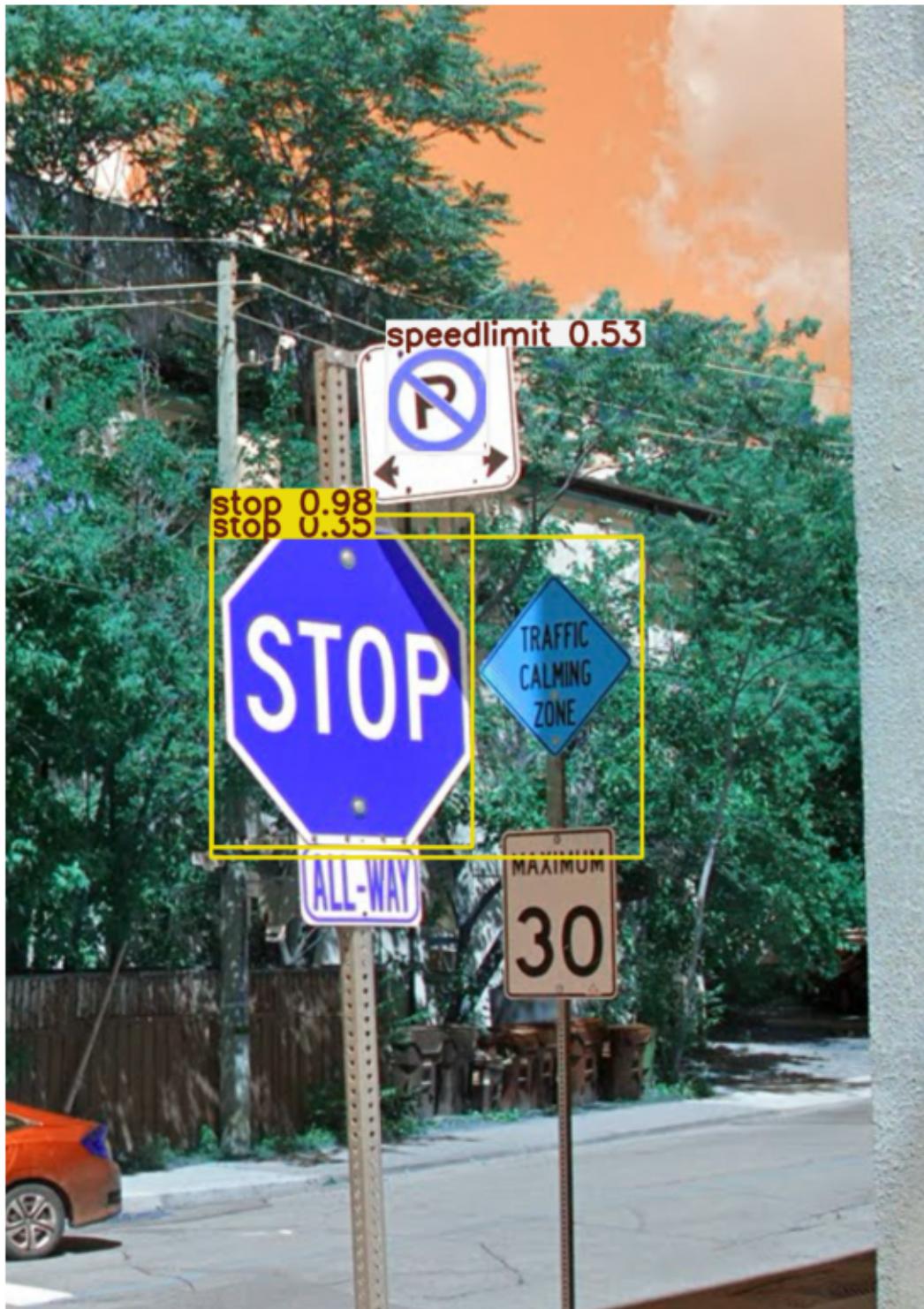


image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image14[1].jpeg: 640x480 2 stops, 1 speedlimit,
23.9ms

Speed: 2.6ms preprocess, 23.9ms inference, 1.2ms postprocess per image at shape (1, 3, 640, 480)

image14[1].jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image7.jpeg: 416x640 (no detections), 24.0ms  
Speed: 2.3ms preprocess, 24.0ms inference, 0.5ms postprocess per image at shape  
(1, 3, 416, 640)
```

image7.jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image16.jpeg: 640x512 1 stop, 25.0ms  
Speed: 2.8ms preprocess, 25.0ms inference, 1.3ms postprocess per image at shape  
(1, 3, 640, 512)
```

image16.jpeg



image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image14.jpeg: 640x544 1 stop, 29.4ms

