

# AIML Capstone Project - Autonomous Driving - Lee Thornquist

Problem Statement 1: Autonomous vehicles (AV) and intelligent transport systems (ITS) are the future of road transport. Automatic detection of vehicles on the road in real-time helps AV technology and makes ITS more intelligent in terms of vehicle tracking, vehicle counting, and road incident response.

Objective Statement 1: As the first part of this project, you need to develop an AI model using a deep learning framework that predicts the type of vehicle present in an image as well as localizes the vehicle by rectangular bounding box.

## Part 1

### 1.1 Create a parent folder for custom model training and child folders to store data

```
In [ ]: import os

# define parent directory
parent_dir = 'yolov5_vehicle_detection'

# define child directories
child_dirs = ["data", "models", "results", "notebooks"]

# create parent directory
if not os.path.exists(parent_dir):
    os.makedirs(parent_dir)

# create child directories
for dir_name in child_dirs:
    dir_path = os.path.join(parent_dir, dir_name)
    if not os.path.exists(dir_path):
        os.makedirs(dir_path)
```

### 1.2 Prepare the dataset for model training

```
In [ ]: import pandas as pd
import shutil
import random

# define paths
data_dir = 'yolov5_vehicle_detection/data'
images_dir = data_dir, 'Images'
labels_csv = data_dir, 'labels.csv'
labels_dir = os.path.join(data_dir, 'labels')
```

```
In [ ]: # create directories

os.makedirs(labels_dir, exist_ok=True)

os.makedirs(os.path.join(data_dir, 'images', 'train'), exist_ok=True)
os.makedirs(os.path.join(data_dir, 'images', 'val'), exist_ok=True)
os.makedirs(os.path.join(data_dir, 'images', 'test'), exist_ok=True)

os.makedirs(os.path.join(labels_dir, 'train'), exist_ok=True)
os.makedirs(os.path.join(labels_dir, 'val'), exist_ok=True)
os.makedirs(os.path.join(labels_dir, 'test'), exist_ok=True)

# I ended up manually changing these to the correct structure for the YOLOv8 model. Attached image shows how I structured the data.
```

```
In [ ]: # loading our data
# Define column names
column_names = ['image_id', 'vehicle_type', 'x_min', 'y_min', 'x_max', 'y_max']

# Load the labels file with column names
labels_df = pd.read_csv("yolov5_vehicle_detection/data/labels.csv", header=None, names=column_names)

labels_df
```

```
In [ ]: # making sure I have no missing values

labels_df.isnull().sum()
```

```
In [ ]: labels_df['vehicle_type'].unique()
```

```
In [ ]: # Complete list of vehicle types and their numeric codes
vehicle_types = {
    'pickup_truck': 0,
    'car': 1,
    'articulated_truck': 2,
    'bus': 3,
    'motorized_vehicle': 4,
    'work_van': 5,
    'single_unit_truck': 6,
    'pedestrian': 7,
    'bicycle': 8,
    'non-motorized_vehicle': 9,
    'motorcycle': 10
}
```

```
In [ ]: # Apply the vehicle type mapping
labels_df['vehicle_type'] = labels_df['vehicle_type'].map(vehicle_types)

# Check for any unmapped vehicle types resulting in NaN
unmapped_vehicle_types = labels_df[labels_df['vehicle_type'].isna()]
if not unmapped_vehicle_types.empty:
    print("Unmapped vehicle types found:")
    print(unmapped_vehicle_types)
else:
    print("All vehicle types mapped successfully!")
```

```
In [ ]: # Image dimensions
image_height = 480
image_width = 720

# Standardize the labels directly in the DataFrame
labels_df['x_center'] = (labels_df['x_min'] + labels_df['x_max']) / 2.0 / image_width
labels_df['y_center'] = (labels_df['y_min'] + labels_df['y_max']) / 2.0 / image_height
labels_df['width'] = (labels_df['x_max'] - labels_df['x_min']) / image_width
labels_df['height'] = (labels_df['y_max'] - labels_df['y_min']) / image_height
```

```
In [ ]: # Define the path to the labels directory
labels_output_dir = os.path.join(data_dir, "labels_yolov5")

# Create the labels directory if it doesn't exist
if not os.path.exists(labels_output_dir):
    os.makedirs(labels_output_dir)
```

```
In [ ]: # Function to write labels to YOLOv8 format text files

def write_yolo_labels(image_id, group):
    file_path = os.path.join(labels_output_dir, f"{int(image_id):08d}.txt")
    with open(file_path, 'w') as f:
```

```
for _, row in group.iterrows():
