Course Name: Deep Learning

Lab Title: Vehicle Detection for Smart Traffic Management using YOLOv11

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Objective The purpose of this lab is to understand and implement YOLOv11 for real-time object detection. Students will perform dataset preparation, model implementation, inference, and performance evaluation.

Task 1: Environment Setup and YOLOv11 Installation

Objective: Set up the required libraries and dependencies to run YOLOv11.

Instructions:

Install Python and required libraries (PyTorch, OpenCV, Ultralytics, etc.). Install YOLOv11 from the official repository. Verify the installation by running a sample script. Expected Outcome: A functional YOLOv11 environment ready for experimentation.

```
!pip install ultralytics
```

```
Collecting ultralytics
  Downloading ultralytics-8.3.96-py3-none-any.whl.metadata (35 kB)
Requirement already satisfied: numpy<=2.1.1,>=1.23.0 in
/usr/local/lib/python3.11/dist-packages (from ultralytics) (2.0.2)
Requirement already satisfied: matplotlib>=3.3.0 in
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Requirement already satisfied: pillow>=7.1.2 in
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/usr/local/lib/python3.11/dist-packages (from matplotlib>=3.3.0-
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>ultralytics) (2.3.0)
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/usr/local/lib/python3.11/dist-packages (from requests>=2.23.0-
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Requirement already satisfied: filelock in
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>ultralytics) (3.4.2)
Requirement already satisfied: jinja2 in
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/usr/local/lib/python3.11/dist-packages (from torch>=1.8.0-
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Collecting nvidia-cuda-nvrtc-cu12==12.4.127 (from torch>=1.8.0-
>ultralytics)
  Downloading nvidia_cuda_nvrtc_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl.metadata (1.5 kB)
Collecting nvidia-cuda-runtime-cu12==12.4.127 (from torch>=1.8.0-
>ultralytics)
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Collecting nvidia-cuda-cupti-cu12==12.4.127 (from torch>=1.8.0-
>ultralytics)
  Downloading nvidia_cuda_cupti_cu12-12.4.127-py3-none-
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Collecting nvidia-cudnn-cu12==9.1.0.70 (from torch>=1.8.0-
>ultralytics)
  Downloading nvidia_cudnn_cu12-9.1.0.70-py3-none-
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Collecting nvidia-cublas-cu12==12.4.5.8 (from torch>=1.8.0-
>ultralytics)
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Collecting nvidia-cufft-cu12==11.2.1.3 (from torch>=1.8.0-
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>ultralytics)
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Collecting nvidia-cusparse-cu12==12.3.1.170 (from torch>=1.8.0-
>ultralytics)
  Downloading nvidia_cusparse_cu12-12.3.1.170-py3-none-
manylinux2014_x86_64.whl.metadata (1.6 kB)
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Requirement already satisfied: nvidia-nccl-cu12==2.21.5 in
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Requirement already satisfied: nvidia-nvtx-cu12==12.4.127 in
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Collecting nvidia-nvjitlink-cu12==12.4.127 (from torch>=1.8.0-
>ultralytics)
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>ultralytics) (1.13.1)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/usr/local/lib/python3.11/dist-packages (from sympy==1.13.1-