Speed: 2.7ms preprocess, 29.4ms inference, 1.5ms postprocess per image at shape (1, 3, 640, 544)

image14.jpeg



image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image3.jpeg: 448x640 1 stop, 280.4ms

Speed: 3.3ms preprocess, 280.4ms inference, 1.8ms postprocess per image at shape (1, 3, 448, 640)

image3.jpeg



image 1/1 /content/drive/My Drive/Colab
Notebooks/Data/Inference_images/image11.jpeg: 640x480 1 trafficlight, 1 crosswalk, 38.7ms
Speed: 2.4ms preprocess, 38.7ms inference, 1.7ms postprocess per image at shape (1, 3, 640, 480)

image11.jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image19.jpeg: 640x480 1 trafficlight, 1 stop,  
36.3ms  
Speed: 2.6ms preprocess, 36.3ms inference, 1.6ms postprocess per image at shape  
(1, 3, 640, 480)
```

image19.jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image8.jpeg: 512x640 (no detections), 54.8ms  
Speed: 3.5ms preprocess, 54.8ms inference, 0.8ms postprocess per image at shape  
(1, 3, 512, 640)
```

image8.jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image0[1].jpeg: 640x448 1 trafficlight, 26.2ms  
Speed: 2.6ms preprocess, 26.2ms inference, 1.3ms postprocess per image at shape  
(1, 3, 640, 448)
```

image0[1].jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image26[1].jpeg: 640x480 (no detections), 24.1ms  
Speed: 2.7ms preprocess, 24.1ms inference, 0.5ms postprocess per image at shape  
(1, 3, 640, 480)
```

image26[1].jpeg



```
image 1/1 /content/drive/My Drive/Colab  
Notebooks/Data/Inference_images/image5.jpeg: 480x640 (no detections), 167.2ms  
Speed: 5.4ms preprocess, 167.2ms inference, 0.6ms postprocess per image at shape  
(1, 3, 480, 640)
```

image5.jpeg



```
AssertionError                                     Traceback (most recent call last)  
<ipython-input-24-c651d11e6ca0> in <cell line: 16>()  
      14 assert os.path.exists(inference_images_path), f"Directory  
      ↪{inference_images_path} does not exist."  
      15 image_files = [f for f in os.listdir(inference_images_path) if f.  
      ↪endswith('.jpg')]  
---> 16 assert len(image_files) > 0, "No JPEG images found in the directory."  
      17  
      18 print(f"Found {len(image_files)} images in the directory.")
```

AssertionError: No JPEG images found in the directory.

```
#Evaluate the model by displaying inference results on validation images
```

```
[ ]: import glob

# Directory containing validation images
val_images_dir = 'road_sign_detection/val/images'

# List all images in the validation directory
val_images = glob.glob(os.path.join(val_images_dir, '*'))

# Function to display images with bounding boxes and labels
def display_inference_results(image_path, model):
    # Read the image
    img = cv2.imread(image_path)
    # Perform inference
    results = model(img)
    # Plot the results
    results[0].plot()
    # Convert the image to RGB for displaying with matplotlib
    img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
    plt.imshow(img_rgb)
    plt.axis('off')
    plt.show()

# Evaluate the model on 10 validation images
for img_path in val_images[:10]: # Displaying results for the first 10 images
    display_inference_results(img_path, model)
```

0: 640x480 1 speedlimit, 78.5ms
 Speed: 3.2ms preprocess, 78.5ms inference, 4.2ms postprocess per image at shape
 (1, 3, 640, 480)



0: 640x480 2 speedlimits, 38.5ms

Speed: 2.5ms preprocess, 38.5ms inference, 3.5ms postprocess per image at shape
(1, 3, 640, 480)



0: 640x480 1 speedlimit, 36.2ms

Speed: 2.5ms preprocess, 36.2ms inference, 1.9ms postprocess per image at shape
(1, 3, 640, 480)



0: 640x480 1 speedlimit, 45.7ms

Speed: 5.4ms preprocess, 45.7ms inference, 1.8ms postprocess per image at shape
(1, 3, 640, 480)



0: 640x480 1 speedlimit, 34.5ms

Speed: 7.1ms preprocess, 34.5ms inference, 1.9ms postprocess per image at shape
(1, 3, 640, 480)



