```
# This command displays the status of the installed GPUs, showing
details like the driver version,
# GPU name, memory usage, and the processes using the GPU.
!nvidia-smi
```

```
Mon Jul 22 00:04:11 2024
+---------------------------------------------------------------------------
------------------+
| NVIDIA-SMI 535.104.05             Driver Version: 535.104.05   CUDA
Version: 12.2     |
|-----------------------------------------+----------------------
+----------------------+
| GPU  Name                 Persistence-M | Bus-Id        Disp.A |
Volatile Uncorr. ECC |
| Fan  Temp   Perf          Pwr:Usage/Cap |         Memory-Usage |
GPU-Util  Compute M. |
|                                         |                      |
MIG M. |
|
=========================================+======================+=====
=================|
|   0  Tesla T4                       Off | 00000000:00:04.0 Off |
0 |
| N/A   51C    P8              10W /  70W |      0MiB / 15360MiB |
0%      Default |
|                                         |                      |
N/A |
+-----------------------------------------+----------------------
+----------------------+


+---------------------------------------------------------------------------
------------------+
| Processes:
|
|  GPU   GI   CI        PID   Type   Process name
GPU Memory |
|        ID   ID
Usage      |
|
=========================================================================
=================|
|  No running processes found
|
+---------------------------------------------------------------------------
------------------+
```

Detecting Waldo with YOLOv8 and YOLOv5: A Hands-on Object Detection Training

Introduction

Welcome to the hands-on training on detecting Waldo using the powerful object detection models YOLOv8 and YOLOv5. In this training, you will learn the complete workflow for creating a object detection system, including dataset preparation, model training, and evaluation.

1. Setup and Installation
2. Dataset Collection and Annotation
3. Preparing the Data
4. Training with YOLOv5
5. Training with YOLOv8
6. Evaluating the Models
7. Using SAHI techinique to detect waldo

Setup and Installation

To begin, we'll need to set up our environment and install the necessary dependencies.

```
import os
HOME = os.getcwd()
print(HOME)
```

```
/content
```

```
import pandas as pd
import matplotlib.pyplot as plt
import xml.etree.ElementTree as ET
import glob
from PIL import Image
```

Installing and Checking Ultralytics

Install Ultralytics

To install the specific version `8.0.196` of the `ultralytics` package, use the following pip command:

```bash !pip install ultralytics==8.0.196
```

```
# Pip install method (recommended)
```

```
!pip install ultralytics==8.0.196

from IPython import display
display.clear_output()

import ultralytics
ultralytics.checks()
```

```
Ultralytics YOLOv8.0.196 🚀 Python-3.10.12 torch-2.3.1+cu121 CUDA:0
(Tesla T4, 15102MiB)
Setup complete ✅ (2 CPUs, 12.7 GB RAM, 30.1/78.2 GB disk)
```

Using Ultralytics YOLO

Import YOLO from Ultralytics

To utilize the YOLO (You Only Look Once) model from the `ultralytics` package, import it as follows:

```python from ultralytics import YOLO

```
from ultralytics import YOLO

from IPython.display import display, Image
# display.clear_output()

from ultralytics import YOLO

from IPython.display import display, Image
# display.clear_output()
```

# Setting Up Dataset Directory and Installing Roboflow

To organize the datasets, first create a new directory named `datasets` in your home directory. You can do this using the following command:

```
!mkdir {HOME}/datasets
%cd {HOME}/datasets

!pip install roboflow --quiet

!pip install roboflow
```

```
/content/datasets
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 76.7/76.7 kB 2.5 MB/s eta
0:00:00
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 178.7/178.7 kB 7.2 MB/s eta
0:00:00
```
```

```
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 54.5/54.5 kB 7.0 MB/s eta
0:00:00
ent already satisfied: roboflow in /usr/local/lib/python3.10/dist-
packages (1.1.36)
Requirement already satisfied: certifi in
/usr/local/lib/python3.10/dist-packages (from roboflow) (2024.7.4)
Requirement already satisfied: chardet==4.0.0 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (4.0.0)
Requirement already satisfied: idna==3.7 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (3.7)
Requirement already satisfied: cycler in
/usr/local/lib/python3.10/dist-packages (from roboflow) (0.12.1)
Requirement already satisfied: kiwisolver>=1.3.1 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.4.5)
Requirement already satisfied: matplotlib in
/usr/local/lib/python3.10/dist-packages (from roboflow) (3.7.1)
Requirement already satisfied: numpy>=1.18.5 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.25.2)
Requirement already satisfied: opencv-python-headless==4.10.0.84 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (4.10.0.84)
Requirement already satisfied: Pillow>=7.1.2 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (9.4.0)
Requirement already satisfied: python-dateutil in
/usr/local/lib/python3.10/dist-packages (from roboflow) (2.8.2)
Requirement already satisfied: python-dotenv in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.0.1)
Requirement already satisfied: requests in
/usr/local/lib/python3.10/dist-packages (from roboflow) (2.31.0)
Requirement already satisfied: six in /usr/local/lib/python3.10/dist-
packages (from roboflow) (1.16.0)
Requirement already satisfied: urllib3>=1.26.6 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (2.0.7)
Requirement already satisfied: tqdm>=4.41.0 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (4.66.4)
Requirement already satisfied: PyYAML>=5.3.1 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (6.0.1)
Requirement already satisfied: requests-toolbelt in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.0.0)
Requirement already satisfied: filetype in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.2.0)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib->roboflow)
(1.2.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib->roboflow)
(4.53.1)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib->roboflow)
(24.1)
```

```
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib->roboflow)
(3.1.2)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.10/dist-packages (from requests->roboflow)
(3.3.2)
```

Roboflow Dataset Download

The following Python code demonstrates how to use the Roboflow library to download a dataset for a specific project and version. Here's a step-by-step breakdown of the code:

```
from roboflow import Roboflow
rf = Roboflow(api_key="vaIQ9aYmyRqVHGw89lcc")
project = rf.workspace("bookdetection-hc8pr").project("waldo7")
version = project.version(1)
dataset = version.download("yolov8")

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

Downloading Dataset Version Zip in waldo7-1 to yolov8:: 100%|
██████████| 32780/32780 [00:01<00:00, 24938.49it/s]



Extracting Dataset Version Zip to waldo7-1 in yolov8:: 100%|
██████████| 447/447 [00:00<00:00, 2590.40it/s]
```

Counting and Visualizing Image Files

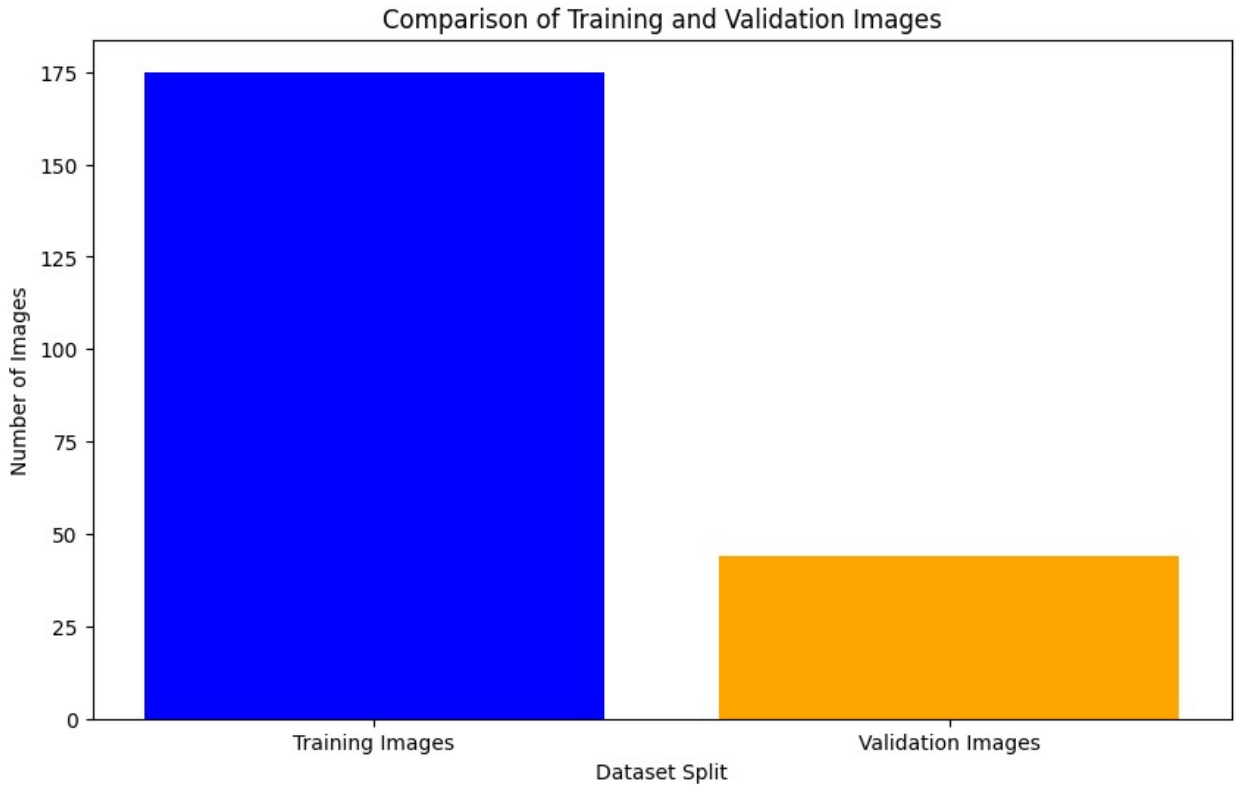
The following code snippet performs the task of counting image files in specified directories and visualizing the results using a bar chart. Here's a step-by-step breakdown of each part:

```
train_images_dir = '/content/datasets/waldo7-1/train/images'
val_images_dir = '/content/datasets/waldo7-1/valid/images'

def count_images(directory):
    """Count the number of image files in the given directory."""
    return len([name for name in os.listdir(directory) if
os.path.isfile(os.path.join(directory, name)) and
name.lower().endswith(('.png', '.jpg', '.jpeg'))])

# Count the number of images in train and validation directories
num_train_images = count_images(train_images_dir)
num_val_images = count_images(val_images_dir)
```

```
print(num_train_images,"images for training")
print(num_val_images,"images for validation")
```

```
175 images for training
44 images for validation
```

```
categories = ['Training Images', 'Validation Images']
num_images = [num_train_images, num_val_images]

plt.figure(figsize=(10, 6))
plt.bar(categories, num_images, color=['blue', 'orange'])
plt.xlabel('Dataset Split')
plt.ylabel('Number of Images')
plt.title('Comparison of Training and Validation Images')
plt.show()
```



YOLOv8 Training Command Explained

Command Arguments

task=detect:

- Purpose: Specifies the task as object detection. Details: YOLO (You Only Look Once) is designed for object detection. This argument tells YOLO to perform object detection on the provided dataset.

mode=train:

- Purpose: Indicates the mode of operation as training. Details: YOLO can be used for various purposes such as inference (making predictions) or evaluation. By setting mode=train, you are instructing YOLO to train the model

model=yolov8s.pt:

- Purpose: Specifies the model checkpoint file to use. Details: yolov8s.pt refers to the YOLOv8 small model checkpoint file. The .pt extension indicates a PyTorch model file. This file contains pre-trained weights that the training process will start from.

data={dataset.location}/data.yaml or data=/content/datasets/waldo7-1/data.yaml:

- Purpose: Provides the path to the dataset configuration file. Details: {dataset.location} is a placeholder for the actual path to your dataset. data.yaml is the configuration file that contains information about the dataset, such as class names and paths to training and validation images.

epochs=80:

- Purpose: Sets the number of training epochs. Details: An epoch is one complete pass through the training dataset. Setting epochs=80 means the model will be trained for 80 epochs. More epochs generally improve model performance but require more time.

imgsz=640:

- Purpose: Defines the image size for training. Details: imgsz=640 resizes each image to 640x640 pixels before feeding it into the model. This size impacts both the training speed and accuracy.

batch=16:

- Purpose: Specifies the batch size. Details: The batch size is the number of images processed together in one forward/backward pass. A batch size of 16 means that 16 images are processed simultaneously.

optimizer=SGD:

- Purpose: Chooses the optimizer for training. Details: SGD stands for Stochastic Gradient Descent, an optimization algorithm used to minimize the loss function and update the model weights.

```
!yolo task=detect mode=train model=yolov8s.pt
data=/content/datasets/waldo7-1/data.yaml epochs=80 imgsz=640
batch=16  optimizer=SGD  plots=True

Ultralytics YOLOv8.2.61 🚀 Python-3.10.12 torch-2.3.1+cu121 CUDA:0
(Tesla T4, 15102MiB)
engine/trainer: task=detect, mode=train, model=yolov8s.pt,
data=/content/datasets/waldo7-1/data.yaml, epochs=80, time=None,
patience=100, batch=16, imgsz=640, save=True, save_period=-1,
```

```
cache=False, device=None, workers=8, project=None, name=train6,
exist_ok=False, pretrained=True, optimizer=SGD, verbose=True, seed=0,
deterministic=True, single_cls=False, rect=False, cos_lr=False,
close_mosaic=10, resume=False, amp=True, fraction=1.0, profile=False,
freeze=None, multi_scale=False, overlap_mask=True, mask_ratio=4,
dropout=0.0, val=True, split=val, save_json=False, save_hybrid=False,
conf=None, iou=0.7, max_det=300, half=False, dnn=False, plots=True,
source=None, vid_stride=1, stream_buffer=False, visualize=False,
augment=False, agnostic_nms=False, classes=None, retina_masks=False,
embed=None, show=False, save_frames=False, save_txt=False,
save_conf=False, save_crop=False, show_labels=True, show_conf=True,
show_boxes=True, line_width=None, format=torchscript, keras=False,
optimize=False, int8=False, dynamic=False, simplify=False, opset=None,
workspace=4, nms=False, lr0=0.01, lrf=0.01, momentum=0.937,
weight_decay=0.0005, warmup_epochs=3.0, warmup_momentum=0.8,
warmup_bias_lr=0.1, box=7.5, cls=0.5, 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, fliplr=0.5, bgr=0.0, mosaic=1.0, mixup=0.0,
copy_paste=0.0, auto_augment=randaugment, erasing=0.4,
crop_fraction=1.0, cfg=None, tracker=botsort.yaml,
save_dir=runs/detect/train6
Overriding model.yaml nc=80 with nc=1

                   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   2116435
ultralytics.nn.modules.head.Detect           [1, [128, 256, 512]]

Model summary: 225 layers, 11,135,987 parameters, 11,135,971
gradients, 28.6 GFLOPs

Transferred 349/355 items from pretrained weights
TensorBoard: Start with 'tensorboard --logdir runs/detect/train6',
view at http://localhost:6006/
Freezing layer 'model.22.dfl.conv.weight'
AMP: running Automatic Mixed Precision (AMP) checks with YOLOv8n...
AMP: checks passed □
train: Scanning /content/datasets/waldo7-1/train/labels.cache... 175
images, 0 backgrounds, 0 corrupt: 100% 175/175 [00:00<?, ?it/s]
albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01,
blur_limit=(3, 7)), ToGray(p=0.01), CLAHE(p=0.01, clip_limit=(1, 4.0),
tile_grid_size=(8, 8))
/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning:
os.fork() was called. os.fork() is incompatible with multithreaded
code, and JAX is multithreaded, so this will likely lead to a
deadlock.
  self.pid = os.fork()
val: Scanning /content/datasets/waldo7-1/valid/labels.cache... 44
```

```
images, 0 backgrounds, 0 corrupt: 100% 44/44 [00:00<?, ?it/s]
Plotting labels to runs/detect/train6/labels.jpg...
optimizer: SGD(lr=0.01, momentum=0.937) with parameter groups 57
weight(decay=0.0), 64 weight(decay=0.0005), 63 bias(decay=0.0)
TensorBoard: model graph visualization added 
Image sizes 640 train, 640 val
Using 2 dataloader workers
Logging results to runs/detect/train6
Starting training for 80 epochs...

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       1/80      4.17G      2.912      25.85      2.166         26
640: 100% 11/11 [00:07<00:00,  1.46it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.27it/s]
                   all         44         45     0.0014     0.0444
0.000701    0.00024

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       2/80      4.07G      2.959      8.767      2.106         23
640: 100% 11/11 [00:03<00:00,  3.50it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.96it/s]
                   all         44         45    0.00167      0.489
0.00453    0.00134

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       3/80      4.13G      2.536      4.089       1.95         20
640: 100% 11/11 [00:03<00:00,  3.56it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.45it/s]
                   all         44         45      0.189     0.0889
0.0742       0.03

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       4/80      4.24G      2.268      3.122      1.648         26
640: 100% 11/11 [00:03<00:00,  2.92it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.82it/s]
                   all         44         45      0.351      0.267
0.198     0.0941

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       5/80      4.13G      2.027      2.829      1.572         22
640: 100% 11/11 [00:04<00:00,  2.73it/s]
```

```
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.97it/s]
                   all         44         45      0.457      0.311
0.291       0.15

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       6/80      4.13G      1.813      2.931      1.425         22
640: 100% 11/11 [00:03<00:00,  3.55it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.83it/s]
                   all         44         45       0.77        0.4
0.527      0.246

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       7/80      4.24G      1.621      2.154      1.299         23
640: 100% 11/11 [00:03<00:00,  3.58it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.43it/s]
                   all         44         45      0.868      0.422
0.557       0.28

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       8/80       4.1G      1.555      1.667      1.242         23
640: 100% 11/11 [00:04<00:00,  2.67it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.64it/s]
                   all         44         45      0.678      0.514
0.567      0.265

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
       9/80      4.24G      1.628      2.225      1.242         22
640: 100% 11/11 [00:03<00:00,  3.55it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.69it/s]
                   all         44         45      0.834      0.489
0.705      0.396

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      10/80       4.1G      1.673      1.556       1.26         18
640: 100% 11/11 [00:03<00:00,  3.66it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.47it/s]
                   all         44         45      0.867      0.581
0.678      0.347
```

```
      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      11/80      4.09G      1.599      1.825      1.189         24
640: 100% 11/11 [00:03<00:00,  3.36it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.32it/s]
                   all         44         45      0.532      0.557
0.598      0.322

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      12/80      4.13G       1.44       1.56      1.102         13
640: 100% 11/11 [00:04<00:00,  2.30it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.84it/s]
                   all         44         45      0.787      0.644
0.703      0.347

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      13/80      4.24G      1.576      1.305      1.159         20
640: 100% 11/11 [00:02<00:00,  3.76it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.90it/s]
                   all         44         45      0.751      0.669
0.746      0.401

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      14/80       4.1G      1.587      1.443      1.152         18
640: 100% 11/11 [00:02<00:00,  3.76it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.84it/s]
                   all         44         45      0.901      0.812
0.898      0.395

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      15/80      4.09G      1.509        1.4      1.163         21
640: 100% 11/11 [00:03<00:00,  2.96it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.92it/s]
                   all         44         45      0.842      0.711
0.85      0.429

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      16/80      4.13G      1.499      1.379      1.141         23
640: 100% 11/11 [00:04<00:00,  2.73it/s]
                 Class     Images  Instances      Box(P          R
```

```
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.83it/s]
                   all         44         45      0.858      0.733
0.807      0.416

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      17/80      4.24G      1.337      1.279       1.09         22
640: 100% 11/11 [00:02<00:00,  3.77it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.74it/s]
                   all         44         45      0.844      0.756
0.825      0.411

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      18/80      4.09G      1.423      1.114      1.125         27
640: 100% 11/11 [00:02<00:00,  3.74it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.00it/s]
                   all         44         45      0.852      0.867
0.874      0.441

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      19/80       4.1G      1.427      1.039      1.107         21
640: 100% 11/11 [00:03<00:00,  2.78it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.80it/s]
                   all         44         45      0.782      0.889
0.897      0.478

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      20/80      4.13G      1.456      1.154      1.092         23
640: 100% 11/11 [00:03<00:00,  3.28it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.09it/s]
                   all         44         45      0.921      0.822
0.892      0.458

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      21/80      4.24G      1.431     0.9806      1.095         16
640: 100% 11/11 [00:02<00:00,  3.68it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.61it/s]
                   all         44         45      0.898      0.786
0.854      0.464

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
```

```
Size
      22/80       4.1G      1.404      1.033      1.076         22
640: 100% 11/11 [00:03<00:00,  3.60it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.36it/s]
                   all         44         45       0.88      0.814
0.89      0.495

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      23/80       4.1G       1.31       1.05      1.046         21
640: 100% 11/11 [00:04<00:00,  2.48it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.69it/s]
                   all         44         45      0.804      0.844
0.904      0.449

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      24/80      4.13G      1.302     0.8991      1.051         14
640: 100% 11/11 [00:02<00:00,  3.74it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.11it/s]
                   all         44         45      0.804      0.911
0.904      0.466

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      25/80      4.24G       1.29     0.8722       1.04         24
640: 100% 11/11 [00:02<00:00,  3.74it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.13it/s]
                   all         44         45      0.832      0.879
0.919       0.45

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      26/80      4.09G      1.336     0.9296      1.036         19
640: 100% 11/11 [00:03<00:00,  3.29it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.94it/s]
                   all         44         45      0.906      0.859
0.946      0.491

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      27/80       4.1G      1.309     0.8185       1.06         26
640: 100% 11/11 [00:04<00:00,  2.73it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.51it/s]
```

```
                   all         44         45       0.94      0.844
0.935      0.486

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      28/80      4.13G      1.196     0.7939      1.009         24
640: 100% 11/11 [00:03<00:00,  3.56it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.45it/s]
                   all         44         45      0.844       0.84
0.896      0.482

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      29/80      4.24G      1.234     0.8059      1.036         20
640: 100% 11/11 [00:03<00:00,  3.63it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.98it/s]
                   all         44         45      0.918      0.745
0.865      0.458

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      30/80       4.1G      1.237     0.8184      1.014         21
640: 100% 11/11 [00:04<00:00,  2.57it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.74it/s]
                   all         44         45      0.941      0.822
0.828      0.404

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      31/80       4.1G      1.179     0.7388     0.9995         18
640: 100% 11/11 [00:03<00:00,  3.34it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.64it/s]
                   all         44         45      0.874      0.773
0.837      0.433

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      32/80      4.12G      1.118     0.7766     0.9865         18
640: 100% 11/11 [00:02<00:00,  3.75it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.36it/s]
                   all         44         45      0.924      0.822
0.896      0.426

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
```

```
      33/80      4.08G      1.237     0.8058      1.017          15
640: 100% 11/11 [00:03<00:00,  3.48it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.24it/s]
                   all         44         45       0.94      0.867
0.913      0.412

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      34/80       4.1G      1.192     0.7815      1.015          19
640: 100% 11/11 [00:04<00:00,  2.46it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.66it/s]
                   all         44         45      0.885      0.778
0.901      0.469

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      35/80       4.1G      1.159     0.7725     0.9947          26
640: 100% 11/11 [00:02<00:00,  3.74it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.44it/s]
                   all         44         45      0.886      0.867
0.914      0.469

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      36/80      4.13G      1.159     0.7466     0.9983          18
640: 100% 11/11 [00:02<00:00,  3.68it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.83it/s]
                   all         44         45      0.905      0.933
0.922      0.472

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      37/80      4.08G      1.114     0.7765     0.9809          12
640: 100% 11/11 [00:03<00:00,  3.32it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.89it/s]
                   all         44         45      0.968      0.889
0.951      0.519

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      38/80      4.11G      1.218     0.7692     0.9781          19
640: 100% 11/11 [00:03<00:00,  2.84it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.22it/s]
                   all         44         45      0.959      0.889
```

```
0.937      0.519

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      39/80      4.09G      1.144     0.7463      1.009         18
640: 100% 11/11 [00:02<00:00,  3.82it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.69it/s]
                   all         44         45       0.89      0.903
0.937      0.525

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      40/80      4.13G      1.098     0.7322     0.9542         20
640: 100% 11/11 [00:03<00:00,  3.61it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.59it/s]
                   all         44         45      0.883      0.911
0.913      0.519

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      41/80      4.23G      1.185     0.7878     0.9781         16
640: 100% 11/11 [00:04<00:00,  2.51it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.77it/s]
                   all         44         45      0.951      0.844
0.915      0.501

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      42/80       4.1G      1.102     0.7227     0.9794         13
640: 100% 11/11 [00:03<00:00,  3.64it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.71it/s]
                   all         44         45      0.949      0.867
0.906      0.522

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      43/80      4.09G      1.107     0.6936     0.9451         19
640: 100% 11/11 [00:02<00:00,  3.73it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.95it/s]
                   all         44         45      0.948      0.867
0.908      0.511

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      44/80      4.12G        1.1     0.7004     0.9608         23
```

```
640: 100% 11/11 [00:03<00:00,  3.32it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.97it/s]
                   all         44         45      0.944      0.911
0.947        0.5

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      45/80      4.08G      1.079     0.6819     0.9648         18
640: 100% 11/11 [00:04<00:00,  2.61it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.36it/s]
                   all         44         45       0.91      0.911
0.939      0.514

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      46/80       4.1G      1.056     0.6945     0.9464         18
640: 100% 11/11 [00:02<00:00,  3.72it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.85it/s]
                   all         44         45       0.94      0.911
0.939      0.513

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      47/80       4.1G      1.007     0.6536     0.9483         20
640: 100% 11/11 [00:02<00:00,  3.78it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.88it/s]
                   all         44         45      0.911      0.911
0.915      0.542

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      48/80      4.13G      1.096     0.6803     0.9831         17
640: 100% 11/11 [00:04<00:00,  2.73it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.72it/s]
                   all         44         45      0.971      0.911
0.936      0.537

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      49/80      4.08G      1.042     0.6381     0.9435         15
640: 100% 11/11 [00:03<00:00,  3.25it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.22it/s]
                   all         44         45      0.953      0.911
0.941      0.553
```

```
      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      50/80      4.09G      1.065     0.6241     0.9351         25
640: 100% 11/11 [00:03<00:00,  3.59it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.01it/s]
                   all         44         45       0.95      0.848
0.937      0.565

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      51/80      4.09G      1.021     0.6433     0.9093         25
640: 100% 11/11 [00:03<00:00,  3.50it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.41it/s]
                   all         44         45      0.976      0.867
0.948      0.571

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      52/80      4.13G      1.021     0.6469     0.9203         22
640: 100% 11/11 [00:04<00:00,  2.52it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.74it/s]
                   all         44         45      0.921      0.889
0.931       0.56

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      53/80      4.24G      1.111     0.6877     0.9449         23
640: 100% 11/11 [00:02<00:00,  3.78it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.31it/s]
                   all         44         45      0.928       0.86
0.926      0.548

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      54/80       4.1G     0.9534      0.599     0.9298         21
640: 100% 11/11 [00:02<00:00,  3.67it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.57it/s]
                   all         44         45      0.932      0.844
0.928      0.537

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      55/80       4.1G     0.9681     0.5806     0.9012         20
640: 100% 11/11 [00:03<00:00,  3.37it/s]
```

```
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.71it/s]
                   all         44         45      0.907      0.844
0.913      0.494

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      56/80      4.12G     0.9951     0.6045     0.9115         26
640: 100% 11/11 [00:04<00:00,  2.52it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.95it/s]
                   all         44         45      0.882      0.889
0.928       0.52

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      57/80      4.24G     0.9876     0.5857     0.9076         21
640: 100% 11/11 [00:02<00:00,  3.73it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.44it/s]
                   all         44         45      0.921      0.911
0.945      0.553

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      58/80       4.1G     0.9642     0.5778     0.9117         17
640: 100% 11/11 [00:02<00:00,  3.71it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.31it/s]
                   all         44         45      0.977      0.927
0.954      0.575

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      59/80       4.1G     0.9266     0.5756     0.9096         20
640: 100% 11/11 [00:04<00:00,  2.64it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.74it/s]
                   all         44         45      0.977      0.933
0.953      0.553

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      60/80      4.12G      0.879      0.553     0.8916         18
640: 100% 11/11 [00:03<00:00,  3.17it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.85it/s]
                   all         44         45      0.954       0.93
0.952      0.549
```

```
      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      61/80      4.24G     0.9212     0.5638     0.9012         24
640: 100% 11/11 [00:02<00:00,  3.78it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.82it/s]
                   all         44         45      0.977      0.933
0.951      0.535

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      62/80       4.1G     0.9006      0.529     0.9081         23
640: 100% 11/11 [00:03<00:00,  3.63it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.47it/s]
                   all         44         45      0.971      0.911
0.94      0.555

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      63/80       4.1G     0.8897     0.5531      0.888         21
640: 100% 11/11 [00:04<00:00,  2.59it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.66it/s]
                   all         44         45      0.948      0.911
0.948      0.524

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      64/80      4.12G     0.9292     0.5681     0.8886         26
640: 100% 11/11 [00:03<00:00,  3.40it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.87it/s]
                   all         44         45      0.952      0.873
0.942       0.53

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      65/80      4.24G     0.8459      0.509     0.9082         18
640: 100% 11/11 [00:02<00:00,  3.85it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.24it/s]
                   all         44         45      0.946      0.889
0.944      0.541

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      66/80       4.1G     0.8918     0.5329     0.8999         18
640: 100% 11/11 [00:03<00:00,  3.62it/s]
                 Class     Images  Instances      Box(P          R
```

```
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.22it/s]
                   all         44         45      0.918      0.889
0.945      0.551

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      67/80       4.1G     0.8452     0.4951     0.8876         15
640: 100% 11/11 [00:04<00:00,  2.44it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.68it/s]
                   all         44         45      0.921      0.911
0.95      0.572

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      68/80      4.12G     0.8791     0.5226     0.9073         18
640: 100% 11/11 [00:03<00:00,  3.55it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.66it/s]
                   all         44         45      0.936      0.911
0.953      0.581

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      69/80      4.24G     0.8648      0.521     0.8854         22
640: 100% 11/11 [00:02<00:00,  3.71it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.25it/s]
                   all         44         45      0.948      0.911
0.957      0.564

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      70/80       4.1G     0.8835     0.5103     0.9012         25
640: 100% 11/11 [00:03<00:00,  3.22it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.76it/s]
                   all         44         45      0.938      0.933
0.957      0.555
Closing dataloader mosaic
albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01,
blur_limit=(3, 7)), ToGray(p=0.01), CLAHE(p=0.01, clip_limit=(1, 4.0),
tile_grid_size=(8, 8))
/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning:
os.fork() was called. os.fork() is incompatible with multithreaded
code, and JAX is multithreaded, so this will likely lead to a
deadlock.
  self.pid = os.fork()

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
```

```
Size
      71/80       4.1G     0.8576     0.5109      0.899         15
640: 100% 11/11 [00:05<00:00,  1.91it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.31it/s]
                   all         44         45      0.924      0.933
0.953      0.557

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      72/80      4.13G     0.8544     0.5016     0.9008         14
640: 100% 11/11 [00:03<00:00,  3.61it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.25it/s]
                   all         44         45      0.929      0.933
0.95      0.563

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      73/80      4.24G     0.7731      0.455     0.8855         14
640: 100% 11/11 [00:03<00:00,  3.29it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.82it/s]
                   all         44         45      0.941      0.933
0.947      0.573

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      74/80       4.1G     0.7582     0.4819     0.8699          7
640: 100% 11/11 [00:03<00:00,  2.82it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.06it/s]
                   all         44         45       0.93      0.933
0.947      0.552

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      75/80       4.1G     0.7853     0.4224      0.869         15
640: 100% 11/11 [00:02<00:00,  3.74it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.92it/s]
                   all         44         45       0.93      0.933
0.95      0.564

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      76/80      4.13G     0.8135     0.4729     0.8924         15
640: 100% 11/11 [00:02<00:00,  3.80it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.81it/s]
```

```
                   all         44         45      0.933      0.933
0.95      0.543

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      77/80      4.24G      0.736     0.4378     0.8495         14
640: 100% 11/11 [00:03<00:00,  3.14it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:01<00:00,  1.97it/s]
                   all         44         45      0.911      0.933
0.952       0.55

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      78/80       4.1G     0.7926     0.4547     0.8717         14
640: 100% 11/11 [00:03<00:00,  3.22it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  3.55it/s]
                   all         44         45      0.909      0.933
0.953      0.552

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      79/80      4.09G     0.7255      0.425     0.8587         15
640: 100% 11/11 [00:02<00:00,  3.75it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  4.05it/s]
                   all         44         45      0.911      0.933
0.954      0.543

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances
Size
      80/80      4.13G     0.7431     0.4406     0.8546         15
640: 100% 11/11 [00:02<00:00,  3.79it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.97it/s]
                   all         44         45      0.912      0.933
0.954      0.552

80 epochs completed in 0.119 hours.
Optimizer stripped from runs/detect/train6/weights/last.pt, 22.5MB
Optimizer stripped from runs/detect/train6/weights/best.pt, 22.5MB

Validating runs/detect/train6/weights/best.pt...
Ultralytics YOLOv8.2.61 🚀 Python-3.10.12 torch-2.3.1+cu121 CUDA:0
(Tesla T4, 15102MiB)
Model summary (fused): 168 layers, 11,125,971 parameters, 0 gradients,
28.4 GFLOPs
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 2/2 [00:00<00:00,  2.02it/s]
```