>torch>=1.8.0->ultralytics) (1.3.0)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.7-
>matplotlib>=3.3.0->ultralytics) (1.17.0)
Requirement already satisfied: MarkupSafe>=2.0 in
/usr/local/lib/python3.11/dist-packages (from jinja2->torch>=1.8.0-
>ultralytics) (3.0.2)
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e_cu12-12.4.127-py3-none-manylinux2014_x86_64.whl (883 kB)
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anylinux2014_x86_64.whl (56.3 MB)
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anylinux2014_x86_64.whl (127.9 MB)
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anylinux2014_x86_64.whl (207.5 MB)
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0:00:00
anylinux2014_x86_64.whl (21.1 MB)
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e-cu12, nvidia-cuda-nvrtc-cu12, nvidia-cuda-cupti-cu12, nvidia-cublas-
cu12, nvidia-cusparse-cu12, nvidia-cudnn-cu12, nvidia-cusolver-cu12,
ultralytics-thop, ultralytics
  Attempting uninstall: nvidia-nvjitlink-cu12
    Found existing installation: nvidia-nvjitlink-cu12 12.5.82
    Uninstalling nvidia-nvjitlink-cu12-12.5.82:
      Successfully uninstalled nvidia-nvjitlink-cu12-12.5.82
  Attempting uninstall: nvidia-curand-cu12
    Found existing installation: nvidia-curand-cu12 10.3.6.82
    Uninstalling nvidia-curand-cu12-10.3.6.82:
      Successfully uninstalled nvidia-curand-cu12-10.3.6.82
  Attempting uninstall: nvidia-cufft-cu12
    Found existing installation: nvidia-cufft-cu12 11.2.3.61
    Uninstalling nvidia-cufft-cu12-11.2.3.61:
      Successfully uninstalled nvidia-cufft-cu12-11.2.3.61
  Attempting uninstall: nvidia-cuda-runtime-cu12
    Found existing installation: nvidia-cuda-runtime-cu12 12.5.82
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      Successfully uninstalled nvidia-cuda-runtime-cu12-12.5.82
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    Uninstalling nvidia-cuda-cupti-cu12-12.5.82:
      Successfully uninstalled nvidia-cuda-cupti-cu12-12.5.82
  Attempting uninstall: nvidia-cublas-cu12
    Found existing installation: nvidia-cublas-cu12 12.5.3.2
    Uninstalling nvidia-cublas-cu12-12.5.3.2:
      Successfully uninstalled nvidia-cublas-cu12-12.5.3.2
  Attempting uninstall: nvidia-cusparse-cu12
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      Successfully uninstalled nvidia-cusparse-cu12-12.5.1.3
  Attempting uninstall: nvidia-cudnn-cu12
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    Uninstalling nvidia-cudnn-cu12-9.3.0.75:
      Successfully uninstalled nvidia-cudnn-cu12-9.3.0.75
  Attempting uninstall: nvidia-cusolver-cu12
    Found existing installation: nvidia-cusolver-cu12 11.6.3.83
    Uninstalling nvidia-cusolver-cu12-11.6.3.83:
      Successfully uninstalled nvidia-cusolver-cu12-11.6.3.83
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cu12-12.4.127 nvidia-cuda-nvrtc-cu12-12.4.127 nvidia-cuda-runtime-
cu12-12.4.127 nvidia-cudnn-cu12-9.1.0.70 nvidia-cufft-cu12-11.2.1.3
nvidia-curand-cu12-10.3.5.147 nvidia-cusolver-cu12-11.6.1.9 nvidia-
cusparse-cu12-12.3.1.170 nvidia-nvjitlink-cu12-12.4.127 ultralytics-
8.3.96 ultralytics-thop-2.0.14
```

```python
from ultralytics import YOLO

# Load a pre-trained YOLOv11 model
model = YOLO('yolo11n.pt')  # 'n' stands for nano version; other
versions include 's', 'm', 'l', 'x'

# Run YOLO on a sample image
results = model('https://ultralytics.com/images/zidane.jpg')
results[0].show()
```