0: 640x480 1 speedlimit, 46.5ms

Speed: 2.5ms preprocess, 46.5ms inference, 4.8ms postprocess per image at shape
(1, 3, 640, 480)



0: 416x640 1 stop, 41.8ms

Speed: 2.5ms preprocess, 41.8ms inference, 1.8ms postprocess per image at shape
(1, 3, 416, 640)



0: 512x640 1 stop, 46.5ms

Speed: 2.6ms preprocess, 46.5ms inference, 1.9ms postprocess per image at shape
(1, 3, 512, 640)



0: 640x480 1 speedlimit, 1 crosswalk, 54.7ms

Speed: 2.8ms preprocess, 54.7ms inference, 1.8ms postprocess per image at shape
(1, 3, 640, 480)



0: 640x480 1 speedlimit, 48.5ms
Speed: 2.5ms preprocess, 48.5ms inference, 1.6ms postprocess per image at shape
(1, 3, 640, 480)



[]:

#Observations: ###Initial Evaluation (Before Fine-Tuning):

Metrics: Precision, recall, mAP50, and mAP50-95 are all 0.

Inference Speed: 11.5ms per image.

Observation: The model completely failed to detect any instances of the classes in the validation set, indicating a poor initial performance. This could be due to inadequate training data, insufficient training epochs, or inappropriate model initialization.

###Evaluation After Fine-Tuning:

Metrics:

Precision: 0.913

Recall: 0.775

mAP50: 0.83

mAP50-95: 0.658

Class-wise Performance:

Trafficlight: Precision 0.884, Recall 0.323, mAP50 0.524, mAP50-95 0.282

Stop: Precision 0.804, Recall 0.932, mAP50 0.92, mAP50-95 0.786

Speedlimit: Precision 0.992, Recall 0.993, mAP50 0.988, mAP50-95 0.874

Crosswalk: Precision 0.973, Recall 0.85, mAP50 0.887, mAP50-95 0.688

Inference Speed: 8.4ms per image.

Observation: Overall Improvement: The fine-tuning process has significantly improved the model's performance across all metrics. Precision, recall, and mAP scores have increased notably. The model shows high precision and recall, particularly for the "stop" and "speedlimit" classes. The "trafficlight" class has a lower recall, indicating room for improvement in detecting these instances.

Class-Wise Insights:

Traffic Light: Precision is relatively high, but recall is low. This suggests that the model correctly identifies traffic lights when it does detect them, but it misses a significant number of them.

Stop: High precision and recall indicate the model is performing well for stop signs. Speed Limit: Exceptional performance in both precision and recall, making this the best-performing class.

Crosswalk: Good balance between precision and recall, with strong mAP scores.

Evaluation After Additional Data Augmentation:

Metrics:

Precision: 0.888

Recall: 0.761

mAP50: 0.801

mAP50-95: 0.64

Class-wise Performance:

Trafficlight: Precision 0.676, Recall 0.362, mAP50 0.449, mAP50-95 0.222

Stop: Precision 0.932, Recall 0.909, mAP50 0.932, mAP50-95 0.817

Speedlimit: Precision 0.993, Recall 0.972, mAP50 0.99, mAP50-95 0.882

Crosswalk: Precision 0.951, Recall 0.8, mAP50 0.834, mAP50-95 0.637

Inference Speed: 26.1ms per image.

Observation: Slight decrease in overall metrics compared to the evaluation after fine-tuning. Precision and recall slightly decreased, with notable impact on the "trafficlight" class performance. The increase in inference time suggests that the additional data augmentation may have added complexity.

#Recommendations:

Improve Trafficlight Detection:

The "trafficlight" class consistently shows lower performance. Consider additional targeted data augmentation (e.g., different lighting conditions, angles) specifically for this class. Increase the number of training samples for the "trafficlight" class if the dataset is imbalanced.

Optimize Data Augmentation:

The data augmentation step led to a slight decrease in performance metrics. Review the augmentation techniques to ensure they are beneficial rather than detrimental. Experiment with different augmentation parameters and strategies to find an optimal balance that enhances model robustness without increasing complexity excessively.

Fine-Tuning Parameters:

Continue fine-tuning the model with a focus on hyperparameter optimization. Adjust learning rates, batch sizes, and the number of epochs to further improve performance. Implement cross-validation to ensure the model's generalizability and to avoid overfitting.

Model Complexity vs. Inference Time:

Consider the trade-off between model complexity and inference speed. If inference time is critical, explore model pruning or quantization techniques to reduce the model size and speed up inference without significantly sacrificing accuracy.