    label = f'{int(row['vehicle_type'])} {row['x_center']:.6f} {row['y_center']:.6f} {row['width']:.6f} {row['height']:.6f}\n'
    f.write(label)
```

```
In [ ]: # Group labels by image_id and apply the function
```

```
grouped = labels_df.groupby('image_id')
grouped.apply(lambda group: write_yolo_labels(group.name, group))
```

```
In [ ]: # Read and print the contents of a few label files to verify
```

```
for label_file in label_files[:5]:
    file_path = os.path.join(labels_output_dir, label_file)
    print(f"\nContents of {label_file}:")
    with open(file_path, 'r') as f:
        print(f.read())
```

```
In [ ]: from sklearn.model_selection import train_test_split
```

```
# Define base directories
data_dir = 'yolov5_vehicle_detection/data'
images_dir = os.path.join(data_dir, "Images")
labels_yolov5_dir = os.path.join(data_dir, "labels_yolov5")
splits_dir = os.path.join(data_dir, "splits")
output_images_dir = os.path.join(data_dir, "images")
output_labels_dir = os.path.join(data_dir, "labels")

# list all image files
existing_images = set(os.listdir(images_dir))
```

```
In [ ]: # Ensure directories for splits
```

```
os.makedirs(splits_dir, exist_ok=True)

for split in ["train", "val", "test"]:
    os.makedirs(os.path.join(output_images_dir, split), exist_ok=True)
    os.makedirs(os.path.join(output_labels_dir, split), exist_ok=True)
```

```
In [ ]: # Function to create and save split datasets
```

```
def create_and_save_splits():
    train_df, temp_df = train_test_split(labels_df, test_size=0.3, random_state=42, stratify=labels_df['vehicle_type'])
    val_df, test_df = train_test_split(temp_df, test_size=0.5, random_state=42, stratify=temp_df['vehicle_type'])

    train_df.to_csv(os.path.join(splits_dir, 'train_labels.csv'), index=False)
    val_df.to_csv(os.path.join(splits_dir, 'val_labels.csv'), index=False)
    test_df.to_csv(os.path.join(splits_dir, 'test_labels.csv'), index=False)
    print("Split files created successfully!")

# Check if split files exist, if not create them
if not (os.path.exists(os.path.join(splits_dir, 'train_labels.csv')) and
        os.path.exists(os.path.join(splits_dir, 'val_labels.csv')) and
        os.path.exists(os.path.join(splits_dir, 'test_labels.csv'))):
    create_and_save_splits()
```

```
In [ ]: # Load split datasets
```

```
train_df = pd.read_csv(os.path.join(splits_dir, "train_labels.csv"))
val_df = pd.read_csv(os.path.join(splits_dir, "val_labels.csv"))
test_df = pd.read_csv(os.path.join(splits_dir, "test_labels.csv"))

# List all image files
existing_images = set(os.listdir(images_dir))
```

```
In [ ]: # Function to filter DataFrame to include only existing images
```

```
def filter_existing_images(df):
    df['image_filename'] = df['image_id'].apply(lambda x: f'{int(x):08d}.jpg')
```

```

    return df[df['image_filename'].isin(existing_images)]

# Filter the DataFrames
train_df_filtered = filter_existing_images(train_df)
val_df_filtered = filter_existing_images(val_df)
test_df_filtered = filter_existing_images(test_df)

```

```

In [ ]: # Function to move files based on DataFrame
def move_files(df, split):
    missing_files = []
    for _, row in df.iterrows():
        image_id = f"{int(row['image_id']):08d}"
        image_filename = f"{image_id}.jpg"
        label_filename = f"{image_id}.txt"

        # Define source and destination paths
        src_image_path = os.path.join(images_dir, image_filename)
        src_label_path = os.path.join(labels_yolov5_dir, label_filename)
        dst_image_path = os.path.join(output_images_dir, split, image_filename)
        dst_label_path = os.path.join(output_labels_dir, split, label_filename)

        # Check if the image file exists before moving
        if os.path.exists(src_image_path) and os.path.exists(src_label_path):
            shutil.move(src_image_path, dst_image_path)
            shutil.move(src_label_path, dst_label_path)
        else:
            missing_files.append(image_id)

    # Log missing files
    if missing_files:
        print(f"Missing files for image IDs: {missing_files}")

# Move files to corresponding directories
move_files(train_df_filtered, "train")
move_files(val_df_filtered, "val")
move_files(test_df_filtered, "test")