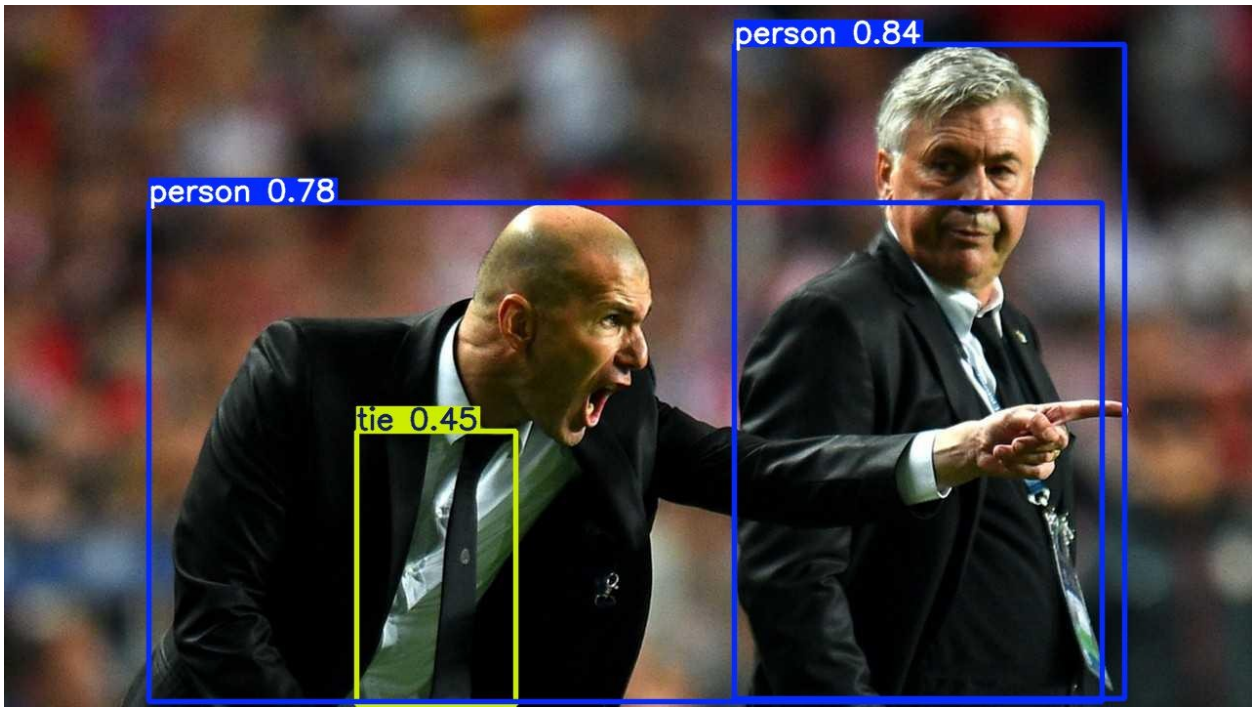
```
Creating new Ultralytics Settings v0.0.6 file □
View Ultralytics Settings with 'yolo settings' or at
'/root/.config/Ultralytics/settings.json'
Update Settings with 'yolo settings key=value', i.e. 'yolo settings
runs_dir=path/to/dir'. For help see
https://docs.ultralytics.com/quickstart/#ultralytics-settings.
Downloading
https://github.com/ultralytics/assets/releases/download/v8.3.0/yolo11n
.pt to 'yolo11n.pt'...

100%|██████████| 5.35M/5.35M [00:00<00:00, 62.1MB/s]


Downloading https://ultralytics.com/images/zidane.jpg to
'zidane.jpg'...

100%|██████████| 49.2k/49.2k [00:00<00:00, 4.73MB/s]

image 1/1 /content/zidane.jpg: 384x640 2 persons, 1 tie, 364.4ms
Speed: 18.1ms preprocess, 364.4ms inference, 38.9ms postprocess per
image at shape (1, 3, 384, 640)
```



