Google Colab Lab Assignment -YOLO 11 Model

Course Name: MDM Deep Learning

Lab Title: YOLOv11 for object detection on the COCO dataset

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Date of Submission: 17/03/2025

Group Members:

1. Yashas Nepalia
2. Rohan Magdum
3. **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.

Steps:

1. **Install Python Libraries:**
   Install required libraries using pip: roboflow and ultralytics (which includes PyTorch, OpenCV, etc.).

In [ ]:

```
# Install roboflow and ultralytics

!pip install roboflow

!pip install ultralytics
```

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 /usr/local/lib/python3.11/dist-packages (from roboflow) (0.12.1)

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)

Requirement already satisfied: Pillow>=7.1.2 in /usr/local/lib/python3.11/dist-packages (from roboflow) (11.1.0)

Requirement already satisfied: pillow-heif>=0.18.0 in /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) (1.0.1)

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)

Requirement already satisfied: ultralytics in /usr/local/lib/python3.11/dist-packages (8.3.94)

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 /usr/local/lib/python3.11/dist-packages (from ultralytics) (3.10.0)

Requirement already satisfied: opencv-python>=4.6.0 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (4.11.0.86)

Requirement already satisfied: pillow>=7.1.2 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (11.1.0)

Requirement already satisfied: pyyaml>=5.3.1 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (6.0.2)

Requirement already satisfied: requests>=2.23.0 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (2.32.3)

Requirement already satisfied: scipy>=1.4.1 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (1.14.1)

Requirement already satisfied: torch>=1.8.0 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (2.6.0+cu124)

Requirement already satisfied: torchvision>=0.9.0 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (0.21.0+cu124)

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Requirement already satisfied: psutil in /usr/local/lib/python3.11/dist-packages (from ultralytics) (5.9.5)

Requirement already satisfied: py-cpuinfo in /usr/local/lib/python3.11/dist-packages (from ultralytics) (9.0.0)

Requirement already satisfied: pandas>=1.1.4 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (2.2.2)

Requirement already satisfied: seaborn>=0.11.0 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (0.13.2)

Requirement already satisfied: ultralytics-thop>=2.0.0 in /usr/local/lib/python3.11/dist-packages (from ultralytics) (2.0.14)

Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib>=3.3.0->ultralytics) (1.3.1)

Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.11/dist-packages (from matplotlib>=3.3.0->ultralytics) (0.12.1)

Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib>=3.3.0->ultralytics) (4.56.0)

Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib>=3.3.0->ultralytics) (1.4.8)

Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib>=3.3.0->ultralytics) (24.2)

Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib>=3.3.0->ultralytics) (3.2.1)

Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.11/dist-packages (from matplotlib>=3.3.0->ultralytics) (2.8.2)

Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.11/dist-packages (from pandas>=1.1.4->ultralytics) (2025.1)

Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.11/dist-packages (from pandas>=1.1.4->ultralytics) (2025.1)

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Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dist-packages (from requests>=2.23.0->ultralytics) (3.7)

Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.11/dist-packages (from requests>=2.23.0->ultralytics) (2.3.0)

Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.11/dist-packages (from requests>=2.23.0->ultralytics) (2025.1.31)

Requirement already satisfied: filelock in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (3.17.0)

Requirement already satisfied: typing-extensions>=4.10.0 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (4.12.2)

Requirement already satisfied: networkx in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (3.4.2)

Requirement already satisfied: jinja2 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (3.1.6)

Requirement already satisfied: fsspec in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (2024.10.0)

Requirement already satisfied: nvidia-cuda-nvrtc-cu12==12.4.127 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (12.4.127)

Requirement already satisfied: nvidia-cuda-runtime-cu12==12.4.127 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (12.4.127)

Requirement already satisfied: nvidia-cuda-cupti-cu12==12.4.127 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (12.4.127)

Requirement already satisfied: nvidia-cudnn-cu12==9.1.0.70 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (9.1.0.70)

Requirement already satisfied: nvidia-cublas-cu12==12.4.5.8 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (12.4.5.8)

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Requirement already satisfied: nvidia-nccl-cu12==2.21.5 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (2.21.5)

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Requirement already satisfied: nvidia-nvjitlink-cu12==12.4.127 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (12.4.127)

Requirement already satisfied: triton==3.2.0 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->ultralytics) (3.2.0)

Requirement already satisfied: sympy==1.13.1 in /usr/local/lib/python3.11/dist-packages (from torch>=1.8.0->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)

Task 2: Dataset Preparation & Preprocessing

Objective:
Load and preprocess a dataset for object detection.

Steps:

1. **Dataset Acquisition:**
    - Use Roboflow to download the COCO dataset (version 34) in YOLOv11 format.
    - Utilize your API key and select the Microsoft workspace.

In [ ]:

```
from roboflow import Roboflow

# Initialize Roboflow with your API key
rf = Roboflow(api_key="sLpQp9tNRxVlPd1zmIqo")

# Load COCO dataset (version 34) from Microsoft workspace
project = rf.workspace("microsoft").project("coco")
version = project.version(34)
dataset = version.download("yolov11")
```

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

2. **Dataset Structure and Preprocessing:**
    - Verify that the dataset has been downloaded with the expected directory structure (train/, valid/, and test/ folders containing images and labels).
    - Confirm that annotations are in the correct YOLO format.