```

```

In [ ]: # creating the yaml file
import yaml

data = {
    'train': 'data/images/train',
    'val': 'data/images/val',
    'test': 'data/images/test',
    'nc': 11,
    'names': ['pickup_truck', 'car', 'articulated_truck', 'bus', 'motorized_vehicle', 'work_van', 'single_unit_truck', 'pedestrian', 'bicycle', 'non-motorized_vehicle', 'motorcycle']
}

yaml_file_path = 'yolov5_vehicle_detection/data.yaml'

with open(yaml_file_path, 'w') as yaml_file:
    yaml.dump(data, yaml_file, default_flow_style=False)

print("YAML file created successfully!")

```

### 1.3 Create an CNN architecture for object detection (YOLOv8)

I originally started with trying to create a YOLOv5 model like we did in class (which is why some of my files have 'YOLOv5' in the name, but I realized there were updated YOLO models so I changed my model to YOLOv8

```

In [1]: import ultralytics
        from ultralytics import YOLO

# Load a YOLOv8 model
model = YOLO('yolov8s.pt') # Load the YOLOv8 architecture file

```

```
# Train the model using your dataset.yaml configuration file
results = model.train(data='/Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/yolov5_vehicle_detection/dataset.yaml',
epochs=5, imgsz=640, batch=16)
```


Ultralytics YOLOv8.2.28 🚀 Python=3.11.5 torch=2.2.2 CPU (Intel Core(TM) i5-7360U 2.30GHz)  
**engine/trainer:** task=detect, mode=train, model=yolov8s.pt, data=/Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/yolov5\_vehicle\_detection/dataset.yaml, epochs=5, time=None, patience=100, batch=16, imgsz=640, save=True, save\_period=-1, cache=False, device=None, workers=8, project=None, name=train15, exist\_ok=False, pretrain ed=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, freez e=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=Fals e, 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, dyna mic=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, dfl=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, f lipplr=0.5, bgr=0.0, mosaic=1.0, mixup=0.0, copy\_paste=0.0, auto\_augment=randaugument, erasing=0.4, crop\_fraction=1.0, cfg=None, tracker=botsort.yaml, save\_dir=runs/detect/train15  
Overriding model.yaml nc=80 with nc=11

	from	n	params	module	arguments
0	-1	1	928	ultralytics.nn.modules.conv.Conv	[3, 32, 3, 2]
1	-1	1	18560	ultralytics.nn.modules.conv.Conv	[32, 64, 3, 2]
2	-1	1	29056	ultralytics.nn.modules.block.C2f	[64, 64, 1, True]
3	-1	1	73984	ultralytics.nn.modules.conv.Conv	[64, 128, 3, 2]
4	-1	2	197632	ultralytics.nn.modules.block.C2f	[128, 128, 2, True]
5	-1	1	295424	ultralytics.nn.modules.conv.Conv	[128, 256, 3, 2]
6	-1	2	788480	ultralytics.nn.modules.block.C2f	[256, 256, 2, True]
7	-1	1	1180672	ultralytics.nn.modules.conv.Conv	[256, 512, 3, 2]
8	-1	1	1838080	ultralytics.nn.modules.block.C2f	[512, 512, 1, True]
9	-1	1	656896	ultralytics.nn.modules.block.SPPF	[512, 512, 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	591360	ultralytics.nn.modules.block.C2f	[768, 256, 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	148224	ultralytics.nn.modules.block.C2f	[384, 128, 1]
16	-1	1	147712	ultralytics.nn.modules.conv.Conv	[128, 128, 3, 2]
17	[-1, 12]	1	0	ultralytics.nn.modules.conv.Concat	[1]
18	-1	1	493056	ultralytics.nn.modules.block.C2f	[384, 256, 1]
19	-1	1	590336	ultralytics.nn.modules.conv.Conv	[256, 256, 3, 2]
20	[-1, 9]	1	0	ultralytics.nn.modules.conv.Concat	[1]
21	-1	1	1969152	ultralytics.nn.modules.block.C2f	[768, 512, 1]
22	[15, 18, 21]	1	2120305	ultralytics.nn.modules.head.Detect	[11, [128, 256, 512]]

Model summary: 225 layers, 11139857 parameters, 11139841 gradients, 28.7 GFLOPs

Transferred 349/355 items from pretrained weights  
**TensorBoard:** Start with 'tensorboard --logdir runs/detect/train15', view at http://localhost:6006/  
Freezing layer 'model.22.dfl.conv.weight'

**train:** Scanning /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/  
**train:** New cache created: /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/yolov5\_vehicle\_detection/data/train/labels.cache  
**val:** Scanning /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07  
**val:** New cache created: /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/yolov5\_vehicle\_detection/data/val/labels.cache

Plotting labels to runs/detect/train15/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=0.000667, 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 0 dataloader workers  
Logging results to **runs/detect/train15**  
Starting training for 5 epochs...