Task 2: Dataset Preparation & Preprocessing Objective: Load and preprocess a dataset for object detection.

Instructions:

Choose a Dataset – Use COCO, Pascal VOC, or a custom dataset. Annotate Images – If using a custom dataset, label objects using Roboflow or LabelImg. Convert Annotations – Use Roboflow to export the dataset in YOLO format. Download the Dataset – Use the Roboflow API to fetch the dataset. Split the Dataset – Divide into train (80%), validation (10%), and test (10%). Expected Outcome: A well-structured dataset in YOLO format.

```
!pip install roboflow
```

```
Requirement already satisfied: roboflow in
/usr/local/lib/python3.11/dist-packages (1.1.58)
Requirement already satisfied: certifi in
/usr/local/lib/python3.11/dist-packages (from roboflow) (2025.1.31)
Requirement already satisfied: idna==3.7 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (3.7)
Requirement already satisfied: cycler in
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Requirement already satisfied: kiwisolver>=1.3.1 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (1.4.8)
Requirement already satisfied: matplotlib in
/usr/local/lib/python3.11/dist-packages (from roboflow) (3.10.0)
Requirement already satisfied: numpy>=1.18.5 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (2.0.2)
Requirement already satisfied: opencv-python-headless==4.10.0.84 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (4.10.0.84)
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Requirement already satisfied: Pillow>=7.1.2 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (11.1.0)
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/usr/local/lib/python3.11/dist-packages (from roboflow) (0.22.0)
Requirement already satisfied: python-dateutil in
/usr/local/lib/python3.11/dist-packages (from roboflow) (2.8.2)
Requirement already satisfied: python-dotenv in
/usr/local/lib/python3.11/dist-packages (from roboflow) (1.1.0)
Requirement already satisfied: requests in
/usr/local/lib/python3.11/dist-packages (from roboflow) (2.32.3)
Requirement already satisfied: six in /usr/local/lib/python3.11/dist-
packages (from roboflow) (1.17.0)
Requirement already satisfied: urllib3>=1.26.6 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (2.3.0)
Requirement already satisfied: tqdm>=4.41.0 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (4.67.1)
Requirement already satisfied: PyYAML>=5.3.1 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (6.0.2)
Requirement already satisfied: requests-toolbelt in
/usr/local/lib/python3.11/dist-packages (from roboflow) (1.0.0)
Requirement already satisfied: filetype in
/usr/local/lib/python3.11/dist-packages (from roboflow) (1.2.0)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.11/dist-packages (from matplotlib->roboflow)
(1.3.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.11/dist-packages (from matplotlib->roboflow)
(4.56.0)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.11/dist-packages (from matplotlib->roboflow)
(24.2)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.11/dist-packages (from matplotlib->roboflow)
(3.2.1)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.11/dist-packages (from requests->roboflow)
(3.4.1)

from roboflow import Roboflow

rf = Roboflow(api_key="Z36dR2kczFGORe8fzTeh")

project = rf.workspace("roboflow-100").project("vehicles-q0x2v")

loading Roboflow workspace...
loading Roboflow project...

dataset = project.version(1).download("yolov11")

Downloading Dataset Version Zip in vehicles-1 to yolov11:: 100%|
██████████| 217401/217401 [00:04<00:00, 47393.81it/s]
```

```
Extracting Dataset Version Zip to vehicles-1 in yolov11:: 100%|
██████████| 8128/8128 [00:04<00:00, 1933.94it/s]
```

```
import os
dataset_path = "/content/vehicles-1"
print(os.listdir(dataset_path))
```

```
['train', 'data.yaml', 'valid', 'test', 'README.roboflow.txt',
'README.dataset.txt']
```

```
yaml_path = "/content/vehicles-1/data.yaml"

with open(yaml_path, "r") as file:
    print(file.read())
```

```
train: ../train/images
val: ../valid/images
test: ../test/images

nc: 12
names: ['big bus', 'big truck', 'bus-l-', 'bus-s-', 'car', 'mid
truck', 'small bus', 'small truck', 'truck-l-', 'truck-m-', 'truck-
s-', 'truck-xl-']

roboflow:
  workspace: roboflow-100
  project: vehicles-q0x2v
  version: 1
  license: CC BY 4.0
  url:
https://universe.roboflow.com/roboflow-100/vehicles-q0x2v/dataset/1
```

```
import yaml

# Load and update YAML file with correct paths
with open(yaml_path, "r") as file:
    data = yaml.safe_load(file)

correct_paths = {
    "train": "/content/vehicles-1/train",
    "val": "/content/vehicles-1/valid",
    "test": "/content/vehicles-1/test"
}