In [ ]:

```
import os

# List files to confirm dataset download
!ls -R /content/COCO-Dataset-34
```

```
/content/COCO-Dataset-34:
data.yaml  README.dataset.txt  README.roboflow.txt  test  train  valid
```

/content/COCO-Dataset-34/test:

images labels

/content/COCO-Dataset-34/test/images:

000000005345_jpg.rf.48e7947456159d44cbe1a733ad832bf1.jpg

000000005425_jpg.rf.96fb87ccc22e6e81c6a800fc4a1210dd.jpg

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/content/COCO-Dataset-34/test/labels:

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/content/COCO-Dataset-34/train:

images labels labels.cache

/content/COCO-Dataset-34/train/images:

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000000009400_jpg.rf.1926c92326b48f77b8b081169668c44e.txt

000000009845_jpg.rf.e229e70f09239f18efbf68ae064b7247.txt

000000011122_jpg.rf.bfc38911a4f880cee0cffa41f275837a.txt

000000012933_jpg.rf.e98d33ed492106c2d80d711bef83d5ce.txt

000000013524_jpg.rf.62e7b283211f3fd55bcf1e1364cc3812.txt

000000014044_jpg.rf.705d3b529479a1a99ddc4bbc78f156ae.txt

000000015002_jpg.rf.81315262e3826c263eeb98454c9915ea.txt

000000015690_jpg.rf.3adbdfb64b57e251c0339af16d13a075.txt

000000017778_jpg.rf.dea0f3c966f432e6e0b2198ddb78640f.txt

000000018290_jpg.rf.0beefa821825a6188aaa43dc0bccb94c.txt

000000018614_jpg.rf.3bb733baf94efba3e208c14748f687ef.txt

000000018728_jpg.rf.5be59d76b01d5c9ed7919c7919ada9c8.txt

000000020291_jpg.rf.86880a9523e87511712bc976ff7eade7.txt

000000021248_jpg.rf.768f85b6c4bf2f060d08d1d5bf676a48.txt

000000021353_jpg.rf.ac4c8d046e14d5baca46987ce66f3756.txt

000000022199_jpg.rf.336aff9c0ebafa13dfbae4efbebe9763.txt

000000022229_jpg.rf.63c40b56ea6ca8600bd0d301d7143a25.txt

000000022526_jpg.rf.8f54e5a73f964df75a7b06d772fa2a50.txt

000000024023_jpg.rf.3a5cda5ea8eedddcbd1d90999ccf2321.txt

000000024980_jpg.rf.5beded38714f45bc2f04d51417b552d0.txt

000000026310_jpg.rf.e333707ea808eae6bc759e7a45e32bd9.txt

000000027246_jpg.rf.2470a0fe8d3deaa9647327a4601ba80b.txt

000000029482_jpg.rf.f37a043f6006625b4a189a2d2196da8d.txt

000000029715_jpg.rf.1539158c462c1ec6a3494478c803cd64.txt

000000030519_jpg.rf.469e348276c997d2c67f1d0e16286e09.txt

000000031373_jpg.rf.7092d7fbf231700030682dd72b7b1ab0.txt

000000032720_jpg.rf.13aa2ce4375761c6a534e259ef419695.txt

000000032990_jpg.rf.bdc9882221cf6630d933b3b48cd7d511.txt

000000034489_jpg.rf.656d672eff71374a5577fd086f4ba724.txt

000000034702_jpg.rf.d91a68a75b16b3ae997e72b5f1411d68.txt

000000035318_jpg.rf.583328d907b37e5b4c297b0b9d911baa.txt

000000035351_jpg.rf.dada74c3812da496ac2cd96746f7bec1.txt

000000037437_jpg.rf.c5d2023789cc50088a4402e52c1e0422.txt

000000039468_jpg.rf.ae709a23f600bbd9e6b23defce534bdb.txt

000000039993_jpg.rf.832d479e79fd38925415503344b6b9e1.txt

000000040658_jpg.rf.ce3b384940c0dd675926320a52d2c336.txt

000000043270_jpg.rf.9e594cfd7829a43be8d233bf6279c3ce.txt

000000043813_jpg.rf.cc5e5901986576a4746d9b3edb2079bb.txt

000000044946_jpg.rf.af6c86f6999b30246bdced6d684a50ce.txt

000000045148_jpg.rf.e551e6c88648e955043cba5143a3d31a.txt

000000047619_jpg.rf.4ba17653fd252aea9d043ebdbea40f29.txt

000000049135_jpg.rf.cd7b7ef54ac9a9cf445bb06753e53966.txt

000000050727_jpg.rf.924ab9fa11edc6d0a091e9747b51cf7d.txt

000000126137_jpg.rf.8a875933888aa097e28a4beed3773aa6.txt

Outcome:

- A well-organized dataset (COCO in YOLOv11 format) ready for training.

Task 3: Training YOLOv11 Model

Objective:
Train YOLOv11 on the prepared dataset.

Steps:

1. **Model Initialization:**
    - Load the YOLOv11 model using the pre-trained weights file (e.g., yolo11n.pt).

In [ ]:

```
from ultralytics import YOLO

# Load YOLOv11 model with pretrained weights
model = YOLO('yolo11n.pt')  # Load YOLOv11 pretrained model

# training parameters
batch_size = 16
epochs = 50
learning_rate = 0.001
```

2. **Set Training Parameters:**
    - Configure key parameters such as epochs, batch size, and lr0 (initial learning rate).
3. **Monitoring Training:**
    - Watch for improvements in loss, mAP, and other metrics as the training progresses.
    - Save the best model weights for further inference.