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size
1/5	0G	1.258	2.107	1.131	41	640: 1
	Class	Images	Instances	Box(P	R	mAP50 m
	all	386	525	0.59	0.272	0.359 0.264
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size

2/5	0G	1.196	1.295	1.091	42	640: 1	
	Class	Images	Instances	Box(P	R	mAP50	m
	all	386	525	0.48	0.467	0.403	0.276
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
3/5	0G	1.157	1.197	1.07	66	640: 1	
	Class	Images	Instances	Box(P	R	mAP50	m
	all	386	525	0.526	0.456	0.485	0.346
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
4/5	0G	1.121	1.098	1.055	31	640: 1	
	Class	Images	Instances	Box(P	R	mAP50	m
	all	386	525	0.596	0.525	0.526	0.396
Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size	
5/5	0G	1.072	0.9667	1.029	33	640: 1	
	Class	Images	Instances	Box(P	R	mAP50	m
	all	386	525	0.654	0.534	0.599	0.452

5 epochs completed in 17.988 hours.  
Optimizer stripped from runs/detect/train15/weights/last.pt, 22.5MB  
Optimizer stripped from runs/detect/train15/weights/best.pt, 22.5MB

Validating runs/detect/train15/weights/best.pt...  
Ultralytics YOLOv8.2.28 🚀 Python-3.11.5 torch-2.2.2 CPU (Intel Core(TM) i5-7360U 2.30GHz)  
Model summary (fused): 168 layers, 11129841 parameters, 0 gradients, 28.5 GFLOPs

	Class	Images	Instances	Box(P	R	mAP50	m
	all	386	525	0.653	0.534	0.601	0.454
	pickup_truck	80	84	0.711	0.558	0.597	0.505
	car	255	324	0.764	0.787	0.796	0.626
	articulated_truck	21	21	0.554	0.667	0.704	0.549
	bus	33	33	0.924	0.879	0.954	0.833
	motorized_vehicle	28	28	0.345	0.179	0.213	0.126
	work_van	14	15	0.364	0.267	0.246	0.193
	single_unit_truck	7	7	0.585	0.286	0.393	0.301
	pedestrian	2	3	0.743	1	0.995	0.675
	bicycle	4	4	0.681	1	0.995	0.746
	non_motorized_vehicle	2	2	1	0	0.0101	0.00705
	motorcycle	4	4	0.515	0.25	0.705	0.436

Speed: 2.9ms preprocess, 367.5ms inference, 0.0ms loss, 1.1ms postprocess per image  
Results saved to **runs/detect/train15**

### 1.4 Evaluate the Model and Check the Test Results

```
In [2]: # Evaluate the model on validation data
val_results = model.val()
print(val_results)
```

Ultralytics YOLOv8.2.28 🚀 Python-3.11.5 torch-2.2.2 CPU (Intel Core(TM) i5-7360U 2.30GHz)  
Model summary (fused): 168 layers, 11129841 parameters, 0 gradients, 28.5 GFLOPs

**val:** Scanning /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07  
Class Images Instances Box(P R mAP50 m



all	386	525	0.653	0.534	0.601	0.454
pickup_truck	80	84	0.711	0.558	0.597	0.505
car	255	324	0.764	0.787	0.796	0.626
articulated_truck	21	21	0.554	0.667	0.704	0.549
bus	33	33	0.924	0.879	0.954	0.833
motorized_vehicle	28	28	0.345	0.179	0.213	0.126
work_van	14	15	0.364	0.267	0.246	0.193
single_unit_truck	7	7	0.585	0.286	0.393	0.301
pedestrian	2	3	0.743	1	0.995	0.675
bicycle	4	4	0.681	1	0.995	0.746
non_motorized_vehicle	2	2	1	0	0.0101	0.00705
motorcycle	4	4	0.515	0.25	0.705	0.436