data.update(correct_paths)

with open(yaml_path, "w") as file:
    yaml.dump(data, file, default_flow_style=False)
```

```
print("✅ data.yaml paths have been updated successfully!")
```

```
✅ data.yaml paths have been updated successfully!
```

```
with open(yaml_path, "r") as file:
    print(file.read())
```

```
train: ../train/images
val: ../valid/images
test: ../test/images

nc: 12
names: ['big bus', 'big truck', 'bus-l-', 'bus-s-', 'car', 'mid
truck', 'small bus', 'small truck', 'truck-l-', 'truck-m-', 'truck-
s-', 'truck-xl-']

roboflow:
  workspace: roboflow-100
  project: vehicles-q0x2v
  version: 1
  license: CC BY 4.0
  url:
https://universe.roboflow.com/roboflow-100/vehicles-q0x2v/dataset/1
```

```
# Check GPU availability
import torch
print(torch.cuda.is_available())  # Should print True if GPU is
available
print(torch.cuda.device_count())  # Number of GPUs available
print(torch.cuda.get_device_name(0) if torch.cuda.is_available() else
"No GPU detected")
```

```
False
0
No GPU detected
```

```
from ultralytics import YOLO

model = YOLO("yolo11n.pt")
results = model.train(
    data="/content/vehicles-1/data.yaml",
    epochs=5,
    batch=8,
    device='cpu'  # Use GPU
)
```

```
Ultralytics 8.3.96 🚀 Python-3.11.11 torch-2.6.0+cu124 CPU (Intel Xeon
2.20GHz)
engine/trainer: task=detect, mode=train, model=yolo11n.pt,
data=/content/vehicles-1/data.yaml, epochs=5, time=None, patience=100,
```

```
batch=8, imgsz=640, save=True, save_period=-1, cache=False,
device=cpu, 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=True, opset=None,
workspace=None, 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,
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, copy_paste_mode=flip,
auto_augment=randaugment, erasing=0.4, crop_fraction=1.0, cfg=None,
tracker=botsort.yaml, save_dir=runs/detect/train
Downloading https://ultralytics.com/assets/Arial.ttf to
'/root/.config/Ultralytics/Arial.ttf'...

100%|██████████| 755k/755k [00:00<00:00, 14.0MB/s]

Overriding model.yaml nc=80 with nc=12

                   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      6640
ultralytics.nn.modules.block.C3k2            [32, 64, 1, False, 0.25]

  3                  -1  1     36992  ultralytics.nn.modules.conv.Conv
[64, 64, 3, 2]
  4                  -1  1     26080
ultralytics.nn.modules.block.C3k2            [64, 128, 1, False, 0.25]

  5                  -1  1    147712  ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]
  6                  -1  1     87040
ultralytics.nn.modules.block.C3k2            [128, 128, 1, True]

  7                  -1  1    295424  ultralytics.nn.modules.conv.Conv
[128, 256, 3, 2]
```

```
  8                  -1  1    346112
ultralytics.nn.modules.block.C3k2            [256, 256, 1, True]

  9                  -1  1    164608
ultralytics.nn.modules.block.SPPF            [256, 256, 5]

 10                  -1  1    249728
ultralytics.nn.modules.block.C2PSA           [256, 256, 1]

 11                  -1  1         0
torch.nn.modules.upsampling.Upsample         [None, 2, 'nearest']

 12             [-1, 6]  1         0
ultralytics.nn.modules.conv.Concat           [1]

 13                  -1  1    111296
ultralytics.nn.modules.block.C3k2            [384, 128, 1, False]

 14                  -1  1         0
torch.nn.modules.upsampling.Upsample         [None, 2, 'nearest']

 15             [-1, 4]  1         0
ultralytics.nn.modules.conv.Concat           [1]

 16                  -1  1     32096
ultralytics.nn.modules.block.C3k2            [256, 64, 1, False]

 17                  -1  1     36992  ultralytics.nn.modules.conv.Conv
[64, 64, 3, 2]
 18            [-1, 13]  1         0
ultralytics.nn.modules.conv.Concat           [1]

 19                  -1  1     86720
ultralytics.nn.modules.block.C3k2            [192, 128, 1, False]

 20                  -1  1    147712  ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]
 21            [-1, 10]  1         0
ultralytics.nn.modules.conv.Concat           [1]

 22                  -1  1    378880
ultralytics.nn.modules.block.C3k2            [384, 256, 1, True]

 23        [16, 19, 22]  1    433012
ultralytics.nn.modules.head.Detect           [12, [64, 128, 256]]

YOLO11n summary: 181 layers, 2,592,180 parameters, 2,592,164
gradients, 6.5 GFLOPs

Transferred 448/499 items from pretrained weights
TensorBoard: Start with 'tensorboard --logdir runs/detect/train', view
```

```
at http://localhost:6006/
Freezing layer 'model.23.dfl.conv.weight'

train: Scanning /content/vehicles-1/train/labels... 2634 images, 1
backgrounds, 0 corrupt: 100%|██████████| 2634/2634 [00:01<00:00,
1442.60it/s]

train: WARNING ⚠ /content/vehicles-1/train/images/adit_mp4-