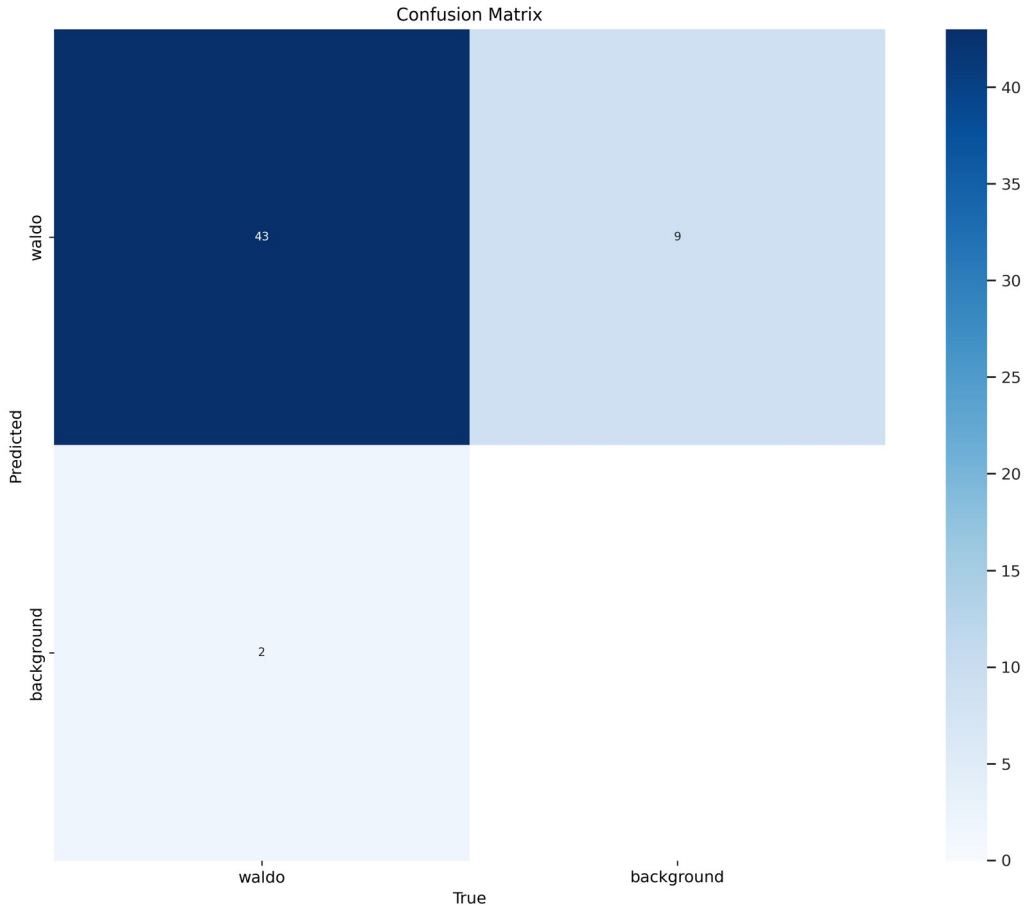
```
                   all         44         45      0.936      0.911
0.953      0.581
Speed: 0.2ms preprocess, 4.9ms inference, 0.0ms loss, 2.8ms
postprocess per image
Results saved to runs/detect/train6
 Learn more at https://docs.ultralytics.com/modes/train
```