Speed: 3.9ms preprocess, 425.8ms inference, 0.0ms loss, 1.4ms postprocess per image

Results saved to **runs/detect/train152**

ultralytics.utils.metrics.DetMetrics object with attributes:

```
ap_class_index: array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10])
box: ultralytics.utils.metrics.Metric object
confusion_matrix: <ultralytics.utils.metrics.ConfusionMatrix object at 0x155dbdb10>
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, 0.03703
7, 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, 0.06106
1, 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, 0.08508
5, 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, 0.1091
1, 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, 0.1331
3, 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, 0.1571
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1,	0.61461,	0.61562,	0.61662,	0.61762,	0.61862,	0.61962,	0.62062,	0.62162,	0.62262,	0.62362,					
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3,	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,	0.7577	
6,	0.75876,	0.75976,	0.76076,	0.76176,	0.76276,	0.76376,	0.76476,	0.76577,	0.76677,	0.76777,					
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8,	0.78278,	0.78378,	0.78478,	0.78579,	0.78679,	0.78779,	0.78879,	0.78979,	0.79079,	0.79179,					
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1,	0.80681,	0.80781,	0.80881,	0.80981,	0.81081,	0.81181,	0.81281,	0.81381,	0.81481,	0.81582,					
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9,	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,	0.9259	
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	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,	0.9499	
5,	0.95095,	0.95195,	0.95295,	0.95395,	0.95495,	0.95596,	0.95696,	0.95796,	0.95896,	0.95996,					
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7,	0.97497,	0.97598,	0.97698,	0.97798,	0.97898,	0.97998,	0.98098,	0.98198,	0.98298,	0.98398,					
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	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,	0.03703	
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	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,	0.06106	
1,	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,	0.08508	
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	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,	0.1091	
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3,	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,	0.1571	
6,	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,	0.1811	
8,	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,	0.2052	
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	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,	0.2292	
3,	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,	0.2532	
5,	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,	0.2772
8,	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,	0.301
3,	0.3023,	0.3033,	0.3043,	0.30531,	0.30631,	0.30731,	0.30831,	0.30931,	0.31031,	0.31131,				
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3,	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,	0.3493
5,	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,	0.3733
7,	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,	0.397
4,	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,	0.4214
2,	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,	0.4454
5,	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,	0.4694
7,	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,	0.4934
9,	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,	0.5175
2,	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,	0.5415
4,	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,	0.5655
7,	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,	0.5895
9,	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,	0.6136
1,	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,	0.6376
4,	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,	0.6616
6,	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,	0.6856
9,	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,	0.7097
1,	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,	0.7337
3,	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,	0.7577
6,	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,	0.7817
8,	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,	0.8058
1,	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,	0.8298
3,	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,	0.8538
5,	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,	0.8778
8,	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,	0.901
9,	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,	0.9259
3,	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,	0.9499
5,	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,	0.9739
7,	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,	0.99
8,	0.999,	1]),	array([[	0.024574,	0.024574,	0.026319,	...,	0,	0,	0],				
	[	0.031412,	0.031414,	0.036393,	...,	0,	0,	0],						
	[	0.050697,	0.050697,	0.076728,	...,	0,	0,	0],						
	...,													
	[	0.032653,	0.032653,	0.052733,	...,	0,	0,	0],						

[illegible]

	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,	0.7817
8,	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,	0.8058
1,	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,	0.8298
3,	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,	0.8538
5,	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,	0.8778
8,	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,	0.901
9,	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,	0.9259
3,	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,	0.9499
5,	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,	0.9739
7,	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,	0.99
8,	0.999,	1]], array([[	0.012442,	0.012442,	0.013339,	...,	1,	1,	1],					
	[	0.015965,	0.015967,	0.018547,	...,	1,	1,	1],						
	[	0.026042,	0.026042,	0.039974,	...,	1,	1,	1],						
	...,													
	[	0.016598,	0.016598,	0.027081,	...,	1,	1,	1],						
	[	0.0035587,	0.0035587,	0.0057917,	...,	1,	1,	1],						
	[	0.028369,	0.028369,	0.064418,	...,	1,	1,	1]]), 'Confidence', 'Precision'], [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,	0.01
8018,	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,	0.03703
7,	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,	0.06106
1,	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,	0.08508
5,	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,	0.1091
1,	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,	0.1331
3,	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,	0.1571
6,	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,	0.1811
8,	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,	0.2052
1,	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,	0.2292
3,	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,	0.2532
5,	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,	0.2772
8,	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,	0.301
3,	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,	0.3253
3,	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,	0.3493
5,	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,	0.3733
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fitness: 0.46885689697962546
keys: ['metrics/precision(B)', 'metrics/recall(B)', 'metrics/mAP50(B)', 'metrics/mAP50-95(B)']
maps: array([ 0.50454, 0.6263, 0.54862, 0.83264, 0.12622, 0.193, 0.30067, 0.67494, 0.74615, 0.0070519, 0.43617])
names: {0: 'pickup_truck', 1: 'car', 2: 'articulated_truck', 3: 'bus', 4: 'motorized_vehicle', 5: 'work_van', 6: 'single_unit_truck', 7: 'pedestrian', 8: 'bicycle', 9: 'non_motorized_veh
icle', 10: 'motorcycle'}
plot: True
results_dict: {'metrics/precision(B)': 0.6533993803646944, 'metrics/recall(B)': 0.5337360624740617, 'metrics/mAP50(B)': 0.600702324926506, 'metrics/mAP50-95(B)': 0.45420740498552764, 'fi
tness': 0.46885689697962546}
save_dir: PosixPath('runs/detect/train152')
speed: {'preprocess': 3.9162641979869783, 'inference': 425.8065983421444, 'loss': 6.361946540792989e-05, 'postprocess': 1.4362051079310283}
task: 'detect'