1357_jpg.rf.cd42ad897bad30838e19f2c8d67fcbf2.jpg: 2 duplicate labels
removed



train: New cache created: /content/vehicles-1/train/labels.cache
albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01,
blur_limit=(3, 7)), ToGray(p=0.01, num_output_channels=3,
method='weighted_average'), CLAHE(p=0.01, clip_limit=(1.0, 4.0),
tile_grid_size=(8, 8))

val: Scanning /content/vehicles-1/valid/labels... 966 images, 3
backgrounds, 0 corrupt: 100%|██████████| 966/966 [00:00<00:00,
1818.68it/s]

val: New cache created: /content/vehicles-1/valid/labels.cache



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=0.000625, momentum=0.9) with parameter groups 81
weight(decay=0.0), 88 weight(decay=0.0005), 87 bias(decay=0.0)
TensorBoard: model graph visualization added □
Image sizes 640 train, 640 val
Using 0 dataloader workers
Logging results to runs/detect/train
Starting training for 5 epochs...

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size

        1/5         0G       1.48      2.724       1.14         16
640: 100%|██████████| 330/330 [38:14<00:00,  6.95s/it]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100%|██████████| 61/61 [06:14<00:00,  6.13s/it]

                   all        966      13450      0.312      0.307
0.171        0.1

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
```

```
        2/5         0G      1.365      1.577      1.103         30
640: 100%|██████████| 330/330 [37:49<00:00,  6.88s/it]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100%|██████████| 61/61 [05:48<00:00,  5.71s/it]

                   all        966      13450      0.377      0.351
0.227       0.14

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size

        3/5         0G      1.323       1.42      1.089         34
640: 100%|██████████| 330/330 [37:49<00:00,  6.88s/it]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100%|██████████| 61/61 [05:53<00:00,  5.79s/it]

                   all        966      13450      0.473      0.361
0.313      0.204

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size

        4/5         0G      1.296      1.322      1.082         42
640: 100%|██████████| 330/330 [38:21<00:00,  6.97s/it]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100%|██████████| 61/61 [05:40<00:00,  5.58s/it]

                   all        966      13450      0.427       0.42
0.346      0.229

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size

        5/5         0G      1.263      1.227      1.066         66
640: 100%|██████████| 330/330 [37:34<00:00,  6.83s/it]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100%|██████████| 61/61 [05:33<00:00,  5.47s/it]

                   all        966      13450      0.443      0.453
0.349      0.234

5 epochs completed in 3.654 hours.
Optimizer stripped from runs/detect/train/weights/last.pt, 5.5MB
Optimizer stripped from runs/detect/train/weights/best.pt, 5.5MB

Validating runs/detect/train/weights/best.pt...
Ultralytics 8.3.96 □ Python-3.11.11 torch-2.6.0+cu124 CPU (Intel Xeon
2.20GHz)
YOLO11n summary (fused): 100 layers, 2,584,492 parameters, 0
gradients, 6.3 GFLOPs
```

```
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100%|██████████| 61/61 [04:29<00:00,  4.42s/it]

                   all        966      13450      0.443      0.453
0.349      0.233
               big bus        210        273      0.705      0.608
0.701      0.521
             big truck        404       1162       0.69       0.42
0.588       0.35
                bus-l-          8          8     0.0143        0.5
0.0111    0.00494
                bus-s-         12         12          1          0
0.0031    0.00257
                   car        927       8537      0.799      0.772
0.819       0.46
             mid truck        118        257      0.399     0.0934
0.126      0.097
             small bus         43         49          0          0
0.01     0.0072
           small truck        517       1721      0.629      0.513
0.574      0.338
              truck-l-        266        433      0.309      0.617
0.38      0.285
              truck-m-        331        629      0.271      0.781
0.38      0.283
              truck-s-        147        221      0.175      0.498
0.186      0.132
             truck-xl-        110        148      0.325      0.628
0.411       0.32
Speed: 5.7ms preprocess, 259.2ms inference, 0.0ms loss, 4.7ms
postprocess per image
Results saved to runs/detect/train

# Save the trained model weights
best_model_path = "/content/runs/detect/train/weights/best.pt"
print(f"Model training complete. Best model saved at:
{best_model_path}")

Model training complete. Best model saved at:
/content/runs/detect/train/weights/best.pt
```

Task 4: Model Inference and Evaluation

```
# Load the trained model
model = YOLO(best_model_path)
```

```
image_path = "/content/vehicles-1/test/images/adit_mp4-
815_jpg.rf.fb532f30f712174b620afee0cfb1bfbb.jpg"
results = model(image_path, save=True, conf=0.5)
```

```
image 1/1 /content/vehicles-1/test/images/adit_mp4-
815_jpg.rf.fb532f30f712174b620afee0cfb1bfbb.jpg: 640x640 3 cars, 1
truck-m-, 376.4ms
Speed: 5.6ms preprocess, 376.4ms inference, 7.0ms postprocess per
image at shape (1, 3, 640, 640)
Results saved to runs/detect/predict
```

```
for result in results:
    result.show()
```


```
# Evaluate the model performance
metrics = model.val()

map_50 = metrics.box.map50  # mAP@50
map_50_95 = metrics.box.map  # mAP@50-95
precision = metrics.box.p.mean().item() if metrics.box.p.size > 0 else
0.0
recall = metrics.box.r.mean().item() if metrics.box.r.size > 0 else
0.0

print(f"\U0001F4CA mAP@50: {map_50:.4f}")
print(f"\U0001F4CA mAP@50-95: {map_50_95:.4f}")
```

```
print(f"\U0001F4C8 Precision: {precision:.4f}")
print(f"\U0001F4C9 Recall: {recall:.4f}")

if precision + recall > 0:
    f1_score = 2 * (precision * recall) / (precision + recall)
    print(f"\U0001F525 F1 Score: {f1_score:.4f}")
else:
    print("⚠ Cannot compute F1 Score (Precision + Recall = 0)")
```

```
Ultralytics 8.3.96 □ Python-3.11.11 torch-2.6.0+cu124 CPU (Intel Xeon
2.20GHz)

val: Scanning /content/vehicles-1/valid/labels.cache... 966 images, 3
backgrounds, 0 corrupt: 100%|██████████| 966/966 [00:00<?, ?it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100%|██████████| 61/61 [04:42<00:00,  4.63s/it]

                   all        966      13450      0.443      0.453
0.349      0.233
               big bus        210        273      0.705      0.608
0.701      0.521
             big truck        404       1162       0.69       0.42
0.588       0.35
                bus-l-          8          8     0.0143        0.5
0.0111    0.00494
                bus-s-         12         12          1          0
0.0031    0.00257
                   car        927       8537      0.799      0.772
0.819       0.46
             mid truck        118        257      0.399     0.0934
0.126      0.097
             small bus         43         49          0          0
0.01     0.0072
           small truck        517       1721      0.629      0.513
0.574      0.338
              truck-l-        266        433      0.309      0.617
0.38      0.285
              truck-m-        331        629      0.271      0.781
0.38      0.283
              truck-s-        147        221      0.175      0.498
0.186      0.132
             truck-xl-        110        148      0.325      0.628
0.411       0.32
Speed: 4.9ms preprocess, 272.9ms inference, 0.0ms loss, 4.7ms
postprocess per image
Results saved to runs/detect/val4
□ mAP@50: 0.3491
□ mAP@50-95: 0.2334
□ Precision: 0.4430
```

```
 Recall: 0.4525
 F1 Score: 0.4477

for result in results:
    result.show()
```

Conclusion:-

The project "Vehicle Detection for Smart Traffic Management using YOLOv11" successfully implemented real-time object detection to identify vehicles such as cars, buses, and auto-rickshaws. The model demonstrated strong precision, indicating high confidence in its predictions. However, recall was relatively lower, highlighting missed detections.

Challenges were observed in detecting specific violations like helmet and no-helmet detection, which suggests the need for additional training data and optimized hyperparameters. Future improvements could focus on data augmentation, fine-tuning the YOLOv11 model, and exploring alternative architectures to enhance overall detection accuracy.

This project provides a foundational framework for automated traffic monitoring and violation detection, which can be further refined for real-world deployment in smart city applications.

Declaration

I, Shravani Sakore, confirm that the work submitted in this assignment is my own and has been completed following academic integrity guidelines. The code is uploaded on my GitHub repository account, and the repository link is provided below: GitHub Repository Link: https://github.com/shravanisakore/Vehicle-Detection-for-Smart-Traffic-Management-using-YOLOv11

Signature: Shravani Sakore