Display the Confusion Matrix

- The confusion matrix is a performance measurement tool for classification problems, showing how predictions match with actual classes. This visualization helps in evaluating the model's performance by illustrating the counts of true positives, false positives, true negatives, and false negatives.

```
%cd {HOME}
Image(filename=f'{HOME}/runs/detect/train6/confusion_matrix.png',
width=900)
```

```
/content
```

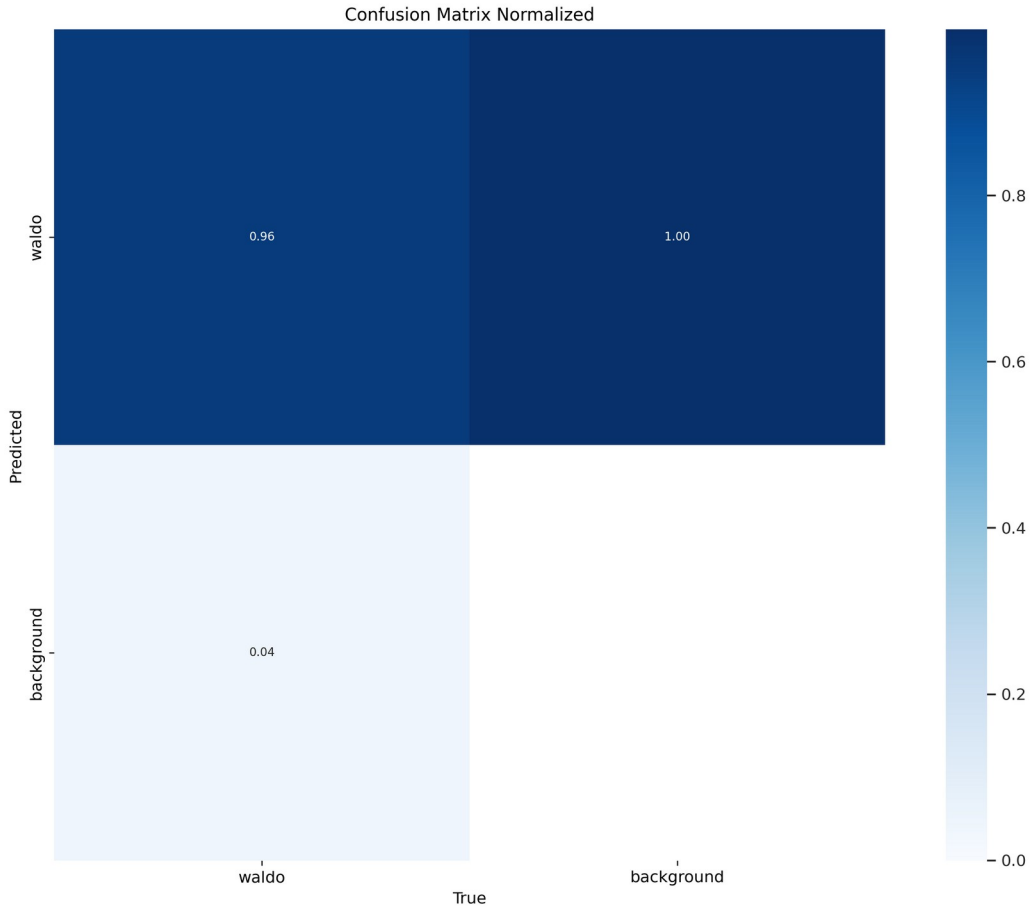


Display the Normalized Confusion Matrix

- The normalized confusion matrix provides a clearer view of the model's performance by showing the proportion of correctly and incorrectly classified samples relative to the total number of samples. It helps in evaluating the model's performance across different classes by normalizing the counts to percentages.

```
%cd {HOME}
Image(filename=f'{HOME}/runs/detect/train6/confusion_matrix_normalized.png', width=900)
```

```
/content
```

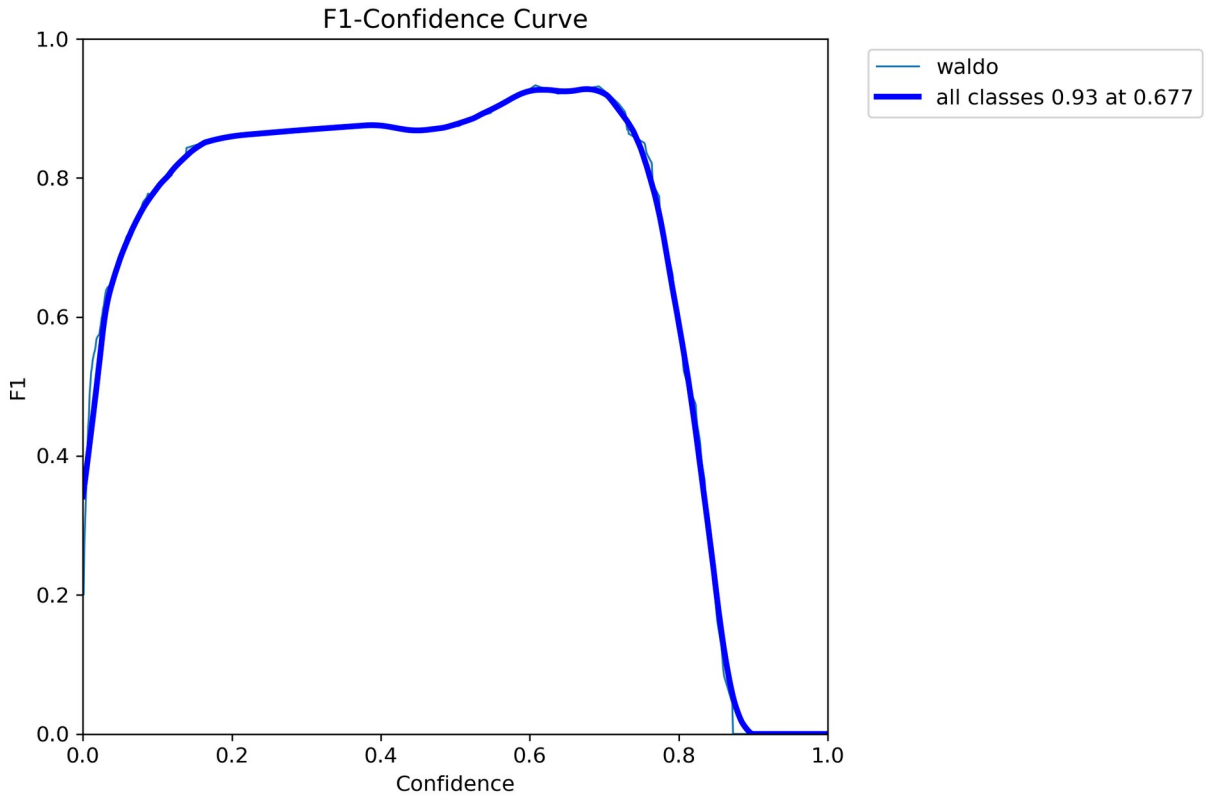


Display the F1 Score Curve

- The F1 score is a metric that combines precision and recall, providing a single score to assess the model's performance, especially in imbalanced datasets. This curve helps in understanding how well the model balances precision and recall over different operating points.

```
%cd {HOME}
Image(filename=f'{HOME}/runs/detect/train6/F1_curve.png', width=900)
```

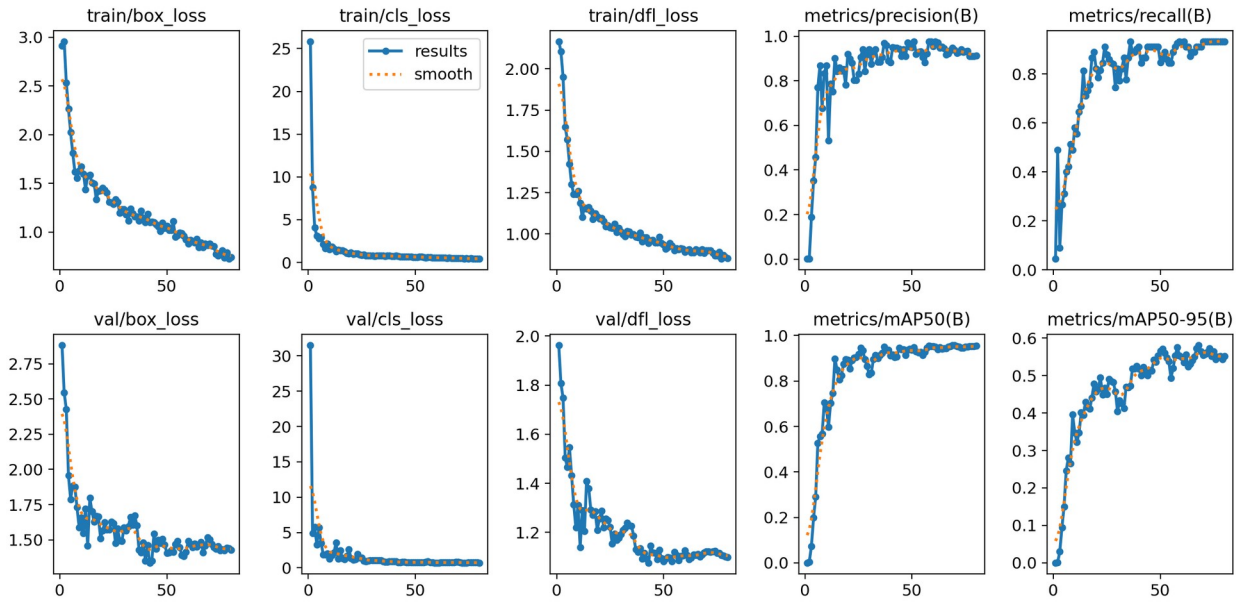
```
/content
```



Display the Results Image

the file typically includes visualizations of the training results, such as detection performance on validation images.

```
%cd {HOME}
Image(filename=f'{HOME}/runs/detect/train6/results.png', width=900)
#The training and validation loss graphs are printed as well as
precison and recall metrics

/content
```



Display an Image with Predictions

- The val_batch0_pred.jpg file shows an image from the validation set with the model's predictions. Each detected object is annotated with its predicted class and the probability (confidence score) that the object belongs to that class. This visualization helps in evaluating how well the model predicts and classifies objects in the validation images.

```
%cd {HOME}
Image(filename=f'{HOME}/runs/detect/train6/val_batch0_pred.jpg',
width=600)
#Images from the training set is printed with the probability of each.

/content
```

Run YOLOv8 for Validation

- The command runs the YOLOv8 CLI tool to validate the trained YOLOv8 model using the specified dataset.
- Precision (P): 0.936 - Indicates the proportion of true positive detections among all detections.
- Recall (R): 0.911 - Indicates the proportion of true positive detections among all actual objects.
- mAP50: 0.953 - Mean Average Precision at IoU threshold 0.50, a standard metric for object detection performance.

- mAP50-95: 0.58 - Mean Average Precision averaged over IoU thresholds from 0.50 to 0.95.

```
%cd {HOME}

!yolo task=detect mode=val
model=/content/runs/detect/train6/weights/best.pt
data=/content/datasets/waldo7-1/data.yaml

/content
Ultralytics YOLOv8.2.61 🚀 Python-3.10.12 torch-2.3.1+cu121 CUDA:0
(Tesla T4, 15102MiB)
Model summary (fused): 168 layers, 11,125,971 parameters, 0 gradients,
28.4 GFLOPs
val: Scanning /content/datasets/waldo7-1/valid/labels.cache... 44
images, 0 backgrounds, 0 corrupt: 100% 44/44 [00:00<?, ?it/s]
                 Class     Images  Instances      Box(P          R
mAP50  mAP50-95): 100% 3/3 [00:02<00:00,  1.21it/s]
                   all         44         45      0.936      0.911
0.953       0.58
Speed: 8.2ms preprocess, 17.0ms inference, 0.0ms loss, 14.7ms
postprocess per image
Results saved to runs/detect/val4
💡 Learn more at https://docs.ultralytics.com/modes/val
```

Run YOLOv8 for Prediction

- The command runs the YOLOv8 CLI tool to perform object detection on a specified image using a pre-trained model

```
%cd {HOME}
!yolo task=detect mode=predict
model={HOME}/runs/detect/train/weights/best.pt conf=0.30
source={HOME}/waldo_1.jpg save=True

/content
Ultralytics YOLOv8.2.61 🚀 Python-3.10.12 torch-2.3.1+cu121 CUDA:0
(Tesla T4, 15102MiB)
Model summary (fused): 168 layers, 11,125,971 parameters, 0 gradients,
28.4 GFLOPs

image 1/1 /content/waldo_1.jpg: 384x640 1 waldo, 69.8ms
Speed: 1.7ms preprocess, 69.8ms inference, 670.3ms postprocess per
image at shape (1, 3, 384, 640)
Results saved to runs/detect/predict2
💡 Learn more at https://docs.ultralytics.com/modes/predict

%cd {HOME}

/content
```

Yolov5 Training

- This command fetches the latest YOLOv5 code, models, and scripts from the Ultralytics GitHub repository, allowing you to use and modify YOLOv5 for object detection

```
#clone YOLOv5 and
!git clone https://github.com/ultralytics/yolov5  # clone repo
%cd yolov5
%pip install -qr requirements.txt # install dependencies
%pip install -q roboflow

import torch
import os
from IPython.display import Image, clear_output  # to display images

print(f"Setup complete. Using torch {torch.__version__}
({torch.cuda.get_device_properties(0).name if
torch.cuda.is_available() else 'CPU'})")
```

```
Cloning into 'yolov5'...
remote: Enumerating objects: 16802, done.ote: Counting objects: 100%
(123/123), done.ote: Compressing objects: 100% (97/97), done.ote:
Total 16802 (delta 54), reused 61 (delta 26), pack-reused
16679━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 207.3/207.3 kB 5.2 MB/s
eta 0:00:00
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 4.5/4.5 MB 18.6 MB/s eta
0:00:00
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 64.9/64.9 kB 8.2 MB/s eta
0:00:00
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 804.2/804.2 kB 28.1 MB/s eta
0:00:00
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 2.3/2.3 MB 39.0 MB/s eta
0:00:00
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 62.7/62.7 kB 8.9 MB/s eta
0:00:00
ERROR: pip's dependency resolver does not currently take into account
all the packages that are installed. This behaviour is the source of
the following dependency conflicts.
ipython 7.34.0 requires jedi>=0.16, which is not installed.
google-colab 1.0.0 requires requests==2.31.0, but you have requests
2.32.3 which is incompatible.
imageio 2.31.6 requires pillow<10.1.0,>=8.3.2, but you have pillow
10.4.0 which is incompatible.
Setup complete. Using torch 2.3.1+cu121 (Tesla T4)
```

Setting Up Dataset Directory and Installing Roboflow

To organize the datasets, first create a new directory named `datasets` in your home directory. You can do this using the following command:

```
!pip install roboflow

from roboflow import Roboflow
rf = Roboflow(api_key="vaIQ9aYmyRqVHGw89lcc")
project = rf.workspace("bookdetection-hc8pr").project("waldo7")
version = project.version(1)
dataset = version.download("yolov5")
```

```
Requirement already satisfied: roboflow in
/usr/local/lib/python3.10/dist-packages (1.1.36)
Requirement already satisfied: certifi in
/usr/local/lib/python3.10/dist-packages (from roboflow) (2024.7.4)
Requirement already satisfied: chardet==4.0.0 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (4.0.0)
Requirement already satisfied: idna==3.7 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (3.7)
Requirement already satisfied: cycler in
/usr/local/lib/python3.10/dist-packages (from roboflow) (0.12.1)
Requirement already satisfied: kiwisolver>=1.3.1 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.4.5)
Requirement already satisfied: matplotlib in
/usr/local/lib/python3.10/dist-packages (from roboflow) (3.7.1)
Requirement already satisfied: numpy>=1.18.5 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.25.2)
Requirement already satisfied: opencv-python-headless==4.10.0.84 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (4.10.0.84)
Requirement already satisfied: Pillow>=7.1.2 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (10.4.0)
Requirement already satisfied: python-dateutil in
/usr/local/lib/python3.10/dist-packages (from roboflow) (2.8.2)
Requirement already satisfied: python-dotenv in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.0.1)
Requirement already satisfied: requests in
/usr/local/lib/python3.10/dist-packages (from roboflow) (2.32.3)
Requirement already satisfied: six in /usr/local/lib/python3.10/dist-
packages (from roboflow) (1.16.0)
Requirement already satisfied: urllib3>=1.26.6 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (2.0.7)
Requirement already satisfied: tqdm>=4.41.0 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (4.66.4)
Requirement already satisfied: PyYAML>=5.3.1 in
/usr/local/lib/python3.10/dist-packages (from roboflow) (6.0.1)
Requirement already satisfied: requests-toolbelt in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.0.0)
Requirement already satisfied: filetype in
/usr/local/lib/python3.10/dist-packages (from roboflow) (1.2.0)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib->roboflow)
```

```
(1.2.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib->roboflow)
(4.53.1)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib->roboflow)
(24.1)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib->roboflow)
(3.1.2)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.10/dist-packages (from requests->roboflow)
(3.3.2)
loading Roboflow workspace...
loading Roboflow project...

Downloading Dataset Version Zip in waldo7-1 to yolov5pytorch:: 100%|
██████████| 32779/32779 [00:01<00:00, 30092.26it/s]



Extracting Dataset Version Zip to waldo7-1 in yolov5pytorch:: 100%|
██████████| 447/447 [00:00<00:00, 3257.67it/s]
```

Train YOLOv5 Model

Running the Python Script:

- !python /content/yolov5/train.py: What It Does: Executes the train.py script located in the yolov5 directory. Purpose: This script is responsible for training the YOLOv5 model on a specified dataset.

Setting Image Size --img 640:

- What It Does: Sets the input image size to 640x640 pixels. Purpose: Defines the resolution at which images will be processed during training. Higher resolutions can improve detection accuracy but require more computational resources.

Setting Batch Size --batch 16:

- What It Does: Sets the batch size to 16. Purpose: Determines the number of images processed together in one forward/backward pass through the model. A batch size of 16 balances memory usage and training speed.

Setting Number of Epochs --epochs 80:

- What It Does: Sets the number of training epochs to 80. Purpose: Defines how many times the entire training dataset will be passed through the model. More epochs typically improve the model's performance but increase training time.

Specifying Dataset --data {dataset.location}/data.yaml:

- What It Does: Points to the data.yaml file of the dataset. Purpose: This file contains information about the dataset, including class names and paths to training and validation images. {dataset.location} is a placeholder for the path where the dataset is downloaded. Setting Pre-trained Weights

--weights yolov5s.pt:

- What It Does: Specifies the pre-trained weights file yolov5s.pt. Purpose: Initializes the model with pre-trained weights, which can speed up training and improve performance by starting from a model that has already learned useful features.

Setting Optimizer --optimizer SGD:

- What It Does: Chooses Stochastic Gradient Descent (SGD) as the optimization algorithm. Purpose: Controls how the model weights are updated during training. SGD is a commonly used optimizer that can perform well for many types of neural network models. Enabling Cache

--cache:

- What It Does: Enables caching of images in memory. Purpose: Speeds up training by reducing the need to load images from disk repeatedly. This can significantly improve training time, especially for large datasets.

```
!python /content/yolov5/train.py --img 640 --batch 16  --epochs 80 --
data {dataset.location}/data.yaml --weights yolov5s.pt  --optimizer
SGD  --cache

2024-07-22 01:34:59.950305: E
external/local_xla/xla/stream_executor/cuda/cuda_dnn.cc:9261] Unable
to register cuDNN factory: Attempting to register factory for plugin
cuDNN when one has already been registered
2024-07-22 01:34:59.950376: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:607] Unable to
register cuFFT factory: Attempting to register factory for plugin
cuFFT when one has already been registered
2024-07-22 01:34:59.953043: E
external/local_xla/xla/stream_executor/cuda/cuda_blas.cc:1515] Unable
to register cuBLAS factory: Attempting to register factory for plugin
cuBLAS when one has already been registered
train: weights=yolov5s.pt, cfg=,
data=/content/yolov5/waldo7-1/data.yaml,
hyp=yolov5/data/hyps/hyp.scratch-low.yaml, epochs=80, batch_size=16,
imgsz=640, rect=False, resume=False, nosave=False, noval=False,
noautoanchor=False, noplots=False, evolve=None,
evolve_population=yolov5/data/hyps, resume_evolve=None, bucket=,
cache=ram, image_weights=False, device=, multi_scale=False,
single_cls=False, optimizer=SGD, sync_bn=False, workers=8,
project=yolov5/runs/train, name=exp, exist_ok=False, quad=False,
cos_lr=False, label_smoothing=0.0, patience=100, freeze=[0],
save_period=-1, seed=0, local_rank=-1, entity=None,
upload_dataset=False, bbox_interval=-1, artifact_alias=latest,
```

```
ndjson_console=False, ndjson_file=False
remote: Enumerating objects: 5, done.ote: Counting objects: 100%
(5/5), done.ote: Compressing objects: 100% (5/5), done.ote: Total 5
(delta 0), reused 0 (delta 0), pack-reused 0
https://github.com/ultralytics/yolov5
 * [new branch]        glenn-jocher-patch-1 -> origin/glenn-jocher-
patch-1
github: up to date with https://github.com/ultralytics/yolov5 □
YOLOv5 □ v7.0-345-g8003649c Python-3.10.12 torch-2.3.1+cu121 CUDA:0
(Tesla T4, 15102MiB)

hyperparameters: 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=0.05, cls=0.5, cls_pw=1.0, obj=1.0,
obj_pw=1.0, iou_t=0.2, anchor_t=4.0, fl_gamma=0.0, 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, mosaic=1.0,
mixup=0.0, copy_paste=0.0
Comet: run 'pip install comet_ml' to automatically track and visualize
YOLOv5 □ runs in Comet
TensorBoard: Start with 'tensorboard --logdir yolov5/runs/train', view
at http://localhost:6006/
Downloading
https://github.com/ultralytics/yolov5/releases/download/v7.0/yolov5s.p
t to yolov5s.pt...
100% 14.1M/14.1M [00:00<00:00, 209MB/s]

Overriding model.yaml nc=80 with nc=1

                 from  n    params  module
arguments
  0                -1  1      3520  models.common.Conv
[3, 32, 6, 2, 2]
  1                -1  1     18560  models.common.Conv
[32, 64, 3, 2]
  2                -1  1     18816  models.common.C3
[64, 64, 1]
  3                -1  1     73984  models.common.Conv
[64, 128, 3, 2]
  4                -1  2    115712  models.common.C3
[128, 128, 2]
  5                -1  1    295424  models.common.Conv
[128, 256, 3, 2]
  6                -1  3    625152  models.common.C3
[256, 256, 3]
  7                -1  1   1180672  models.common.Conv
[256, 512, 3, 2]
  8                -1  1   1182720  models.common.C3
[512, 512, 1]
  9                -1  1    656896  models.common.SPPF
```

```
[512, 512, 5]
 10                -1  1    131584  models.common.Conv
[512, 256, 1, 1]
 11                -1  1         0
torch.nn.modules.upsampling.Upsample    [None, 2, 'nearest']
 12           [-1, 6]  1         0  models.common.Concat
[1]
 13                -1  1    361984  models.common.C3
[512, 256, 1, False]
 14                -1  1     33024  models.common.Conv
[256, 128, 1, 1]
 15                -1  1         0
torch.nn.modules.upsampling.Upsample    [None, 2, 'nearest']
 16           [-1, 4]  1         0  models.common.Concat
[1]
 17                -1  1     90880  models.common.C3
[256, 128, 1, False]
 18                -1  1    147712  models.common.Conv
[128, 128, 3, 2]
 19          [-1, 14]  1         0  models.common.Concat
[1]
 20                -1  1    296448  models.common.C3
[256, 256, 1, False]
 21                -1  1    590336  models.common.Conv
[256, 256, 3, 2]
 22          [-1, 10]  1         0  models.common.Concat
[1]
 23                -1  1   1182720  models.common.C3
[512, 512, 1, False]
 24      [17, 20, 23]  1     16182  models.yolo.Detect
[1, [[10, 13, 16, 30, 33, 23], [30, 61, 62, 45, 59, 119], [116, 90,
156, 198, 373, 326]], [128, 256, 512]]
Model summary: 214 layers, 7022326 parameters, 7022326 gradients, 15.9
GFLOPs

Transferred 343/349 items from yolov5s.pt
AMP: checks passed 
optimizer: SGD(lr=0.01) with parameter groups 57 weight(decay=0.0), 60
weight(decay=0.0005), 60 bias
albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01,
blur_limit=(3, 7)), ToGray(p=0.01), CLAHE(p=0.01, clip_limit=(1, 4.0),
tile_grid_size=(8, 8))
train: Scanning /content/yolov5/waldo7-1/train/labels.cache... 175
images, 0 backgrounds, 0 corrupt: 100% 175/175 [00:00<?, ?it/s]
train: Caching images (0.2GB ram): 100% 175/175 [00:01<00:00,
157.45it/s]
/usr/lib/python3.10/multiprocessing/popen_fork.py:66: RuntimeWarning:
os.fork() was called. os.fork() is incompatible with multithreaded
code, and JAX is multithreaded, so this will likely lead to a
```

```
deadlock.
  self.pid = os.fork()
val: Scanning /content/yolov5/waldo7-1/valid/labels.cache... 44
images, 0 backgrounds, 0 corrupt: 100% 44/44 [00:00<?, ?it/s]
val: Caching images (0.1GB ram): 100% 44/44 [00:00<00:00, 57.68it/s]

AutoAnchor: 5.86 anchors/target, 1.000 Best Possible Recall (BPR).
Current anchors are a good fit to dataset □
Plotting labels to yolov5/runs/train/exp6/labels.jpg...
Image sizes 640 train, 640 val
Using 2 dataloader workers
Logging results to yolov5/runs/train/exp6
Starting training for 80 epochs...

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       0/79      3.66G     0.1205    0.02779          0         17
640: 100% 11/11 [00:09<00:00,  1.15it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:02<00:00,  1.07s/it]
                   all         44         45          0          0
0          0

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       1/79      4.48G     0.1138    0.02277          0         13
640: 100% 11/11 [00:02<00:00,  4.21it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.12it/s]
                   all         44         45   0.000227     0.0667
0.000135   1.35e-05

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       2/79      4.48G     0.1118    0.01902          0         27
640: 100% 11/11 [00:02<00:00,  3.75it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.92it/s]
                   all         44         45   0.000227     0.0667
0.000126    3.3e-05

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       3/79      4.48G     0.1045    0.01752          0         19
640: 100% 11/11 [00:03<00:00,  2.78it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.82it/s]
                   all         44         45   7.58e-05     0.0222
3.95e-05   2.37e-05
```

```
      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       4/79      4.48G    0.09953    0.01778          0         21
640: 100% 11/11 [00:02<00:00,  4.30it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.69it/s]
                   all         44         45   0.000455      0.133
0.000282   7.29e-05

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       5/79      4.48G    0.09859    0.01605          0         18
640: 100% 11/11 [00:02<00:00,  4.14it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.84it/s]
                   all         44         45   0.000606      0.178
0.000389   7.39e-05

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       6/79      4.48G    0.09478    0.01691          0         22
640: 100% 11/11 [00:02<00:00,  4.35it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.12it/s]
                   all         44         45   0.000606      0.178
0.000448   0.000196

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       7/79      4.48G    0.09388    0.01731          0         23
640: 100% 11/11 [00:03<00:00,  2.85it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.35it/s]
                   all         44         45   0.000909      0.267
0.000794   0.000269

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       8/79      4.48G    0.08823    0.01745          0         27
640: 100% 11/11 [00:02<00:00,  3.68it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.34it/s]
                   all         44         45   0.000985      0.289
0.00108   0.000294

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
       9/79      4.48G    0.08392    0.01651          0         25
640: 100% 11/11 [00:02<00:00,  4.34it/s]
                 Class     Images  Instances          P          R
```

```
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.39it/s]
                   all         44         45    0.00121      0.356
0.00337    0.00085

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      10/79      4.48G    0.08101    0.01759          0         24
640: 100% 11/11 [00:02<00:00,  4.41it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.90it/s]
                   all         44         45    0.00209        0.6
0.00746    0.00227

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      11/79      4.48G    0.07687    0.01868          0         24
640: 100% 11/11 [00:03<00:00,  3.05it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.32it/s]
                   all         44         45    0.00275      0.778
0.0625     0.0152

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      12/79      4.48G    0.07223    0.01723          0         24
640: 100% 11/11 [00:03<00:00,  3.05it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.68it/s]
                   all         44         45    0.00313      0.889
0.082     0.0169

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      13/79      4.48G    0.06836    0.01745          0         18
640: 100% 11/11 [00:02<00:00,  4.33it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.07it/s]
                   all         44         45     0.0887      0.222
0.0752     0.0145

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      14/79      4.48G     0.0658    0.01658          0         23
640: 100% 11/11 [00:02<00:00,  4.26it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.05it/s]
                   all         44         45    0.00624      0.867
0.172     0.0573

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
```

```
Size
      15/79      4.48G    0.06515    0.01781          0         18
640: 100% 11/11 [00:02<00:00,  4.19it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.24it/s]
                   all         44         45    0.00313      0.911
0.153     0.0463

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      16/79      4.48G    0.06431      0.018          0         21
640: 100% 11/11 [00:03<00:00,  3.10it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.70it/s]
                   all         44         45    0.00327      0.956
0.187      0.057

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      17/79      4.48G    0.05875    0.01713          0         20
640: 100% 11/11 [00:02<00:00,  3.79it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.05it/s]
                   all         44         45     0.0119      0.867
0.323      0.102

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      18/79      4.48G    0.05674    0.01602          0         22
640: 100% 11/11 [00:02<00:00,  4.37it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.19it/s]
                   all         44         45      0.648      0.245
0.33     0.0934

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      19/79      4.48G    0.05681      0.017          0         18
640: 100% 11/11 [00:02<00:00,  4.07it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.76it/s]
                   all         44         45      0.629      0.226
0.295      0.104

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      20/79      4.48G    0.05619    0.01614          0         22
640: 100% 11/11 [00:03<00:00,  3.20it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.05it/s]
```

```
                   all         44         45      0.583      0.178
0.249      0.103

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      21/79      4.48G    0.05291    0.01608          0         18
640: 100% 11/11 [00:03<00:00,  2.97it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.53it/s]
                   all         44         45      0.766      0.378
0.471      0.173

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      22/79      4.48G    0.04995    0.01632          0         21
640: 100% 11/11 [00:02<00:00,  4.24it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.63it/s]
                   all         44         45      0.413      0.222
0.21     0.0789

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      23/79      4.48G    0.05237    0.01637          0         20
640: 100% 11/11 [00:02<00:00,  4.11it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.92it/s]
                   all         44         45      0.776      0.333
0.446      0.171

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      24/79      4.48G    0.04981    0.01428          0         21
640: 100% 11/11 [00:02<00:00,  4.02it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.10it/s]
                   all         44         45      0.776      0.378
0.46      0.113

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      25/79      4.48G    0.05429     0.0129          0         18
640: 100% 11/11 [00:03<00:00,  2.97it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.51it/s]
                   all         44         45      0.817      0.422
0.588      0.228

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
```

```
      26/79      4.48G     0.0521    0.01432          0          23
640: 100% 11/11 [00:02<00:00,  3.98it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.05it/s]
                   all         44         45      0.769        0.4
0.462      0.171

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      27/79      4.48G    0.04834    0.01394          0          20
640: 100% 11/11 [00:02<00:00,  4.36it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.18it/s]
                   all         44         45      0.781      0.477
0.594      0.241

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      28/79      4.48G    0.04969    0.01395          0          16
640: 100% 11/11 [00:02<00:00,  4.26it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.06it/s]
                   all         44         45      0.842      0.511
0.626       0.23

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      29/79      4.48G    0.04956    0.01307          0          17
640: 100% 11/11 [00:03<00:00,  3.12it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.28it/s]
                   all         44         45      0.841      0.533
0.635       0.23

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      30/79      4.48G    0.04746    0.01246          0          20
640: 100% 11/11 [00:03<00:00,  3.10it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.15it/s]
                   all         44         45      0.922      0.524
0.663      0.251

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      31/79      4.48G    0.04727    0.01312          0          27
640: 100% 11/11 [00:02<00:00,  4.24it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.02it/s]
                   all         44         45      0.846        0.6
```

```
0.702      0.307

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      32/79      4.48G    0.04543    0.01272          0         26
640: 100% 11/11 [00:02<00:00,  4.24it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.19it/s]
                   all         44         45      0.825       0.63
0.738      0.313

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      33/79      4.48G    0.04645    0.01218          0         20
640: 100% 11/11 [00:03<00:00,  3.60it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.33it/s]
                   all         44         45       0.82      0.622
0.747      0.316

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      34/79      4.48G    0.04347    0.01137          0         18
640: 100% 11/11 [00:03<00:00,  2.88it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.83it/s]
                   all         44         45      0.749      0.664
0.722      0.265

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      35/79      4.48G    0.04573    0.01151          0         21
640: 100% 11/11 [00:02<00:00,  4.06it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.11it/s]
                   all         44         45      0.721      0.622
0.698      0.278

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      36/79      4.48G    0.04047    0.01184          0         13
640: 100% 11/11 [00:02<00:00,  4.38it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.21it/s]
                   all         44         45      0.704      0.644
0.725      0.288

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      37/79      4.48G    0.04523    0.01111          0         15
```

```
640: 100% 11/11 [00:02<00:00,  4.28it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.03it/s]
                   all         44         45      0.743      0.733
0.807      0.309

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      38/79      4.48G     0.0425    0.01205          0         19
640: 100% 11/11 [00:03<00:00,  3.15it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.42it/s]
                   all         44         45      0.751      0.667
0.75      0.343

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      39/79      4.48G    0.04213   0.009556          0         22
640: 100% 11/11 [00:03<00:00,  2.83it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.28it/s]
                   all         44         45      0.828      0.667
0.801      0.371

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      40/79      4.48G    0.04535    0.01037          0         27
640: 100% 11/11 [00:02<00:00,  4.34it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.64it/s]
                   all         44         45      0.888      0.707
0.823      0.366

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      41/79      4.48G     0.0404    0.01058          0         19
640: 100% 11/11 [00:02<00:00,  4.32it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.04it/s]
                   all         44         45      0.886      0.756
0.803      0.373

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      42/79      4.48G    0.03933   0.009997          0         24
640: 100% 11/11 [00:02<00:00,  3.95it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.87it/s]
                   all         44         45      0.847      0.741
0.811      0.378
```

```
      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      43/79      4.48G    0.04022    0.01001          0         16
640: 100% 11/11 [00:03<00:00,  2.88it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.87it/s]
                   all         44         45      0.823      0.733
0.812      0.388

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      44/79      4.48G    0.03991   0.009386          0         18
640: 100% 11/11 [00:03<00:00,  3.43it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.85it/s]
                   all         44         45      0.859      0.733
0.825      0.385

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      45/79      4.48G    0.03839    0.01012          0         23
640: 100% 11/11 [00:02<00:00,  4.29it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.01it/s]
                   all         44         45      0.886      0.733
0.83      0.414

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      46/79      4.48G    0.03795   0.009762          0         21
640: 100% 11/11 [00:02<00:00,  4.23it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.02it/s]
                   all         44         45      0.878      0.711
0.847      0.395

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      47/79      4.48G    0.03833   0.009807          0         20
640: 100% 11/11 [00:03<00:00,  3.28it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.12it/s]
                   all         44         45      0.894      0.711
0.83      0.358

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      48/79      4.48G    0.03739   0.009665          0         24
640: 100% 11/11 [00:03<00:00,  2.90it/s]
```

```
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.83it/s]
                   all         44         45      0.907      0.711
0.823      0.349

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      49/79      4.48G    0.03846   0.009097          0         18
640: 100% 11/11 [00:02<00:00,  3.92it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.09it/s]
                   all         44         45      0.875      0.689
0.791      0.369

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      50/79      4.48G     0.0377   0.009421          0         17
640: 100% 11/11 [00:02<00:00,  4.26it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.10it/s]
                   all         44         45      0.851      0.759
0.836       0.44

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      51/79      4.48G    0.03658   0.009181          0         21
640: 100% 11/11 [00:02<00:00,  4.34it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.94it/s]
                   all         44         45      0.857      0.798
0.852      0.444

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      52/79      4.48G    0.03852   0.008489          0         19
640: 100% 11/11 [00:03<00:00,  3.08it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.15it/s]
                   all         44         45      0.896      0.766
0.854      0.411

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      53/79      4.48G    0.03616   0.009133          0         19
640: 100% 11/11 [00:03<00:00,  2.94it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.49it/s]
                   all         44         45      0.871      0.778
0.856      0.419
```

```
      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      54/79      4.48G    0.03413    0.00892          0         13
640: 100% 11/11 [00:02<00:00,  4.34it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.08it/s]
                   all         44         45      0.887      0.756
0.864      0.434

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      55/79      4.48G    0.03776   0.008997          0         24
640: 100% 11/11 [00:02<00:00,  4.19it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.09it/s]
                   all         44         45       0.85      0.733
0.84       0.41

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      56/79      4.48G    0.03301   0.007689          0         19
640: 100% 11/11 [00:02<00:00,  4.13it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.18it/s]
                   all         44         45      0.869      0.733
0.867      0.446

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      57/79      4.48G     0.0351   0.009232          0         19
640: 100% 11/11 [00:03<00:00,  2.92it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.87it/s]
                   all         44         45      0.874      0.778
0.874      0.434

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      58/79      4.48G    0.03736   0.009578          0         21
640: 100% 11/11 [00:02<00:00,  4.27it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.09it/s]
                   all         44         45      0.878      0.798
0.874      0.428

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      59/79      4.48G    0.03479   0.008936          0         18
640: 100% 11/11 [00:02<00:00,  4.30it/s]
                 Class     Images  Instances          P          R
```

```
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.26it/s]
                   all         44         45      0.897      0.774
0.884      0.445

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      60/79      4.48G    0.03371   0.008347          0         24
640: 100% 11/11 [00:02<00:00,  4.38it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.04it/s]
                   all         44         45      0.842      0.826
0.881       0.43

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      61/79      4.48G    0.03239   0.009155          0         21
640: 100% 11/11 [00:03<00:00,  3.08it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.71it/s]
                   all         44         45       0.88      0.814
0.883      0.456

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      62/79      4.48G    0.03071   0.008251          0         25
640: 100% 11/11 [00:03<00:00,  3.20it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.15it/s]
                   all         44         45      0.878      0.778
0.887       0.45

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      63/79      4.48G    0.03339   0.008987          0         24
640: 100% 11/11 [00:02<00:00,  4.34it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.19it/s]
                   all         44         45      0.856      0.791
0.886      0.446

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      64/79      4.48G    0.03114   0.007717          0         29
640: 100% 11/11 [00:02<00:00,  4.33it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.13it/s]
                   all         44         45      0.931      0.733
0.885      0.457

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
```

```
Size
      65/79      4.48G    0.03384   0.007615          0         19
640: 100% 11/11 [00:03<00:00,  3.61it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.85it/s]
                   all         44         45       0.93      0.733
0.877      0.438

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      66/79      4.48G    0.03032   0.008065          0         15
640: 100% 11/11 [00:04<00:00,  2.74it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.24it/s]
                   all         44         45      0.915      0.711
0.873      0.448

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      67/79      4.48G     0.0313   0.008261          0         24
640: 100% 11/11 [00:02<00:00,  4.33it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.09it/s]
                   all         44         45       0.92      0.711
0.879       0.47

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      68/79      4.48G    0.02909   0.007898          0         23
640: 100% 11/11 [00:02<00:00,  4.27it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.92it/s]
                   all         44         45      0.919      0.711
0.877       0.46

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      69/79      4.48G    0.02935   0.007453          0         16
640: 100% 11/11 [00:02<00:00,  4.06it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.67it/s]
                   all         44         45      0.829        0.8
0.879      0.472

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      70/79      4.48G    0.02966   0.008425          0         19
640: 100% 11/11 [00:03<00:00,  2.92it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.74it/s]
```

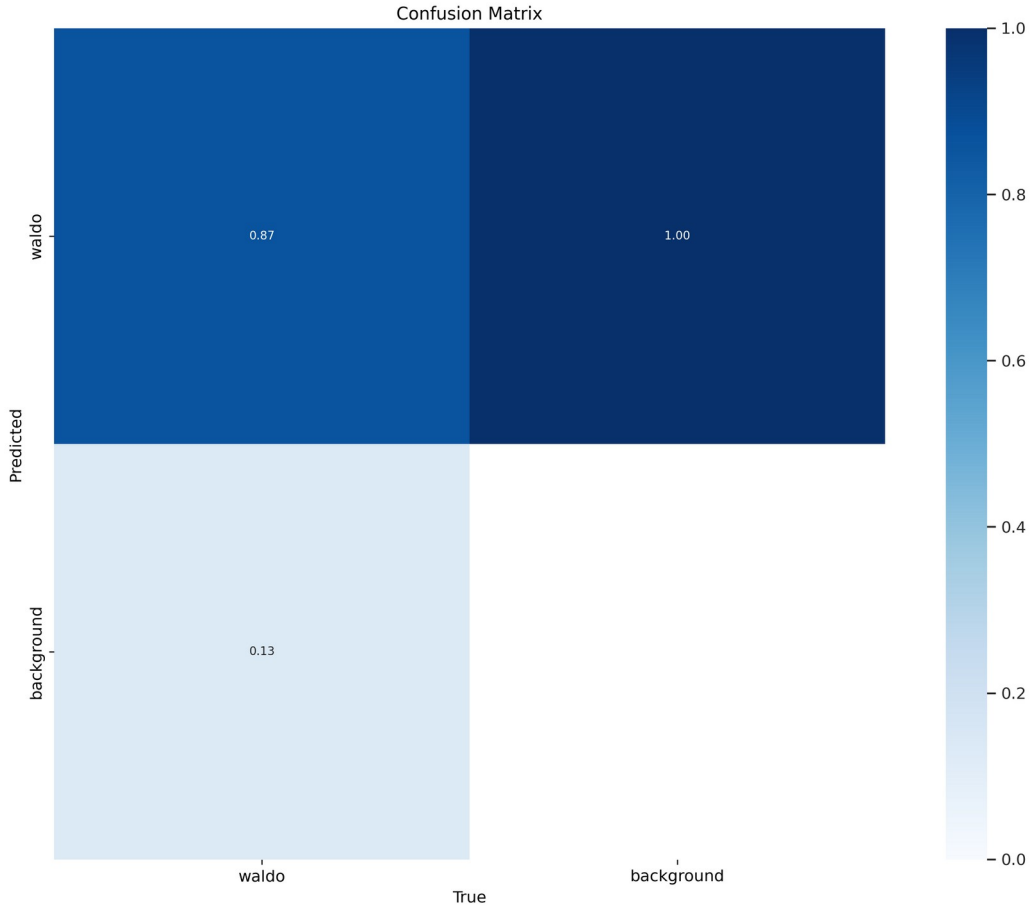
```
                   all         44         45      0.942      0.756
0.883      0.498

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      71/79      4.48G    0.02827   0.008406          0         26
640: 100% 11/11 [00:02<00:00,  4.22it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.94it/s]
                   all         44         45      0.937      0.756
0.885      0.459

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      72/79      4.48G    0.02922   0.007721          0         23
640: 100% 11/11 [00:02<00:00,  4.30it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.04it/s]
                   all         44         45      0.931      0.756
0.888      0.476

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      73/79      4.48G    0.02967   0.008078          0         20
640: 100% 11/11 [00:02<00:00,  4.24it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.08it/s]
                   all         44         45      0.938      0.756
0.889      0.491

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      74/79      4.48G    0.02843   0.007629          0         19
640: 100% 11/11 [00:03<00:00,  3.01it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.02it/s]
                   all         44         45      0.934      0.756
0.893      0.487

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      75/79      4.48G    0.02924   0.008114          0         26
640: 100% 11/11 [00:03<00:00,  2.93it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.15it/s]
                   all         44         45      0.935      0.756
0.894       0.47

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
```

```
      76/79      4.48G    0.02837   0.007847          0         29
640: 100% 11/11 [00:02<00:00,  4.33it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  3.95it/s]
                   all         44         45      0.938      0.756
0.894      0.481

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      77/79      4.48G    0.02834   0.007133          0         20
640: 100% 11/11 [00:02<00:00,  4.24it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  4.00it/s]
                   all         44         45      0.944      0.751
0.897      0.487

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      78/79      4.48G    0.02916   0.007699          0         26
640: 100% 11/11 [00:02<00:00,  4.28it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.95it/s]
                   all         44         45      0.907      0.756
0.887      0.462

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances
Size
      79/79      4.48G    0.02974   0.007398          0         15
640: 100% 11/11 [00:03<00:00,  3.01it/s]
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:00<00:00,  2.11it/s]
                   all         44         45      0.902      0.756
0.888      0.467

80 epochs completed in 0.097 hours.
Optimizer stripped from yolov5/runs/train/exp6/weights/last.pt, 14.4MB
Optimizer stripped from yolov5/runs/train/exp6/weights/best.pt, 14.4MB

Validating yolov5/runs/train/exp6/weights/best.pt...
Fusing layers...
Model summary: 157 layers, 7012822 parameters, 0 gradients, 15.8
GFLOPs
                 Class     Images  Instances          P          R
mAP50   mAP50-95: 100% 2/2 [00:01<00:00,  1.79it/s]
                   all         44         45       0.94      0.756
0.883      0.498
Results saved to yolov5/runs/train/exp6
```

Display the Confusion Matrix

- The confusion matrix is a performance measurement tool for classification problems, showing how predictions match with actual classes. This visualization helps in evaluating the model's performance by illustrating the counts of true positives, false positives, true negatives, and false negatives.

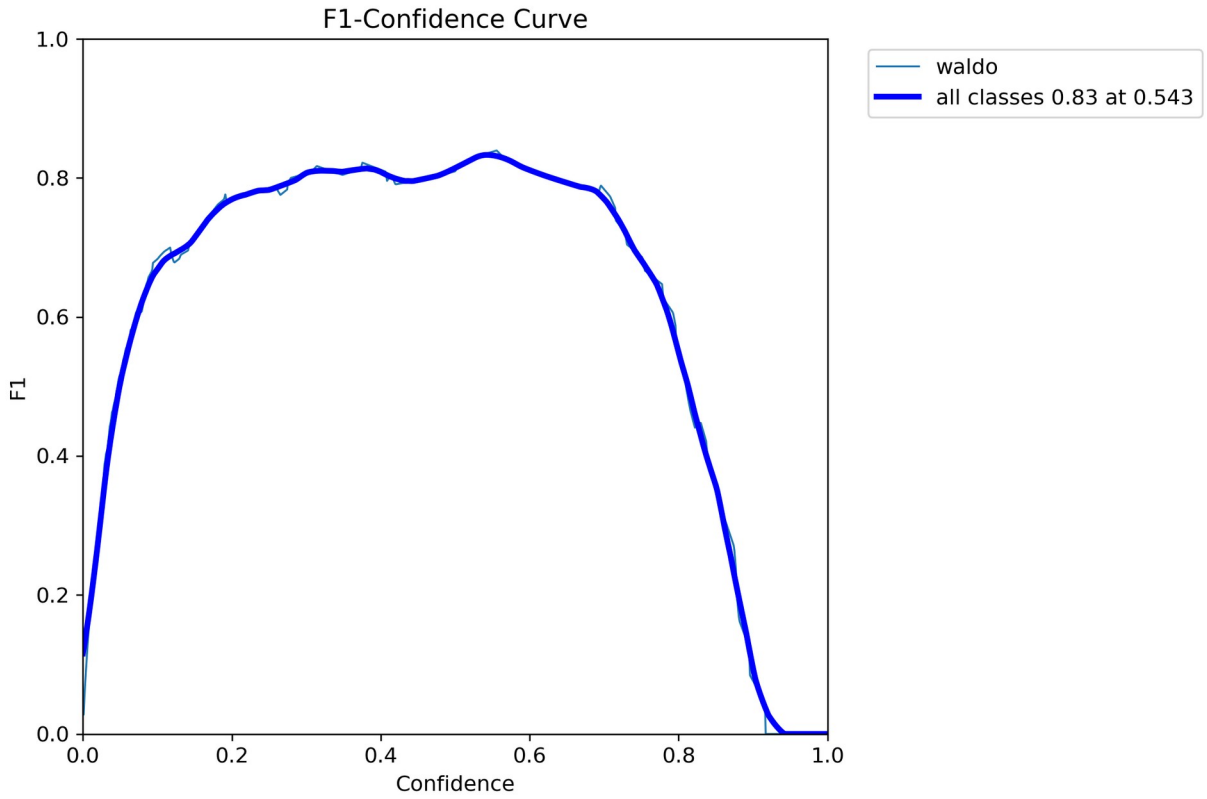
```
Image(filename=f'/content/yolov5/runs/train/exp6/confusion_matrix.png', width=900)
```



Display the F1 Score Curve

- The F1 score is a metric that combines precision and recall, providing a single score to assess the model's performance, especially in imbalanced datasets. This curve helps in understanding how well the model balances precision and recall over different operating points.

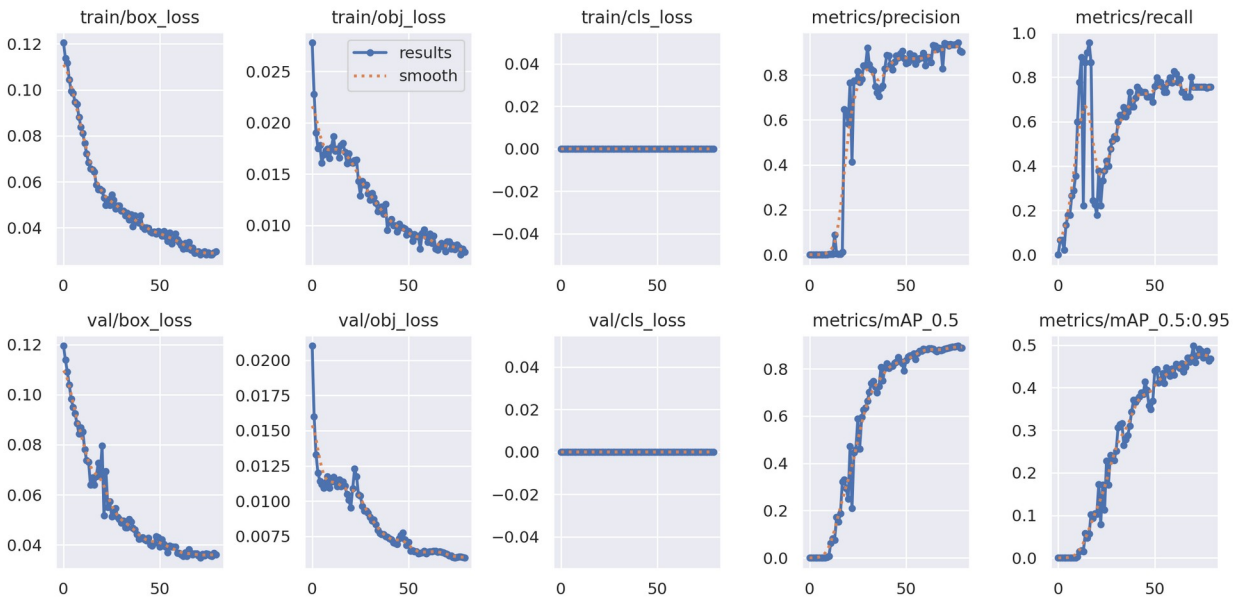
```
Image(filename=f'/content/yolov5/runs/train/exp6/F1_curve.png', width=900)
```



Display the Results Image

the file typically includes visualizations of the training results, such as detection performance on validation images.

```
Image(filename=f'/content/yolov5/runs/train/exp6/results.png',
width=900)
```



Display an Image with Predictions

- The val_batch0_pred.jpg file shows an image from the validation set with the model's predictions. Each detected object is annotated with its predicted class. This visualization helps in evaluating how well the model predicts and classifies objects in the validation images.

```
Image(filename=f'/content/yolov5/runs/train/exp6/train_batch1.jpg',
width=900)
```

Run YOLOv8 for Prediction

- The command runs the YOLOv8 CLI tool to perform object detection on a specified image using a pre-trained model

```
!python /content/yolov5/detect.py --weights
/content/yolov5/runs/train/exp6/weights/best.pt --img 640 --conf 0.3
--source /content/waldo_1.jpg

detect: weights=['/content/yolov5/runs/train/exp6/weights/best.pt'],
source=/content/waldo_1.jpg, data=yolov5/data/coco128.yaml,
imgsz=[640, 640], conf_thres=0.1, iou_thres=0.45, max_det=1000,
```

```
device=, view_img=False, save_txt=False, save_csv=False,
save_conf=False, save_crop=False, nosave=False, classes=None,
agnostic_nms=False, augment=False, visualize=False, update=False,
project=yolov5/runs/detect, name=exp, exist_ok=False,
line_thickness=3, hide_labels=False, hide_conf=False, half=False,
dnn=False, vid_stride=1
YOLOv5 □ v7.0-345-g8003649c Python-3.10.12 torch-2.3.1+cu121 CUDA:0
(Tesla T4, 15102MiB)

Fusing layers...
Model summary: 157 layers, 7012822 parameters, 0 gradients, 15.8
GFLOPs
image 1/1 /content/waldo_1.jpg: 384x640 4 waldos, 51.4ms
Speed: 0.5ms pre-process, 51.4ms inference, 530.9ms NMS per image at
shape (1, 3, 640, 640)
Results saved to yolov5/runs/detect/exp3
```

SAHI (Slicing Aided Hyper Inference)

Overview

SAHI, short for Slicing Aided Hyper Inference, is a method designed to improve the performance and accuracy of object detection models, especially on large images or images with densely packed objects. It works by slicing large images into smaller, more manageable pieces, performing inference on these smaller slices, and then combining the results.

Key Features

1. **Slicing Large Images**:
   - SAHI slices large images into smaller tiles, enabling the model to process each tile independently. This approach is particularly useful for high-resolution images where objects might be small and spread across a large area.
2. **Handling Dense Object Regions**:
   - By breaking down the image, SAHI allows for better detection in densely populated object areas. Smaller slices mean the model can focus on detailed regions without being overwhelmed by the entire image's complexity.
3. **Combining Results**:
   - After processing the slices, SAHI merges the detection results to form a cohesive output. This ensures that objects detected in different slices are correctly mapped back to their original positions in the large image.
4. **Improving Detection Accuracy**:
   - The slicing mechanism helps in improving the overall detection accuracy by ensuring that objects at different scales and positions are effectively detected without being missed due to image size constraints.

How SAHI Works

1. Image Slicing

The input image is divided into smaller overlapping or non-overlapping tiles. Overlapping tiles can help in ensuring that objects near the edges of slices are not missed.

2. Model Inference

Each tile is then fed independently to the object detection model (like YOLO). The model processes each tile and returns detection results for that specific region.

3. Post-Processing

The detection results from all the tiles are then combined. This step involves adjusting the coordinates of the detected objects to their original positions in the large image.

```
from sahi.utils.yolov8 import (
    download_yolov8s_model
)

from sahi import AutoDetectionModel
import torch
from sahi.utils.cv import read_image
from sahi.utils.file import download_from_url
from sahi.predict import get_prediction, get_sliced_prediction,
predict
from sahi.predict import visualize_object_predictions
from IPython.display import Image
from numpy import asarray
from ultralytics import YOLO

yolov8_model_path = "your_model_path"
download_yolov8s_model(yolov8_model_path)

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
print(f"Using device: {device}")

detection_model = AutoDetectionModel.from_pretrained(
    model_type='yolov8',
    model_path=yolov8_model_path,
    confidence_threshold=0.2,
    device=device, # or 'cuda:0'
)

image_path = 'your_image_path'

result = get_prediction(image_path, detection_model)
result.export_visuals(export_dir="demo_data/")
```

```
Image("demo_data/prediction_visual.png")

result = get_sliced_prediction(
    image_path,
    detection_model,
    slice_height = 256,
    slice_width = 256,
    overlap_height_ratio = 0.2,
    overlap_width_ratio = 0.2
)

result.export_visuals(export_dir="demo_data/")

Image("demo_data/prediction_visual.png")
```

Conclusion: YOLOv8 vs YOLOv5 with SAHI

Performance Comparison

While both YOLOv5 and YOLOv8 are highly effective object detection models, YOLOv8 has shown substantial improvements over YOLOv5 in various aspects, even when SAHI (Slicing Aided Hyper Inference) is applied. Here's a comparison highlighting why YOLOv8 often outperforms YOLOv5:

1. **Architectural Advancements**

- **YOLOv8**: Incorporates several architectural enhancements over YOLOv5, including more efficient backbone networks and improved neck designs. These upgrades lead to better feature extraction and more accurate object localization and classification.
- **YOLOv5**: Although effective, it lacks some of the architectural innovations present in YOLOv8, which can limit its performance on complex and diverse datasets.

2. **Accuracy and Speed**

- **YOLOv8**: Offers significant improvements in both accuracy and inference speed. YOLOv8's advancements in model architecture and optimization techniques result in higher mAP (mean Average Precision) and faster detection times compared to YOLOv5.
- **YOLOv5 with SAHI**: SAHI improves the accuracy of YOLOv5 by addressing challenges related to large images and dense object regions. However, the inherent limitations of YOLOv5's architecture still affect its overall performance relative to YOLOv8.

3. **Handling of Large and Complex Images**

- **YOLOv8**: Its optimized architecture enables it to handle large and complex images more effectively without requiring additional techniques like SAHI. YOLOv8's inherent capabilities make it more robust and efficient in processing high-resolution and densely packed images.

- **YOLOv5 with SAHI**: While SAHI enhances YOLOv5's ability to process large images by slicing them into manageable tiles, the underlying model architecture still imposes constraints. YOLOv5's performance, even with SAHI, may not match the efficiency and accuracy of YOLOv8.

4. **Resource Efficiency**

- **YOLOv8**: Optimized to deliver high performance while maintaining computational efficiency. It achieves better results with lower computational resources, making it suitable for deployment in resource-constrained environments.
- **YOLOv5 with SAHI**: The SAHI technique, while useful, adds computational overhead due to the need for slicing and merging images. YOLOv5 may require more computational resources and time to achieve comparable results to YOLOv8.

Summary

In summary, while SAHI significantly enhances YOLOv5's performance on large and complex images by improving object detection accuracy and efficiency, YOLOv8 generally outperforms YOLOv5 even when SAHI is applied. YOLOv8's advanced architecture provides superior accuracy, faster inference times, and better handling of large and complex images, making it a more powerful and efficient choice for modern object detection tasks. The improvements in YOLOv8 make it a preferred option for applications requiring high performance and precision, even beyond the benefits of techniques like SAHI.