```

```

In [4]: # Evaluate the model on test data
dataset_path = '/Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/yolov5_vehicle_detection/dataset.yaml'
test_results = model.val(data=dataset_path, split='test')
print(test_results)

```

Ultralytics YOLOv8.2.28 🚀 Python=3.11.5 torch=2.2.2 CPU (Intel Core(TM) i5-7360U 2.30GHz)

val: Scanning /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07

val: New cache created: /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/yolov5\_vehicle\_detection/data/test/labels.cache

Class	Images	Instances	Box(P	R	mAP50	m
-------	--------	-----------	-------	---	-------	---

all	290	330	0.76	0.587	0.671	0.502
pickup_truck	59	59	0.805	0.56	0.677	0.576
car	179	195	0.796	0.8	0.812	0.682
articulated_truck	14	14	0.586	0.643	0.676	0.544
bus	18	18	0.944	0.944	0.964	0.867
motorized_vehicle	22	22	0.217	0.0455	0.0905	0.0398
work_van	9	9	1	0.425	0.526	0.489
single_unit_truck	4	4	0.852	0.25	0.46	0.379
bicycle	3	3	0.64	1	0.995	0.441
motorcycle	6	6	1	0.618	0.838	0.5

Speed: 2.9ms preprocess, 396.8ms inference, 0.0ms loss, 1.3ms postprocess per image