In [ ]:

```
results = model.train(
   data='/content/COCO-Dataset-34/data.yaml',  # Path to data.yaml
   epochs=50,              # Number of epochs
   batch=16,               # Batch size
   lr0=0.001,              # Learning rate
   imgsz=640               # Input size
)
```

Ultralytics 8.3.94 🚀 Python-3.11.11 torch-2.6.0+cu124 CUDA:0 (Tesla T4, 15095MiB)

engine/trainer: task=detect, mode=train, model=yolo11n.pt, data=/content/COCO-Dataset-34/data.yaml, epochs=50, time=None, patience=100, batch=16, imgsz=640, save=True, save_period=-1, cache=False, device=None, workers=8, project=None, name=train3, 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=0.001, 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/train3

Overriding model.yaml nc=80 with nc=78

	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	462024	ultralytics.nn.modules.head.Detect	[78, [64, 128, 256]]

YOLO11n summary: 181 layers, 2,621,192 parameters, 2,621,176 gradients, 6.6 GFLOPs

Transferred 448/499 items from pretrained weights

TensorBoard: Start with 'tensorboard --logdir runs/detect/train3', view at http://localhost:6006/

Freezing layer 'model.23.dfl.conv.weight'

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

AMP: checks passed ✅

train: Scanning /content/COCO-Dataset-34/train/labels.cache... 135 images, 3 backgrounds, 0 corrupt: 100%|[redacted]| 135/135 [00:00<?, ?it/s]

albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01, blur_limit=(3, 7)), ToGray(p=0.01, 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/COCO-Dataset-34/valid/labels.cache... 55 images, 0 backgrounds, 0 corrupt: 100%|[redacted]| 55/55 [00:00<?, ?it/s]

Plotting labels to runs/detect/train3/labels.jpg...

optimizer: 'optimizer=auto' found, ignoring 'lr0=0.001' and 'momentum=0.937' and determining best 'optimizer', 'lr0' and 'momentum' automatically...

optimizer: AdamW(lr=0.000122, 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 2 dataloader workers

Logging results to **runs/detect/train3**

Starting training for 50 epochs...

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

1/50 2.63G 1.112 4.977 1.175 100 640: 100%|[redacted]| 9/9 [00:04<00:00, 2.13it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|[redacted]| 2/2 [00:00<00:00, 3.81it/s]

all 55 397 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

2/50 3.46G 1.096 4.94 1.153 74 640: 100%|[redacted]| 9/9 [00:03<00:00, 2.44it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|[redacted]| 2/2 [00:00<00:00, 4.19it/s]

all 55 397 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

3/50 3.48G 1.047 4.898 1.159 56 640: 100%|[redacted]| 9/9 [00:02<00:00, 3.59it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.71it/s]

all 55 397 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

4/50 3.48G 1.072 4.929 1.145 33 640: 100%|██████████| 9/9 [00:02<00:00, 3.65it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.57it/s]

all 55 397 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

5/50 3.49G 1.104 4.903 1.134 79 640: 100%|██████████| 9/9 [00:04<00:00, 2.13it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.45it/s]

all 55 397 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

6/50 3.5G 1.11 4.877 1.15 56 640: 100%|██████████| 9/9 [00:02<00:00, 3.68it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.94it/s]

all 55 397 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

7/50 3.5G 1.064 4.817 1.134 74 640: 100%|██████████| 9/9 [00:02<00:00, 3.59it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.57it/s]

all 55 397 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

8/50 3.5G 1.054 4.754 1.118 56 640: 100%|██████████| 9/9 [00:02<00:00, 3.11it/s]

Class Images Instances Box(P R mAP50 mAP50-95):
100%|██████████| 2/2 [00:00<00:00, 2.17it/s]

all 55 397 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

9/50 3.5G 1.121 4.736 1.126 95 640: 100%|██████████| 9/9
[00:02<00:00, 3.69it/s]

Class Images Instances Box(P R mAP50 mAP50-95):
100%|██████████| 2/2 [00:00<00:00, 3.86it/s]

all 55 397 0.0175 0.000335 0.00894 0.00864

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

10/50 3.5G 1.023 4.651 1.121 43 640: 100%|██████████| 9/9
[00:02<00:00, 3.82it/s]

Class Images Instances Box(P R mAP50 mAP50-95):
100%|██████████| 2/2 [00:00<00:00, 3.07it/s]

all 55 397 0.0156 0.000894 0.0083 0.00747

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

11/50 3.5G 1.074 4.664 1.14 87 640: 100%|██████████| 9/9
[00:02<00:00, 3.91it/s]

Class Images Instances Box(P R mAP50 mAP50-95):
100%|██████████| 2/2 [00:00<00:00, 2.66it/s]

all 55 397 0.0373 0.0353 0.0366 0.0354

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

12/50 3.5G 1.041 4.579 1.126 43 640: 100%|██████████| 9/9
[00:03<00:00, 2.84it/s]

Class Images Instances Box(P R mAP50 mAP50-95):
100%|██████████| 2/2 [00:00<00:00, 3.27it/s]

all 55 397 0.0333 0.073 0.0486 0.0466

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

13/50 3.5G 1.038 4.534 1.098 69 640: 100%|██████████| 9/9
[00:02<00:00, 3.69it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|| 2/2 [00:00<00:00, 3.24it/s]

all 55 397 0.0256 0.086 0.052 0.0496

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

14/50 3.5G 1.157 4.508 1.149 107 640: 100%| 9/9 [00:02<00:00, 3.74it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 3.12it/s]

all 55 397 0.0277 0.109 0.0551 0.0519

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

15/50 3.5G 1.087 4.44 1.127 94 640: 100%| 9/9 [00:03<00:00, 2.94it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:01<00:00, 1.67it/s]

all 55 397 0.0194 0.11 0.0529 0.0499

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

16/50 3.5G 1.104 4.412 1.123 82 640: 100%| 9/9 [00:02<00:00, 3.76it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 2.77it/s]

all 55 397 0.0224 0.128 0.0587 0.0529

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

17/50 3.5G 1.119 4.377 1.158 64 640: 100%| 9/9 [00:02<00:00, 3.87it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 2.79it/s]

all 55 397 0.0219 0.136 0.055 0.0484

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

18/50 3.52G 1.106 4.336 1.109 88 640: 100%| 9/9 [00:02<00:00, 3.66it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.31it/s]

all 55 397 0.022 0.153 0.0596 0.0507

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

19/50 3.53G 1.083 4.27 1.131 43 640: 100%|██████████| 9/9 [00:02<00:00, 3.03it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.80it/s]

all 55 397 0.0212 0.165 0.0636 0.0535

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

20/50 3.55G 1.072 4.222 1.105 93 640: 100%|██████████| 9/9 [00:02<00:00, 3.73it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.61it/s]

all 55 397 0.0195 0.187 0.0652 0.0552

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

21/50 3.55G 1.069 4.188 1.138 63 640: 100%|██████████| 9/9 [00:02<00:00, 3.61it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.47it/s]

all 55 397 0.0199 0.203 0.0593 0.048

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

22/50 3.55G 1.041 4.161 1.114 76 640: 100%|██████████| 9/9 [00:03<00:00, 2.77it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.54it/s]

all 55 397 0.0202 0.22 0.0693 0.0573

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

23/50 3.55G 1.082 4.15 1.15 103 640: 100%|██████████| 9/9 [00:02<00:00, 3.62it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|| 2/2 [00:00<00:00, 3.04it/s]

all 55 397 0.0201 0.233 0.0723 0.0602

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

24/50 3.55G 1.067 4.144 1.117 80 640: 100%| 9/9 [00:02<00:00, 3.79it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 2.93it/s]

all 55 397 0.02 0.249 0.07 0.0584

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

25/50 3.55G 1.077 3.985 1.119 69 640: 100%| 9/9 [00:02<00:00, 3.43it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:01<00:00, 1.81it/s]

all 55 397 0.0197 0.264 0.0707 0.0589

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

26/50 3.58G 1.074 3.983 1.125 40 640: 100%| 9/9 [00:02<00:00, 3.42it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 3.54it/s]

all 55 397 0.0205 0.276 0.0723 0.0605

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

27/50 3.58G 1.049 3.954 1.104 48 640: 100%| 9/9 [00:02<00:00, 3.74it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 2.92it/s]

all 55 397 0.02 0.261 0.0724 0.0608

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

28/50 3.58G 1.087 3.86 1.145 52 640: 100%| 9/9 [00:02<00:00, 3.69it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|| 2/2 [00:00<00:00, 2.46it/s]

all 55 397 0.525 0.0934 0.0733 0.0605

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

29/50 3.58G 1.082 3.802 1.131 39 640: 100%| 9/9 [00:03<00:00, 2.98it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 2.31it/s]

all 55 397 0.55 0.093 0.0746 0.0601

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

30/50 3.58G 1.035 3.831 1.133 44 640: 100%| 9/9 [00:02<00:00, 3.76it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 3.61it/s]

all 55 397 0.529 0.0938 0.0761 0.0609

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

31/50 3.58G 1.067 3.893 1.122 69 640: 100%| 9/9 [00:02<00:00, 3.92it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:00<00:00, 2.77it/s]

all 55 397 0.691 0.074 0.0803 0.0646

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

32/50 3.58G 1.081 3.801 1.13 80 640: 100%| 9/9 [00:03<00:00, 2.86it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%| 2/2 [00:01<00:00, 1.79it/s]

all 55 397 0.693 0.0911 0.0844 0.0657

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

33/50 3.58G 1.008 3.759 1.09 70 640: 100%| 9/9 [00:02<00:00, 3.72it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.12it/s]

all 55 397 0.712 0.0841 0.0845 0.0665

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

34/50 3.58G 1.106 3.739 1.12 66 640: 100%|██████████| 9/9 [00:02<00:00, 3.96it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.51it/s]

all 55 397 0.712 0.0802 0.085 0.0674

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

35/50 3.58G 1.09 3.738 1.119 97 640: 100%|██████████| 9/9 [00:02<00:00, 3.83it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:01<00:00, 1.81it/s]

all 55 397 0.71 0.0802 0.0863 0.0686

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

36/50 3.58G 1.055 3.714 1.115 52 640: 100%|██████████| 9/9 [00:02<00:00, 3.32it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.06it/s]

all 55 397 0.697 0.0849 0.0886 0.0719

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

37/50 3.58G 1.036 3.573 1.095 58 640: 100%|██████████| 9/9 [00:02<00:00, 3.67it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.38it/s]

all 55 397 0.715 0.0852 0.0894 0.0724

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

38/50 3.58G 1.067 3.665 1.149 82 640: 100%|██████████| 9/9 [00:02<00:00, 3.97it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.44it/s]

all 55 397 0.715 0.087 0.0916 0.0717

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

39/50 3.58G 1.002 3.61 1.102 38 640: 100%|██████████| 9/9 [00:03<00:00, 2.74it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.26it/s]

all 55 397 0.72 0.0883 0.1 0.0804

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

40/50 3.58G 1.031 3.618 1.127 53 640: 100%|██████████| 9/9 [00:02<00:00, 3.77it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.48it/s]

all 55 397 0.715 0.0807 0.0999 0.0794

Closing dataloader mosaic

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))

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

41/50 3.58G 1.055 3.485 1.125 47 640: 100%|██████████| 9/9 [00:03<00:00, 2.38it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.27it/s]

all 55 397 0.667 0.0908 0.1 0.0793

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

42/50 3.58G 1.051 3.433 1.112 52 640: 100%|██████████| 9/9 [00:02<00:00, 3.06it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.14it/s]

all 55 397 0.647 0.0912 0.102 0.081

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

43/50 3.58G 1.032 3.408 1.106 49 640: 100%|██████████| 9/9 [00:02<00:00, 4.26it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.30it/s]

all 55 397 0.646 0.105 0.104 0.0823

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

44/50 3.58G 1.044 3.475 1.133 23 640: 100%|██████████| 9/9 [00:02<00:00, 4.09it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.91it/s]

all 55 397 0.649 0.112 0.106 0.084

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

45/50 3.58G 1.06 3.357 1.119 47 640: 100%|██████████| 9/9 [00:02<00:00, 3.88it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:01<00:00, 1.86it/s]

all 55 397 0.648 0.113 0.105 0.0833

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

46/50 3.58G 1.072 3.447 1.126 49 640: 100%|██████████| 9/9 [00:02<00:00, 4.15it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.37it/s]

all 55 397 0.631 0.116 0.105 0.0837

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

47/50 3.58G 1.06 3.341 1.102 42 640: 100%|██████████| 9/9 [00:02<00:00, 4.11it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.24it/s]

all 55 397 0.629 0.115 0.105 0.0838

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

48/50 3.58G 1.052 3.392 1.097 67 640: 100%|██████████| 9/9 [00:02<00:00, 4.00it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.91it/s]

all 55 397 0.629 0.116 0.105 0.0836

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

49/50 3.58G 1.011 3.34 1.116 31 640: 100%|██████████| 9/9 [00:02<00:00, 3.19it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 2.25it/s]

all 55 397 0.611 0.116 0.105 0.084

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size

50/50 3.58G 1.051 3.366 1.114 58 640: 100%|██████████| 9/9 [00:02<00:00, 4.17it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.65it/s]

all 55 397 0.593 0.119 0.106 0.0838

50 epochs completed in 0.055 hours.

Optimizer stripped from runs/detect/train3/weights/last.pt, 5.5MB

Optimizer stripped from runs/detect/train3/weights/best.pt, 5.5MB

Validating runs/detect/train3/weights/best.pt...

Ultralytics 8.3.94 🚀 Python-3.11.11 torch-2.6.0+cu124 CUDA:0 (Tesla T4, 15095MiB)

YOLO11n summary (fused): 100 layers, 2,613,378 parameters, 0 gradients, 6.5 GFLOPs

Class Images Instances Box(P R mAP50 mAP50-95): 100%|██████████| 2/2 [00:00<00:00, 3.03it/s]

all 55 397 0.649 0.111 0.105 0.084

backpack 1 1 0 0 0 0

banana 1 2 1 0 0 0

baseball bat	1	1	1	0	0	0
baseball glove	1	4	1	0	0	0
bench	3	4	0	0	0	0
bicycle	3	3	0	0	0	0
bird	2	4	1	0	0	0
boat	1	1	1	0	0.0585	0.0468
bottle	4	7	0.113	0.429	0.0654	0.0393
bus	3	3	0.196	0.262	0.178	0.178
cake	1	8	1	0	0	0
car	5	13	0.15	0.231	0.186	0.123
cat	2	2	0.442	1	0.663	0.341
cell phone	4	4	1	0	0	0
chair	6	16	0.253	0.0625	0.0619	0.0366
clock	2	2	0.18	0.5	0.126	0.1
couch	1	1	1	0	0	0
cup	4	10	0.708	0.3	0.372	0.243
dining table	6	8	1	0	0.114	0.0852
dog	2	4	0	0	0.0248	0.0154
donut	2	12	1	0	0	0
elephant	2	13	0.309	0.154	0.226	0.188
fire hydrant	3	3	0.888	0.333	0.361	0.323
fork	1	1	1	0	0	0
frisbee	1	1	1	0	0	0
handbag	5	11	1	0	0	0
horse	1	1	0.329	1	0.995	0.995
keyboard	2	7	1	0	0.00807	0.00726
kite	1	3	1	0	0	0
knife	2	3	1	0	0	0

laptop	4	10	1	0	0.224	0.212
microwave	1	4	1	0	0	0
motorcycle	3	4	0	0	0.113	0.104
mouse	3	4	1	0	0	0
oven	1	1	1	0	0	0
person	35	157	0.5	0.516	0.524	0.334
pizza	1	1	0	0	0.199	0.139
potted plant	1	1	1	0	0	0
refrigerator	2	3	0	0	0	0
remote	2	2	1	0	0.0229	0.016
sink	1	1	0.0951	0.476	0.199	0.159
skateboard	2	8	0	0	0.01	0.00903
snowboard	2	2	1	0	0.0286	0.00572
sports ball	2	2	1	0	0	0
stop sign	2	2	1	0	0.0362	0.0245
suitcase	1	1	0	0	0.014	0.00657
surfboard	2	3	1	0	0	0
tennis racket	3	3	1	0	0	0
tie	2	2	1	0	0	0
toilet	1	1	0	0	0	0
traffic light	1	1	1	0	0	0
train	3	6	1	0	0.0786	0.0655
truck	5	8	0.0987	0.0863	0.038	0.0261
tv	4	8	1	0	0.0499	0.0449
umbrella	5	5	1	0	0	0
vase	1	1	0.752	1	0.995	0.895
wine glass	1	3	0	0	0.0383	0.0212

Speed: 0.2ms preprocess, 2.3ms inference, 0.0ms loss, 3.1ms postprocess per image

Results saved to **runs/detect/train3**

Outcome:

- A successfully trained YOLOv11 model with improved detection accuracy and better performance metrics.

Task 4: Model Inference and Evaluation

Objective:
Test the trained model on new images and videos and evaluate its performance.

Steps:

1. **Load Trained Model:**
    - Load the best-performing model weights saved during training.

In [ ]:

```
from ultralytics import YOLO

# Load the trained model weights
model = YOLO('/content/runs/detect/train/weights/best.pt')
```

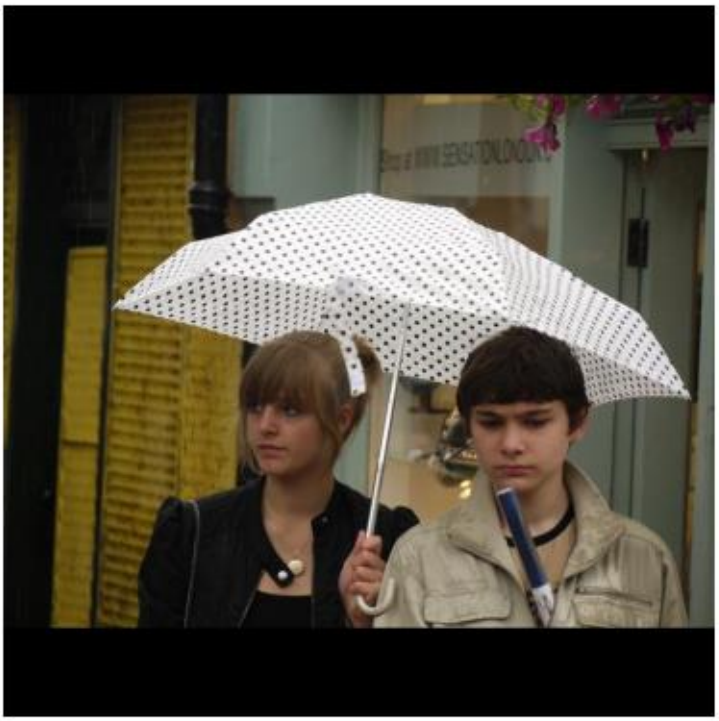
2. **Run Inference:**
    - Choose a test image from the dataset and run the model's prediction.

In [ ]:

```
import cv2
from matplotlib import pyplot as plt
import os

# Path to test images
```

```
test_image_path = '/content/COCO-Dataset-34/test/images/'

# List test images
test_images = os.listdir(test_image_path)

# Run inference on the first test image
img_path = os.path.join(test_image_path, test_images[3])

# Perform inference
results = model.predict(img_path, save=True)

# Display result
img = cv2.imread(img_path)
plt.imshow(cv2.cvtColor(img, cv2.COLOR_BGR2RGB))
plt.axis('off')
plt.show()
```

```
image 1/1 /content/COCO-Dataset-34/test/images/000000025668_jpg.rf.f67afc05b355ac25bef196980e6d7f99.jpg: 640x640 2 persons, 19.0ms
Speed: 2.6ms preprocess, 19.0ms inference, 5.7ms postprocess per image at shape (1, 3, 640, 640)
Results saved to runs/detect/predict3
```



3. **Evaluate Model Performance:**
    - Compute and display key metrics such as mAP@50, mAP@50-95, Precision, Recall, and F1-Score.

In [ ]:

 # Evaluate model performance on the validation set

metrics = model.val()

Ultralytics 8.3.94 🚀 Python-3.11.11 torch-2.6.0+cu124 CUDA:0 (Tesla T4, 15095MiB)

val: Scanning /content/COCO-Dataset-34/valid/labels.cache... 55 images, 0 backgrounds, 0 corrupt: 100%|██████████| 55/55 [00:00<?, ?it/s]

Class	Images	Instances	Box(P	R	mAP50	mAP50-95):
100%|██████████| 4/4 [00:02<00:00, 1.66it/s]						
all	55	397	0.649	0.111	0.105	0.0839
backpack	1	1	0	0	0	0
banana	1	2	1	0	0	0

baseball bat	1	1	1	0	0	0
baseball glove	1	4	1	0	0	0
bench	3	4	0	0	0	0
bicycle	3	3	0	0	0	0
bird	2	4	1	0	0	0
boat	1	1	1	0	0.0622	0.0498
bottle	4	7	0.113	0.429	0.0654	0.0393
bus	3	3	0.184	0.245	0.179	0.179
cake	1	8	1	0	0	0
car	5	13	0.15	0.231	0.18	0.122
cat	2	2	0.441	1	0.663	0.341
cell phone	4	4	1	0	0	0
chair	6	16	0.253	0.0625	0.0614	0.0363
clock	2	2	0.18	0.5	0.126	0.1
couch	1	1	1	0	0	0
cup	4	10	0.707	0.3	0.373	0.244
dining table	6	8	1	0	0.105	0.0772
dog	2	4	0	0	0.0248	0.0155
donut	2	12	1	0	0	0
elephant	2	13	0.31	0.154	0.226	0.188
fire hydrant	3	3	0.889	0.333	0.362	0.324
fork	1	1	1	0	0	0
frisbee	1	1	1	0	0	0
handbag	5	11	1	0	0	0
horse	1	1	0.33	1	0.995	0.995
keyboard	2	7	1	0	0.00821	0.00657
kite	1	3	1	0	0	0
knife	2	3	1	0	0	0

laptop	4	10	1	0	0.224	0.212
microwave	1	4	1	0	0	0
motorcycle	3	4	0	0	0.113	0.104
mouse	3	4	1	0	0	0
oven	1	1	1	0	0	0
person	35	157	0.498	0.51	0.516	0.334
pizza	1	1	0	0	0.199	0.139
potted plant	1	1	1	0	0	0
refrigerator	2	3	0	0	0	0
remote	2	2	1	0	0.0229	0.016
sink	1	1	0.0923	0.462	0.199	0.159
skateboard	2	8	0	0	0.01	0.00903
snowboard	2	2	1	0	0.0286	0.00572
sports ball	2	2	1	0	0	0
stop sign	2	2	1	0	0.0355	0.0241
suitcase	1	1	0	0	0.014	0.00657
surfboard	2	3	1	0	0	0
tennis racket	3	3	1	0	0	0
tie	2	2	1	0	0	0
toilet	1	1	0	0	0	0
traffic light	1	1	1	0	0	0
train	3	6	1	0	0.0786	0.0707
truck	5	8	0.094	0.0823	0.0378	0.0265
tv	4	8	1	0	0.0501	0.0451
umbrella	5	5	1	0	0	0
vase	1	1	0.75	1	0.995	0.895
wine glass	1	3	0	0	0.0364	0.0205

Speed: 7.3ms preprocess, 12.0ms inference, 0.0ms loss, 2.9ms postprocess per image

Results saved to **runs/detect/val8**

In [ ]:

```
# Display key metrics
print(f"mAP@50: {metrics.box.map50:.4f}")    # Mean Average Precision at IoU 0.5
print(f"mAP@50-95: {metrics.box.map:.4f}")   # Mean Average Precision at IoU 0.5 to 0.95
print(f"Precision: {metrics.box.mp:.4f}")    # Mean Precision
print(f"Recall: {metrics.box.mr:.4f}")       # Mean Recall
```

mAP@50: 0.1051

mAP@50-95: 0.0839

Precision: 0.6490

Recall: 0.1107

In [ ]:

```
precision = metrics.box.mp
recall = metrics.box.mr

if precision + recall > 0:
    f1_score = 2 * (precision * recall) / (precision + recall)
    print(f"F1 Score: {f1_score:.4f}")
else:
    print("F1 Score: Undefined (precision + recall = 0)")
```

F1 Score: 0.1891

4. **Visualize Inference Results:**
    - Use glob to locate the saved prediction image, then display it using matplotlib or PIL.

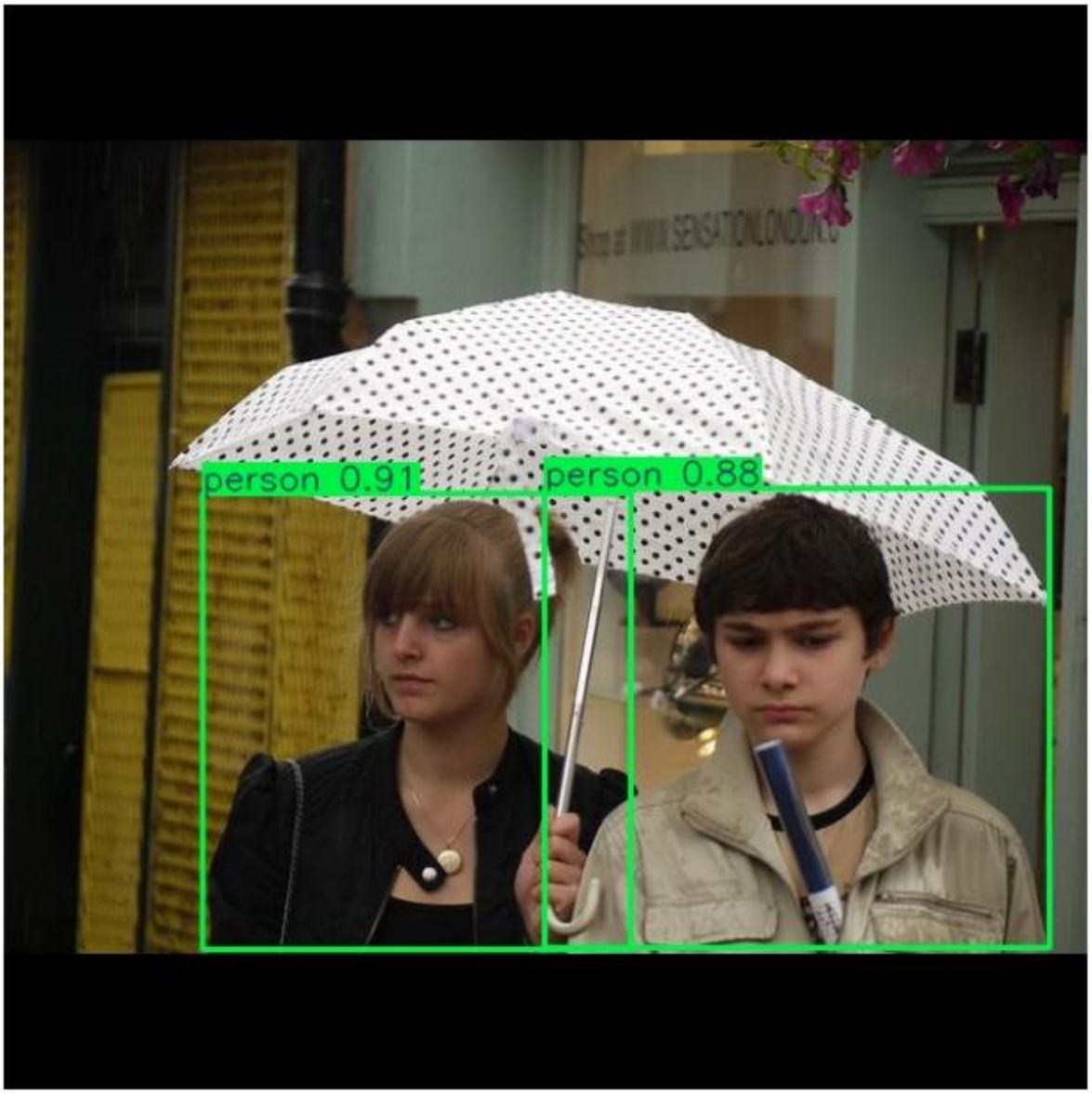
In [ ]:

```
import cv2
import matplotlib.pyplot as plt
from PIL import Image
import glob

# Run inference
results = model.predict(img_path, save=True, show=False)

# Find the saved prediction file
result_img_path = glob.glob('runs/detect/predict*/*.jpg')[3]

# Load and display the result using PIL and matplotlib
img = Image.open(result_img_path)
plt.figure(figsize=(8, 8))
plt.imshow(img)
plt.axis('off')
plt.show()
```

```
image 1/1 /content/COCO-Dataset-34/test/images/000000025668_jpg.rf.f67afc05b355ac25bef196980e6d7f99.jpg: 640x640 2 persons, 10.4ms
```

Speed: 2.3ms preprocess, 10.4ms inference, 1.3ms postprocess per image at shape (1, 3, 640, 640)

Results saved to **runs/detect/predict3**



Discussion and Conclusion

After running inference and visualizing the detection results on the COCO test images, the following performance metrics were observed:

- **mAP@50:** 0.1051
- **mAP@50-95:** 0.0839
- **Precision:** 0.6490
- **Recall:** 0.1107

- **F1 Score:** 0.1891

Discussion:

1. **Precision vs. Recall:**
    - The model achieves a relatively high precision (~0.65), indicating that when it predicts an object, it is often correct.
    - However, the recall is notably low (~0.11), meaning that the model is missing a large number of objects present in the images. This imbalance suggests that while the model is cautious in its predictions, it is not sensitive enough to detect all relevant objects.
2. **Training Considerations:**
    - The current training setup, although a good starting point, appears to be insufficient for achieving robust detection performance on the COCO dataset.
    - Increasing training epochs, applying more extensive data augmentation, and further hyperparameter tuning (such as adjusting the learning rate schedule and modifying anchor boxes) are potential strategies to improve recall without compromising precision.
3. **Visual Inspection:**
    - The visualizations show that detected objects have correctly drawn bounding boxes and appropriate confidence scores. However, many objects are still missed, which is consistent with the low recall metric.
    - The visualization reinforces the notion that while the model is reliable when it makes a detection, its overall sensitivity is low.

Conclusion:

- **Strengths:** The model demonstrates reliable detections when it does identify an object, as evidenced by the high precision. This is promising for applications where false positives are particularly problematic.
- **Weaknesses:** The low recall and overall mAP highlight the need for improvement in detecting all relevant objects in a scene.

Overall, this experiment provides valuable insights into the strengths and limitations of using YOLOv11 for object detection on the COCO dataset. With further refinements, the model can be optimized to achieve a more balanced performance, which is crucial for real-world applications.

Declaration

I, Yashas Nepalia, 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/YashasNepalia/Deep-Learning.git

Signature: Yashas Nepalia