Results saved to **runs/detect/train154**

ultralytics.utils.metrics.DetMetrics object with attributes:

```
ap_class_index: array([ 0,  1,  2,  3,  4,  5,  6,  8, 10])
box: ultralytics.utils.metrics.Metric object
confusion_matrix: <ultralytics.utils.metrics.ConfusionMatrix object at 0x167afa390>
curves: ['Precision-Recall(B)', 'F1-Confidence(B)', 'Precision-Confidence(B)', 'Recall-Confidence(B)']
curves_results: [[array([
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9,	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,	0.6136	
1,	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,	0.6376	
4,	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,	0.6616	
6,	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,	0.6856	
9,	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,	0.7097	
1,	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,	0.7337	
3,	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,	0.7577	
6,	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,	0.7817	
8,	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,	0.8058	
1,	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,	0.8298	
3,	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,	0.8538	
5,	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,	0.8778	
8,	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,	0.901	
9,	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,	0.9259	
3,	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,	0.9499	
5,	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,	0.9739	
7,	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,	0.99	
8,	0.999,	1]],	array([[	1,	1,	1, ...,	0.0014686,	0.00073428,	0],						
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	[	1,	1,	1, ...,	0.0007075,	0.00035375,	0],								
	...,														
	[	1,	1,	1, ...,	6.5106e-05,	3.2553e-05,	0],								
	[	1,	1,	1, ...,	1,	1,	0],								
	[	1,	1,	1, ...,	0.00048829,	0.00024415,	0]]),	'Recall',	'Precision'],	[array([	0,	0.001001,	0.002002,	0.003003,	0.004
004,	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,	0.03703	
7,	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,	0.06106	
1,	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,	0.08508	
5,	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,	0.1091	
1,	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,	0.1331	
3,	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,	0.1571	
6,	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,	0.1811	
8,	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,	0.2052	
1,	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,	0.2292	
3,	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,	0.2532	
5,	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,	0.2772	
8,	0.27828,	0.27928,	0.28028,	0.28128,	0.28228,	0.28328,	0.28428,	0.28529,	0.28629,	0.28729,					



3,	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,	0.301
	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,	0.3253
3,	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,	0.3493
5,	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,	0.3733
7,	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,	0.397
4,	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,	0.4214
2,	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,	0.4454
5,	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,	0.4694
7,	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,	0.4934
9,	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,	0.5175
2,	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,	0.5415
4,	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,	0.5655
7,	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,	0.5895
9,	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,	0.6136
1,	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,	0.6376
4,	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,	0.6616
6,	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,	0.6856
9,	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,	0.7097
1,	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,	0.7337
3,	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,	0.7577
6,	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,	0.7817
8,	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,	0.8058
1,	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,	0.8298
3,	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,	0.8538
5,	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,	0.8778
8,	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,	0.901
9,	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,	0.9259
3,	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,	0.9499
5,	0.95095,	0.95195,	0.95295,	0.95395,	0.95495,	0.95596,	0.95696,	0.95796,	0.95896,	0.95996,				

4,	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,	0.03703
7,	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,	0.06106
1,	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,	0.08508
5,	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,	0.1091
1,	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,	0.1331
3,	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,	0.1571
6,	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,	0.1811
8,	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,	0.2052
1,	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,	0.2292
3,	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,	0.2532
5,	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,	0.2772
8,	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,	0.301
3,	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,	0.3253
3,	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,	0.3493
5,	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,	0.3733
7,	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,	0.397
4,	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,	0.4214
2,	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,	0.4454
5,	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,	0.4694
7,	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,	0.4934
9,	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,	0.5175
2,	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,	0.5415
4,	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,	0.5655
7,	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,	0.5895
9,	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,	0.6136
1,	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,	0.6376
4,	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,	0.6616
6,	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,	0.6856
9,	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,	0.7097
1,	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,	0.7337
3,	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,	0.7577
6,	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,	0.7817
8,	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,	0.8058	
1,	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,	0.8298	
3,	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,	0.8538	
5,	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,	0.8778	
8,	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,	0.901	
9,	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,	0.9259	
3,	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,	0.9499	
5,	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,	0.9739	
7,	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,	0.99	
8,	0.999,	1]],	array([[	0.012433,	0.012433,	0.013729,	...,	1,	1,	1],					
	[	0.012896,	0.012898,	0.015147,	...,	1,	1,	1],							
	[	0.025243,	0.025243,	0.041368,	...,	1,	1,	1],							
	...,														
	[	0.0081301,	0.0081301,	0.013909,	...,	1,	1,	1],							
	[	0.010033,	0.010033,	0.016244,	...,	1,	1,	1],							
	[	0.04065,	0.04065,	0.079317,	...,	1,	1,	1]]),	'Confidence',	'Precision'],	[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,	0.01	
8018,	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,	0.03703	
7,	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,	0.06106	
1,	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,	0.08508	
5,	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,	0.1091	
1,	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,	0.1331	
3,	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,	0.1571	
6,	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,	0.1811	
8,	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,	0.2052	
1,	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,	0.2292	
3,	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,	0.2532	
5,	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,	0.2772	
8,	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,	0.301	
3,	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,	0.3253	
3,	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,	0.3493	
5,	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,	0.3733	
7,	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,	0.397	
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	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,	0.4454	
5,	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,	0.4694	
7,	0.47047,	0.47147,	0.47247,	0.47347,	0.47447,	0.47548,	0.47648,	0.47748,	0.47848,	0.47948,					
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```

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...],
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[ 1, 1, 1, ..., 0, 0, 0],
[ 0.83333, 0.83333, 0.83333, ..., 0, 0, 0]]), 'Confidence', 'Recall'])
fitness: 0.5188837936017358
keys: ['metrics/precision(B)', 'metrics/recall(B)', 'metrics/mAP50(B)', 'metrics/mAP50-95(B)']
maps: array([ 0.57597, 0.68196, 0.54416, 0.86656, 0.039794, 0.48923, 0.37911, 0.502, 0.44142, 0.502, 0.49975])
names: {0: 'pickup_truck', 1: 'car', 2: 'articulated_truck', 3: 'bus', 4: 'motorized_vehicle', 5: 'work_van', 6: 'single_unit_truck', 7: 'pedestrian', 8: 'bicycle', 9: 'non_motorized_veh
icle', 10: 'motorcycle'}
plot: True
results_dict: {'metrics/precision(B)': 0.7600850933747962, 'metrics/recall(B)': 0.5873930307929995, 'metrics/mAP50(B)': 0.6708715091977615, 'metrics/mAP50-95(B)': 0.5019962696466218, 'fi
tness': 0.5188837936017358}
save_dir: PosixPath('runs/detect/train154')
speed: {'preprocess': 2.9239432565097148, 'inference': 396.81344278927503, 'loss': 8.714610132677802e-05, 'postprocess': 1.253045838454674}
task: 'detect'

```

## 1.5 Run Inferences on Sample Images

```
In [17]: import os
from ultralytics import YOLO
import matplotlib.pyplot as plt
```

```
from PIL import Image, ImageDraw, ImageFont
import numpy as np
```

```
In [21]: # Load the trained model
model = YOLO('/Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/runs/detect/train15/weights/best.pt')
```

```
In [22]: # Path to your sample images
sample_images_path = '/Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/sample_images'
output_images_path = '/Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/output_images'

# Ensure the output directory exists
os.makedirs(output_images_path, exist_ok=True)
```

```
In [24]: # Run inference on the sample images
results = model.predict(source=sample_images_path, save=True, save_dir=output_images_path)

# Function to draw bounding boxes on the image
def draw_boxes(image, boxes, labels, scores, class_names):
    draw = ImageDraw.Draw(image)
    font = ImageFont.load_default()
    for box, label, score in zip(boxes, labels, scores):
        x1, y1, x2, y2 = box
        draw.rectangle([x1, y1, x2, y2], outline="red", width=3)
        draw.text((x1, y1), f"{class_names[label]} {score:.2f}", fill="red", font=font)
    return image

# Class names based on your dataset.yaml
class_names = ['pickup_truck', 'car', 'articulated_truck', 'bus', 'motorized_vehicle',
               'work_van', 'single_unit_truck', 'pedestrian', 'bicycle', 'non_motorized_vehicle', 'motorcycle']

# Display the results
for result in results:
    img_path = result.path
    img = Image.open(img_path)

    # Retrieve boxes, labels, and scores
    boxes = result.boxes.xyxy.numpy() # Bounding box coordinates in (x1, y1, x2, y2) format
    labels = result.boxes.cls.numpy().astype(int) # Class labels
    scores = result.boxes.conf.numpy() # Confidence scores

    # Draw boxes on the image
    img_with_boxes = draw_boxes(img, boxes, labels, scores, class_names)

    # Display the image
    plt.figure(figsize=(10, 10))
    plt.imshow(img_with_boxes)
    plt.axis('off')
    plt.show()
```

```
image 1/6 /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/sample_images/image1.jpeg: 544x640 7 cars, 6 work_vans, 435.6ms
image 2/6 /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/sample_images/image2.jpeg: 416x640 1 pickup_truck, 10 cars, 1 bus, 341.7ms
image 3/6 /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/sample_images/image3.jpeg: 480x640 4 pickup_trucks, 4 cars, 4 buss, 1 work_van, 407.6ms
image 4/6 /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/sample_images/image4.jpeg: 448x640 3 pickup_trucks, 1 car, 2 articulated_truck s, 1 single_unit_truck, 344.7ms
image 5/6 /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/sample_images/image5.jpeg: 384x640 3 pickup_trucks, 9 cars, 5 work_vans, 303.6ms
image 6/6 /Users/leethornquist/Desktop/AI:ML Caltech Bootcamp/Foundations/07 - Capstone/Autonomous Driving/sample_images/image6.jpeg: 448x640 3 buss, 430.4ms
Speed: 4.4ms preprocess, 377.3ms inference, 1.4ms postprocess per image at shape (1, 3, 448, 640)
Results saved to runs/detect/predict2
<Figure size 1000x1000 with 1 Axes>
<Figure size 1000x1000 with 1 Axes>
<Figure size 1000x1000 with 1 Axes>
<Figure size 1000x1000 with 1 Axes>
<Figure size 1000x1000 with 1 Axes>
```

<Figure size 1000x1000 with 1 Axes>

I attached some examples of the image inferences. The model is very good with identifying cars but struggles with other categories.

Part 2 in separate file

In [ ]:

