Deep Learning Lab
Lab Assignment NO.03
Object Detection and Multi Object Classification

1.1 Lab Title: YOLOv12 Model on Flank_Yoke Dataset

1.1.1 Student Details

- **Name:** Md Yaseen Alam
- **PRN:** 202201040060
- **Roll No.:** 23
- **Division:** A2

1.1.2 Group Members

- Vaibhav Jadhav, 202201040027
- Vidya Bingi, 202201040019
- Om Borle, 202201040035

- **Links:**
- **Colab**: https://colab.research.google.com/drive/1AMQbdkubIoimLpQaFfufbFR_XNh50XTF?usp=sharing
- **Github**: https://github.com/Dante-hero/Lab-Assignment-NO.03-Object-Detection-and-Multi-Object-Classification
- **Dataset**:https://app.roboflow.com/maskface-swciq/sample-project-drkwz/1

1.2 Objective

- To perform defect detection on the **Flank_Yoke** dataset using deep learning models.
- To preprocess images and annotations for model training.
- To fine-tune a pre-trained object detection model (e.g., **YOLO**, **SSD**) for industrial defect detection.
- To evaluate model performance using metrics like **IoU** (Intersection over Union) and **mAP** (mean Average Precision).

- To analyze **real-time defect detection and classification** results for quality assurance.
- To develop a **robust vision-based defect detection system** for identifying faults in flank yoke components.
- To improve manufacturing efficiency by **automating defect detection** in mechanical parts.

[ ]:
```
import os
HOME = os.getcwd()
print(HOME)
```

```
/content
```

[ ]:
```
# Pip install method (recommended)

!pip install ultralytics

from IPython import display
display.clear_output()

import ultralytics
ultralytics.checks()
```

```
Ultralytics 8.3.94 Python-3.11.11 torch-2.6.0+cu124 CUDA:0 (Tesla T4,
15095MiB)
Setup complete (2 CPUs, 12.7 GB RAM, 41.1/112.6 GB disk)
```

[ ]:
```
from ultralytics import YOLO

from IPython.display import display, Image
```

[ ]:
```
%cd {HOME}
!yolo task=detect mode=predict model=yolo12s.pt conf=0.25 source='https://media.
roboflow.com/notebooks/examples/dog.jpeg' save=True
```

```
/content
Downloading
https://github.com/ultralytics/assets/releases/download/v8.3.0/yolo12s.pt to
'yolo12s.pt'...
100% 18.1M/18.1M [00:00<00:00, 73.5MB/s]
Ultralytics 8.3.94 Python-3.11.11 torch-2.6.0+cu124 CUDA:0 (Tesla T4,
15095MiB)
YOLOv12s summary (fused): 159 layers, 9,261,840 parameters, 0 gradients, 21.4
GFLOPs

Downloading https://media.roboflow.com/notebooks/examples/dog.jpeg to
'dog.jpeg'...
100% 104k/104k [00:00<00:00, 82.8MB/s]
```

image 1/1 /content/dog.jpeg: 640x384 1 person, 1 car, 1 dog, 1 handbag, 54.7ms
Speed: 12.4ms preprocess, 54.7ms inference, 345.5ms postprocess per image at shape (1, 3, 640, 384)
Results saved to **runs/detect/predict**
Learn more at https://docs.ultralytics.com/modes/predict

1.3 Custom Training

[ ]:
```
!mkdir {HOME}/datasets
%cd {HOME}/datasets

!pip install roboflow

from roboflow import Roboflow
rf = Roboflow(api_key="WXdDGWePf6jCCSvJLl5i")
project = rf.workspace("maskface-swciq").project("sample-project-drkwz")
version = project.version(1)
dataset = version.download("yolov12")
```

/content/datasets
Requirement already satisfied: roboflow in /usr/local/lib/python3.11/dist-packages (1.1.58)
Requirement already satisfied: certifi in /usr/local/lib/python3.11/dist-packages (from roboflow) (2025.1.31)
Requirement already satisfied: idna==3.7 in /usr/local/lib/python3.11/dist-packages (from roboflow) (3.7)
Requirement already satisfied: cycler in /usr/local/lib/python3.11/dist-packages (from roboflow) (0.12.1)
Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from roboflow) (1.4.8)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.11/dist-packages (from roboflow) (3.10.0)
Requirement already satisfied: numpy>=1.18.5 in /usr/local/lib/python3.11/dist-packages (from roboflow) (2.0.2)
Requirement already satisfied: opencv-python-headless==4.10.0.84 in /usr/local/lib/python3.11/dist-packages (from roboflow) (4.10.0.84)
Requirement already satisfied: Pillow>=7.1.2 in /usr/local/lib/python3.11/dist-packages (from roboflow) (11.1.0)
Requirement already satisfied: pillow-heif>=0.18.0 in /usr/local/lib/python3.11/dist-packages (from roboflow) (0.22.0)
Requirement already satisfied: python-dateutil in /usr/local/lib/python3.11/dist-packages (from roboflow) (2.8.2)
Requirement already satisfied: python-dotenv in /usr/local/lib/python3.11/dist-packages (from roboflow) (1.0.1)
Requirement already satisfied: requests in /usr/local/lib/python3.11/dist-packages (from roboflow) (2.32.3)
Requirement already satisfied: six in /usr/local/lib/python3.11/dist-packages (from roboflow) (1.17.0)

```
Requirement already satisfied: urllib3>=1.26.6 in
/usr/local/lib/python3.11/dist-packages (from roboflow) (2.3.0)
Requirement already satisfied: tqdm>=4.41.0 in /usr/local/lib/python3.11/dist-
packages (from roboflow) (4.67.1)
Requirement already satisfied: PyYAML>=5.3.1 in /usr/local/lib/python3.11/dist-
packages (from roboflow) (6.0.2)
Requirement already satisfied: requests-toolbelt in
/usr/local/lib/python3.11/dist-packages (from roboflow) (1.0.0)
Requirement already satisfied: filetype in /usr/local/lib/python3.11/dist-
packages (from roboflow) (1.2.0)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.11/dist-packages (from matplotlib->roboflow) (1.3.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.11/dist-packages (from matplotlib->roboflow) (4.56.0)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.11/dist-packages (from matplotlib->roboflow) (24.2)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.11/dist-packages (from matplotlib->roboflow) (3.2.1)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.11/dist-packages (from requests->roboflow) (3.4.1)
loading Roboflow workspace...
loading Roboflow project...

Downloading Dataset Version Zip in Sample-Project-1 to yolov12::
100%|          | 2249/2249 [00:00<00:00, 7275.40it/s]



Extracting Dataset Version Zip to Sample-Project-1 in yolov12:: 100%|          |
72/72 [00:00<00:00, 6052.51it/s]
```

[ ]:
```
%cd {HOME}

!yolo task=detect mode=train model=yolo12s.pt data=/content/datasets/
  Sample-Project-1/data.yaml  epochs=100  imgsz=640  plots=True
```

```
/content
Ultralytics 8.3.94      Python-3.11.11 torch-2.6.0+cu124 CUDA:0 (Tesla T4,
15095MiB)
engine/trainer: task=detect, mode=train, model=yolo12s.pt,
data=/content/datasets/Sample-Project-1/data.yaml, epochs=100, time=None,
patience=100, batch=16, imgsz=640, save=True, save_period=-1, cache=False,
device=None, workers=8, project=None, name=train, exist_ok=False,
pretrained=True, optimizer=auto, verbose=True, seed=0, deterministic=True,
single_cls=False, rect=False, cos_lr=False, close_mosaic=10, resume=False,
amp=True, fraction=1.0, profile=False, freeze=None, multi_scale=False,
overlap_mask=True, mask_ratio=4, dropout=0.0, val=True, split=val,
save_json=False, save_hybrid=False, conf=None, iou=0.7, max_det=300, half=False,
```

```
dnn=False, plots=True, source=None, vid_stride=1, stream_buffer=False,
visualize=False, augment=False, agnostic_nms=False, classes=None,
retina_masks=False, embed=None, show=False, save_frames=False, save_txt=False,
save_conf=False, save_crop=False, show_labels=True, show_conf=True,
show_boxes=True, line_width=None, format=torchscript, keras=False,
optimize=False, int8=False, dynamic=False, simplify=True, opset=None,
workspace=None, nms=False, lr0=0.01, lrf=0.01, momentum=0.937,
weight_decay=0.0005, warmup_epochs=3.0, warmup_momentum=0.8, warmup_bias_lr=0.1,
box=7.5, cls=0.5, dfl=1.5, pose=12.0, kobj=1.0, nbs=64, hsv_h=0.015, hsv_s=0.7,
hsv_v=0.4, degrees=0.0, translate=0.1, scale=0.5, shear=0.0, perspective=0.0,
flipud=0.0, fliplr=0.5, bgr=0.0, mosaic=1.0, mixup=0.0, copy_paste=0.0,
copy_paste_mode=flip, auto_augment=randaugment, erasing=0.4, crop_fraction=1.0,
cfg=None, tracker=botsort.yaml, save_dir=runs/detect/train
Downloading https://ultralytics.com/assets/Arial.ttf to
'/root/.config/Ultralytics/Arial.ttf'...
100% 755k/755k [00:00<00:00, 23.9MB/s]
WARNING: All log messages before absl::InitializeLog() is called are written to
STDERR
E0000 00:00:1742722476.685067 5574 cuda_dnn.cc:8310] Unable to register cuDNN
factory: Attempting to register factory for plugin cuDNN when one has already
been registered
E0000 00:00:1742722476.745102 5574 cuda_blas.cc:1418] Unable to register
cuBLAS factory: Attempting to register factory for plugin cuBLAS when one has
already been registered
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     26080  ultralytics.nn.modules.block.C3k2
[64, 128, 1, False, 0.25]
  3                  -1  1    147712  ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]
  4                  -1  1    103360  ultralytics.nn.modules.block.C3k2
[128, 256, 1, False, 0.25]
  5                  -1  1    590336  ultralytics.nn.modules.conv.Conv
[256, 256, 3, 2]
  6                  -1  2    689408  ultralytics.nn.modules.block.A2C2f
[256, 256, 2, True, 4]
  7                  -1  1   1180672  ultralytics.nn.modules.conv.Conv
[256, 512, 3, 2]
  8                  -1  2   2689536  ultralytics.nn.modules.block.A2C2f
[512, 512, 2, True, 1]
  9                  -1  1         0  torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']
```

```
 10              [-1, 6]  1         0  ultralytics.nn.modules.conv.Concat
[1]
 11                  -1  1    345856  ultralytics.nn.modules.block.A2C2f
[768, 256, 1, False, -1]
 12                  -1  1         0  torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']
 13              [-1, 4]  1         0  ultralytics.nn.modules.conv.Concat
[1]
 14                  -1  1     95104  ultralytics.nn.modules.block.A2C2f
[512, 128, 1, False, -1]
 15                  -1  1    147712  ultralytics.nn.modules.conv.Conv
[128, 128, 3, 2]
 16             [-1, 11]  1         0  ultralytics.nn.modules.conv.Concat
[1]
 17                  -1  1    296704  ultralytics.nn.modules.block.A2C2f
[384, 256, 1, False, -1]
 18                  -1  1    590336  ultralytics.nn.modules.conv.Conv
[256, 256, 3, 2]
 19              [-1, 8]  1         0  ultralytics.nn.modules.conv.Concat
[1]
 20                  -1  1   1511424  ultralytics.nn.modules.block.C3k2
[768, 512, 1, True]
 21        [14, 17, 20]  1    819795  ultralytics.nn.modules.head.Detect
[1, [128, 256, 512]]
YOLOv12s summary: 272 layers, 9,253,523 parameters, 9,253,507 gradients, 21.5
GFLOPs

Transferred 685/691 items from pretrained weights
TensorBoard: Start with 'tensorboard --logdir runs/detect/train',
view at http://localhost:6006/
Freezing layer 'model.21.dfl.conv.weight'
AMP: running Automatic Mixed Precision (AMP) checks...
Downloading
https://github.com/ultralytics/assets/releases/download/v8.3.0/yolo11n.pt to
'yolo11n.pt'...
100% 5.35M/5.35M [00:00<00:00, 100MB/s]
AMP: checks passed
train: Scanning /content/datasets/Sample-Project-1/train/labels...
25 images, 0 backgrounds, 0 corrupt: 100% 25/25 [00:00<00:00, 1604.28it/s]
train: New cache created: /content/datasets/Sample-
Project-1/train/labels.cache
albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01,
blur_limit=(3, 7)), ToGray(p=0.01, num_output_channels=3,
method='weighted_average'), CLAHE(p=0.01, clip_limit=(1.0, 4.0),
tile_grid_size=(8, 8))
val: Scanning /content/datasets/Sample-Project-1/valid/labels... 2
images, 0 backgrounds, 0 corrupt: 100% 2/2 [00:00<00:00, 534.17it/s]
val: New cache created: /content/datasets/Sample-
```

```
Project-1/valid/labels.cache
Plotting labels to runs/detect/train/labels.jpg...
optimizer: 'optimizer=auto' found, ignoring 'lr0=0.01' and
'momentum=0.937' and determining best 'optimizer', 'lr0' and 'momentum'
automatically...
optimizer: AdamW(lr=0.002, momentum=0.9) with parameter groups 113
weight(decay=0.0), 120 weight(decay=0.0005), 119 bias(decay=0.0)
TensorBoard: model graph visualization added
Image sizes 640 train, 640 val
Using 2 dataloader workers
Logging results to runs/detect/train
Starting training for 100 epochs...

      Epoch    GPU_mem box_loss    cls_loss    dfl_loss  Instances       Size
      1/100      6.03G     0.9427       2.922       1.447         26        640:
100% 2/2 [00:02<00:00,    1.12s/it]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:01<00:00,1.20s/it]
                   all          2          4          1      0.442      0.524
0.47

      Epoch    GPU_mem box_loss    cls_loss    dfl_loss  Instances       Size
      2/100      6.03G     0.9529       2.789       1.479         37        640:
100% 2/2 [00:00<00:00,    2.35it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 18.92it/s]
                   all          2          4      0.904        0.5      0.523
0.47

      Epoch    GPU_mem box_loss    cls_loss    dfl_loss  Instances       Size
      3/100      6.03G     0.9856       2.885       1.444         29        640:
100% 2/2 [00:00<00:00,    2.91it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 14.96it/s]
                   all          2          4       0.93        0.5      0.527
0.474

      Epoch    GPU_mem box_loss    cls_loss    dfl_loss  Instances       Size
      4/100      6.07G     0.8891        2.78       1.342         33        640:
100% 2/2 [00:01<00:00,    1.93it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 12.02it/s]
                   all          2          4      0.972          1      0.995
0.958

      Epoch    GPU_mem box_loss    cls_loss    dfl_loss  Instances       Size
      5/100      6.12G     0.6105       1.415       1.142         36        640:
100% 2/2 [00:00<00:00,    2.25it/s]
```

```
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00,  18.25it/s]
                   all          2          4          1      0.726      0.945
0.885

      Epoch    GPU_mem box_loss  cls_loss  dfl_loss  Instances       Size
      6/100      6.16G   0.5139     1.143     1.015         33        640:
100% 2/2 [00:00<00:00,  2.81it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 18.37it/s]
                   all          2          4      0.989          1      0.995
0.92

      Epoch    GPU_mem box_loss  cls_loss  dfl_loss  Instances       Size
      7/100      6.2G   0.6514     1.166     1.113         32        640:
100% 2/2 [00:00<00:00,  2.87it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 18.46it/s]
                   all          2          4      0.986          1      0.995
0.895

      Epoch    GPU_mem box_loss  cls_loss  dfl_loss  Instances       Size
      8/100      6.23G   0.6434     1.018     1.069         36        640:
100% 2/2 [00:00<00:00,  2.81it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 16.10it/s]
                   all          2          4          1          1      0.995
0.92

      Epoch    GPU_mem  box_loss  cls_loss  dfl_loss  Instances       Size
      9/100      6.27G    0.5847    0.8281     1.017         27        640:
100% 2/2 [00:00<00:00,  2.92it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 17.85it/s]
                   all          2          4          1          1      0.995
0.945

      Epoch    GPU_mem box_loss  cls_loss  dfl_loss  Instances       Size
     10/100      6.31G   0.6159    0.8114     1.052         33        640:
100% 2/2 [00:00<00:00,  2.98it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 16.91it/s]
                   all          2          4          1          1      0.995
0.829

      Epoch    GPU_mem box_loss  cls_loss  dfl_loss  Instances       Size
     11/100      6.35G   0.5514    0.7016    0.9864         32        640:
100% 2/2 [00:00<00:00,  3.01it/s]
```

Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 8.01it/s]
all 2 4 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
24/100 7.01G 0.5594 0.5675 0.9462 42 640: 100% 2/2 [00:00<00:00, 2.98it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 17.25it/s]
all 2 4 0 0 0 0

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
25/100 7.05G 0.5987 0.6003 1.059 31 640: 100% 2/2 [00:00<00:00, 2.97it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.66it/s]
all 2 4 0.00167 0.25 0.00115 0.000346

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
26/100 7.09G 0.6468 0.5918 1.014 30 640: 100% 2/2 [00:00<00:00, 2.94it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.11it/s]
all 2 4 0.00333 0.5 0.00312 0.000312

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
27/100 7.15G 0.6015 0.5409 1.022 39 640: 100% 2/2 [00:00<00:00, 2.97it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.21it/s]
all 2 4 0.635 0.5 0.511 0.483

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
28/100 7.19G 0.6196 0.5394 1.019 33 640: 100% 2/2 [00:00<00:00, 3.15it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.86it/s]
all 2 4 0.635 0.5 0.511 0.483

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
29/100 7.21G 0.6137 0.549 1.011 24 640:

Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.29it/s]
all 2 4 0.658 1 0.849 0.764

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
30/100 7.26G 0.5574 0.4901 0.976 36 640: 100% 2/2 [00:00<00:00, 2.90it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 19.14it/s]
all 2 4 1 0.99 0.995 0.858

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
31/100 7.3G 0.604 0.5368 1.025 35 640: 100% 2/2 [00:00<00:00, 3.16it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.26it/s]
all 2 4 1 0.99 0.995 0.858

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
32/100 7.32G 0.5759 0.5104 1.018 35 640: 100% 2/2 [00:00<00:00, 2.43it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 11.73it/s]
all 2 4 0.932 1 0.995 0.837

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
33/100 7.38G 0.5622 0.5001 1.035 29 640: 100% 2/2 [00:00<00:00, 2.89it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.55it/s]
all 2 4 0.628 1 0.995 0.564

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
34/100 7.42G 0.5193 0.465 0.9872 31 640: 100% 2/2 [00:00<00:00, 3.14it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 17.18it/s]
all 2 4 0.628 1 0.995 0.564

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
35/100 7.44G 0.6054 0.502 0.9881 47 640: 100% 2/2 [00:00<00:00, 2.98it/s]

Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 16.87it/s]
all 2 4 0.935 1 0.995 0.833

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
48/100 8.1G 0.566 0.4784 0.9752 41 640: 100% 2/2 [00:00<00:00, 2.95it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.55it/s]
all 2 4 0.425 1 0.995 0.759

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
49/100 8.14G 0.5938 0.4895 1.03 41 640: 100% 2/2 [00:00<00:00, 3.11it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 16.64it/s]
all 2 4 0.425 1 0.995 0.759

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
50/100 8.21G 0.5744 0.5344 1.024 30 640: 100% 2/2 [00:00<00:00, 2.62it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 11.56it/s]
all 2 4 0.912 1 0.995 0.933

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
51/100 8.25G 0.5175 0.4512 0.9762 31 640: 100% 2/2 [00:00<00:00, 2.27it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 11.70it/s]
all 2 4 0.912 1 0.995 0.933

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
52/100 8.32G 0.5661 0.452 0.9641 41 640: 100% 2/2 [00:00<00:00, 2.94it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.93it/s]
all 2 4 0.963 1 0.995 0.895

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
53/100 8.36G 0.5288 0.4673 1.046 22 640: 100% 2/2 [00:00<00:00, 3.13it/s]

Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 17.07it/s]
all 2 4 0.963 1 0.995
0.895

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
54/100 8.43G 0.577 0.4786 1.026 29 640:
100% 2/2 [00:00<00:00, 2.91it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 18.32it/s]
all 2 4 0.978 1 0.995
0.895

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
55/100 8.47G 0.4472 0.3826 0.9149 25 640:
100% 2/2 [00:00<00:00, 3.10it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 18.75it/s]
all 2 4 0.978 1 0.995
0.895

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
56/100 8.51G 0.5504 0.4431 0.9714 35 640:
100% 2/2 [00:00<00:00, 2.94it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 17.47it/s]
all 2 4 0.978 1 0.995
0.855

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
57/100 8.58G 0.5579 0.4514 0.9933 39 640:
100% 2/2 [00:00<00:00, 3.13it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 17.67it/s]
all 2 4 0.978 1 0.995
0.855

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
58/100 8.62G 0.5533 0.4347 0.9996 34 640:
100% 2/2 [00:00<00:00, 2.95it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 17.88it/s]
all 2 4 0.632 1 0.828
0.558

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
59/100 8.69G 0.5862 0.4532 0.9929 35 640:
100% 2/2 [00:00<00:00, 3.12it/s]

Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 10.60it/s]
all 2 4 0.632 1 0.828
0.558

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
60/100 8.73G 0.4688 0.4183 0.9271 35 640:
100% 2/2 [00:00<00:00, 2.05it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 12.33it/s]
all 2 4 0.665 0.992 0.849
0.566

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
61/100 8.77G 0.4879 0.406 0.9539 35 640:
100% 2/2 [00:00<00:00, 2.96it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 19.02it/s]
all 2 4 0.665 0.992 0.849
0.566

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
62/100 8.84G 0.5324 0.4326 0.9597 35 640:
100% 2/2 [00:00<00:00, 2.95it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 19.22it/s]
all 2 4 0.774 1 0.995
0.635

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
63/100 8.88G 0.4599 0.3851 0.9073 44 640:
100% 2/2 [00:00<00:00, 3.13it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 18.83it/s]
all 2 4 0.774 1 0.995
0.635

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
64/100 8.95G 0.467 0.4044 0.9356 32 640:
100% 2/2 [00:00<00:00, 2.86it/s]
Class Images Instances Box(P R mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 18.70it/s]
all 2 4 0.924 1 0.995
0.705

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
65/100 8.99G 0.4483 0.3875 0.9203 28 640:

Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 17.87it/s]
all 2 4 0.988 1 0.995 0.964

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
72/100 9.4G 0.417 0.3541 0.9259 26 640: 100% 2/2 [00:00<00:00, 2.92it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 19.20it/s]
all 2 4 0.986 1 0.995 0.933

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
73/100 9.44G 0.4241 0.3667 0.8988 27 640: 100% 2/2 [00:00<00:00, 3.09it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 17.66it/s]
all 2 4 0.986 1 0.995 0.933

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
74/100 9.51G 0.4125 0.3365 0.9104 31 640: 100% 2/2 [00:00<00:00, 2.92it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.26it/s]
all 2 4 0.986 1 0.995 0.929

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
75/100 9.55G 0.4304 0.3476 0.9328 36 640: 100% 2/2 [00:00<00:00, 3.07it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.30it/s]
all 2 4 0.986 1 0.995 0.929

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
76/100 9.59G 0.4511 0.3759 0.9146 43 640: 100% 2/2 [00:00<00:00, 2.91it/s]
Class Images Instances Box(P R mAP50 mAP50-95): 100% 1/1 [00:00<00:00, 18.46it/s]
all 2 4 0.987 1 0.995 0.92

Epoch GPU_mem box_loss cls_loss dfl_loss Instances Size
77/100 9.66G 0.4091 0.3433 0.9324 36 640: 100% 2/2 [00:00<00:00, 3.11it/s]

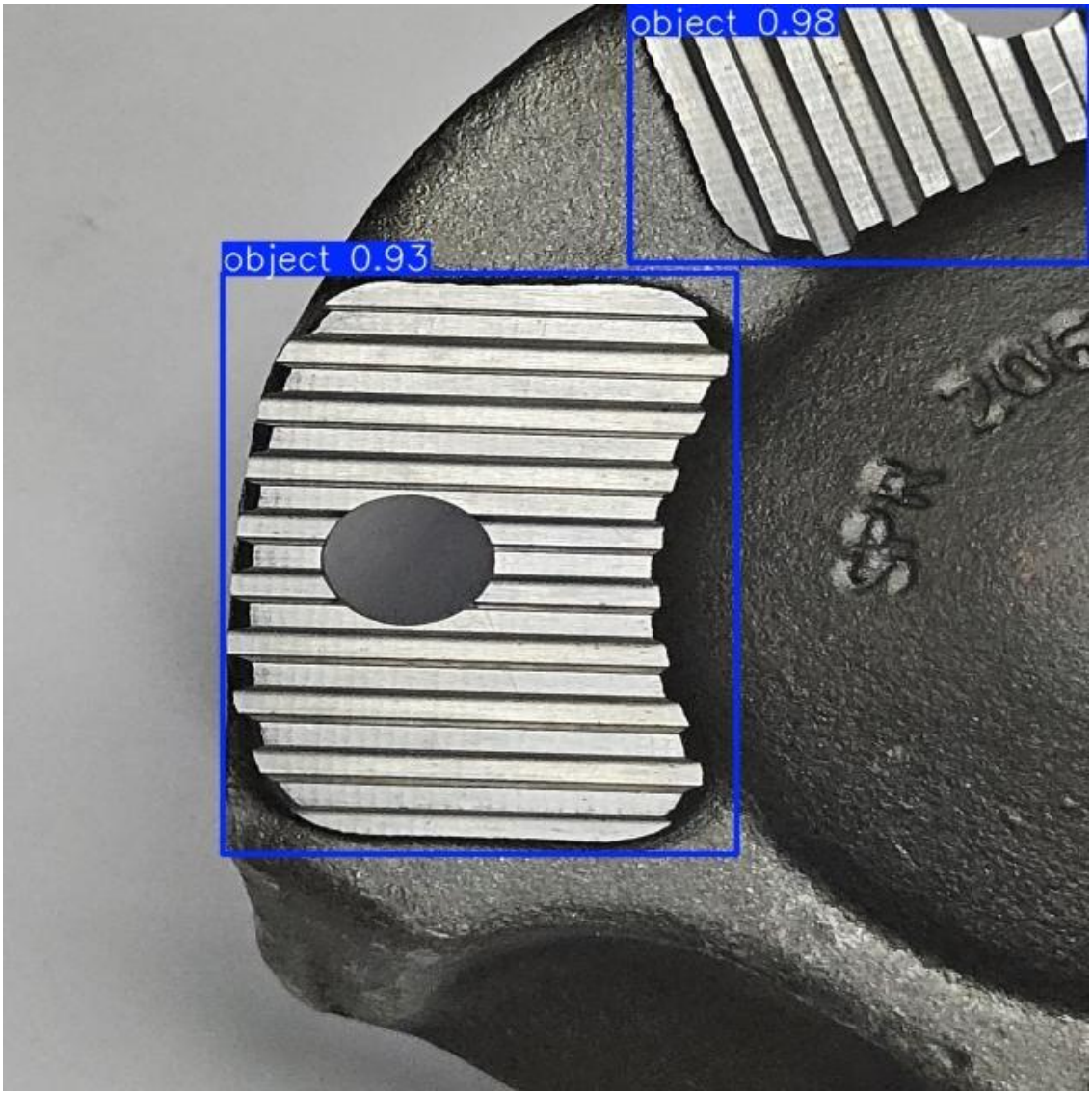
```
0.932

100 epochs completed in 0.042 hours.
Optimizer stripped from runs/detect/train/weights/last.pt, 18.9MB
Optimizer stripped from runs/detect/train/weights/best.pt, 18.9MB

Validating runs/detect/train/weights/best.pt...
Ultralytics 8.3.94      Python-3.11.11 torch-2.6.0+cu124 CUDA:0 (Tesla T4,
15095MiB)
YOLOv12s summary (fused): 159 layers, 9,231,267 parameters, 0 gradients, 21.2
GFLOPs
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100% 1/1 [00:00<00:00, 26.09it/s]
                   all          2          4      0.989          1      0.995
0.995
Speed: 0.3ms preprocess, 13.3ms inference, 0.0ms loss, 1.0ms postprocess per
image
Results saved to runs/detect/train
  Learn more at https://docs.ultralytics.com/modes/train
```

[ ]:
```
# Code for Task 4
# Load Trained Model Weights
from ultralytics import YOLO

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

[ ]:
```
# Run Inference on Test Images
# Inference on a test image
results = model('/content/datasets/Sample-Project-1/test/images/
  20250222_120244_010_jpg.rf.337a8a168d149e13534a7722a76f0166.jpg', save=True,
  conf=0.5) # Save output with bounding boxes
```

```
image 1/1 /content/datasets/Sample-Project-1/test/images/20250222_120244_010_jpg
.rf.337a8a168d149e13534a7722a76f0166.jpg: 640x640 2 objects, 20.9ms
Speed: 3.1ms preprocess, 20.9ms inference, 152.7ms postprocess per image at
shape (1, 3, 640, 640)
Results saved to runs/detect/predict2
```

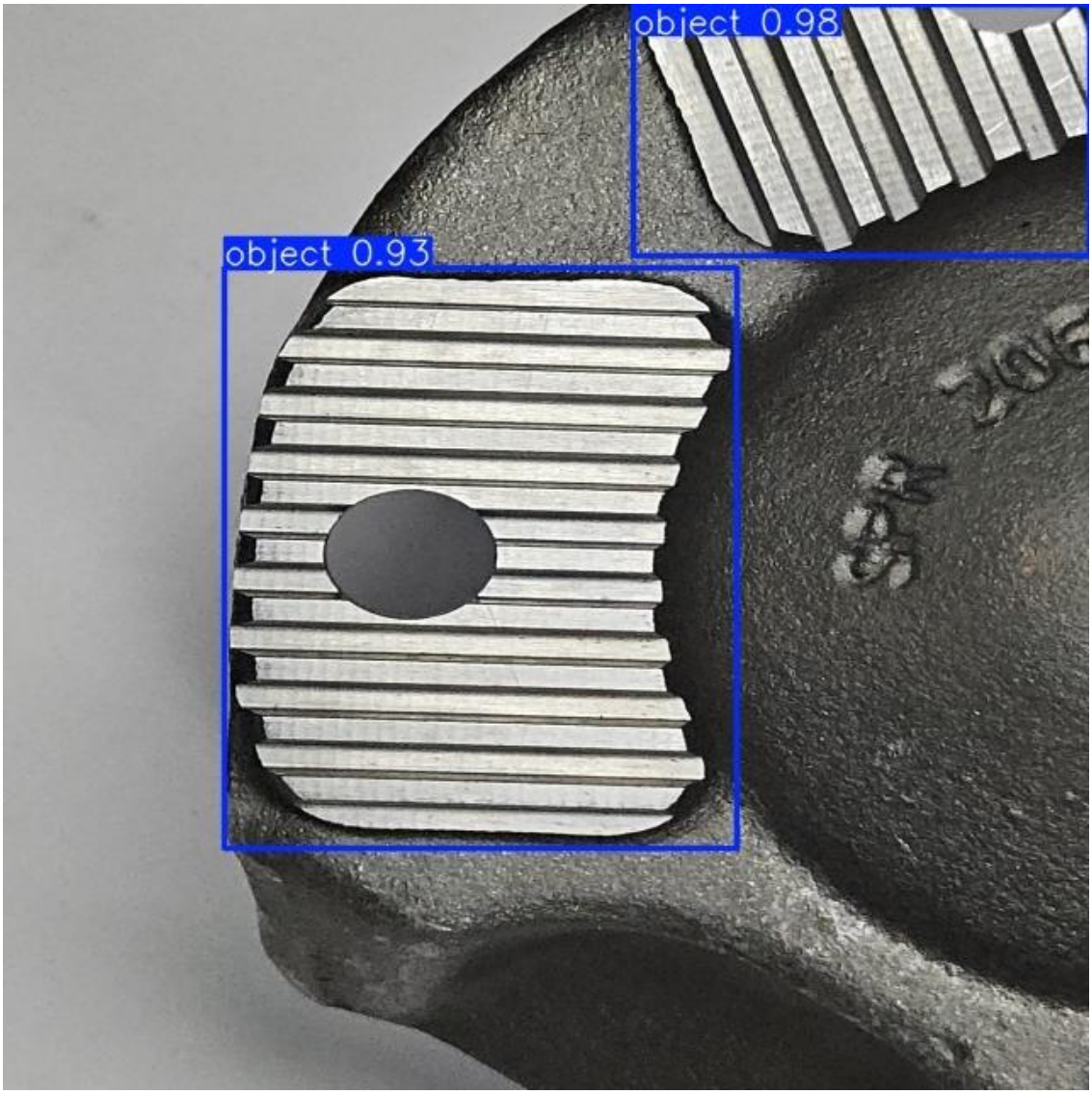
[ ]:
```
from IPython.display import Image as IPyImage, display

display(IPyImage("/content/runs/detect/predict2/20250222_120244_010_jpg.rf.
  337a8a168d149e13534a7722a76f0166.jpg", width=1000))
```



[ ]:
```
# Inference on a test image
results = model('/content/datasets/Sample-Project-1/test/images/
  20250222_120244_027_jpg.rf.cc601d060663b5039d0cd912f3849743.jpg', save=True,
  conf=0.5)  # Save output with bounding boxes
```

```
image 1/1 /content/datasets/Sample-Project-1/test/images/20250222_120244_027_jpg
.rf.cc601d060663b5039d0cd912f3849743.jpg: 640x640 2 objects, 21.7ms
Speed: 3.1ms preprocess, 21.7ms inference, 1.7ms postprocess per image at shape
(1, 3, 640, 640)
Results saved to runs/detect/predict2
```

[ ]:
```
display(IPyImage("/content/runs/detect/predict2/20250222_120244_027_jpg.rf.
  cc601d060663b5039d0cd912f3849743.jpg", width=1000))
```



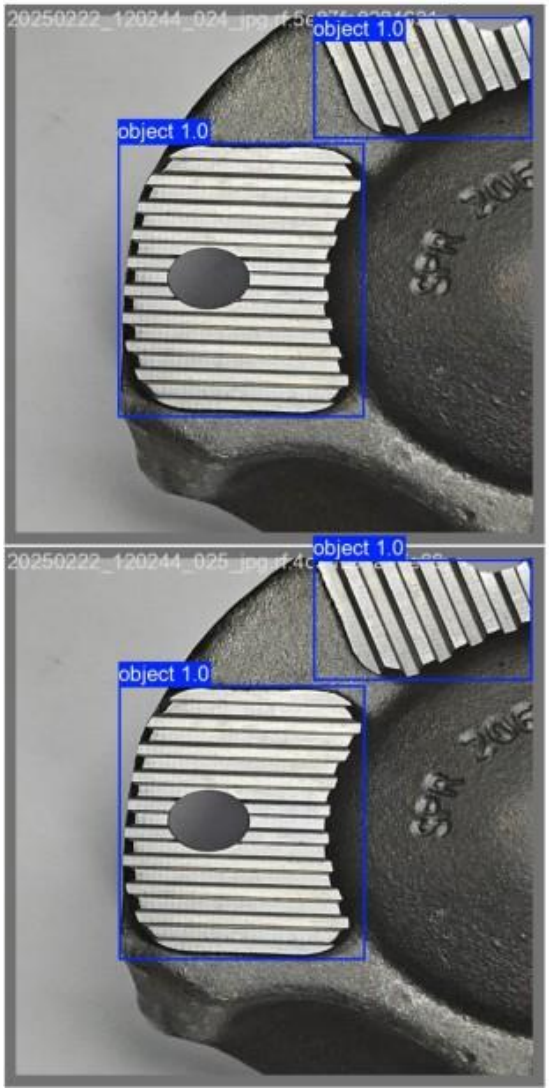
[ ]:
```
# Evaluate model performance
metrics = model.val()  # Evaluates on validation dataset from data.yaml

# Mean Average Precision
print(f"mAP@0.5: {metrics.box.map50:.4f}")
print(f"mAP@0.5:0.95: {metrics.box.map:.4f}")

# Mean Precision and Recall (use as properties, NOT methods)
precision = metrics.box.mp
recall = metrics.box.mr
```

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

# F1 Score
f1_score = 2 * (precision * recall) / (precision + recall + 1e-6)
print(f"F1 Score: {f1_score:.4f}")
```

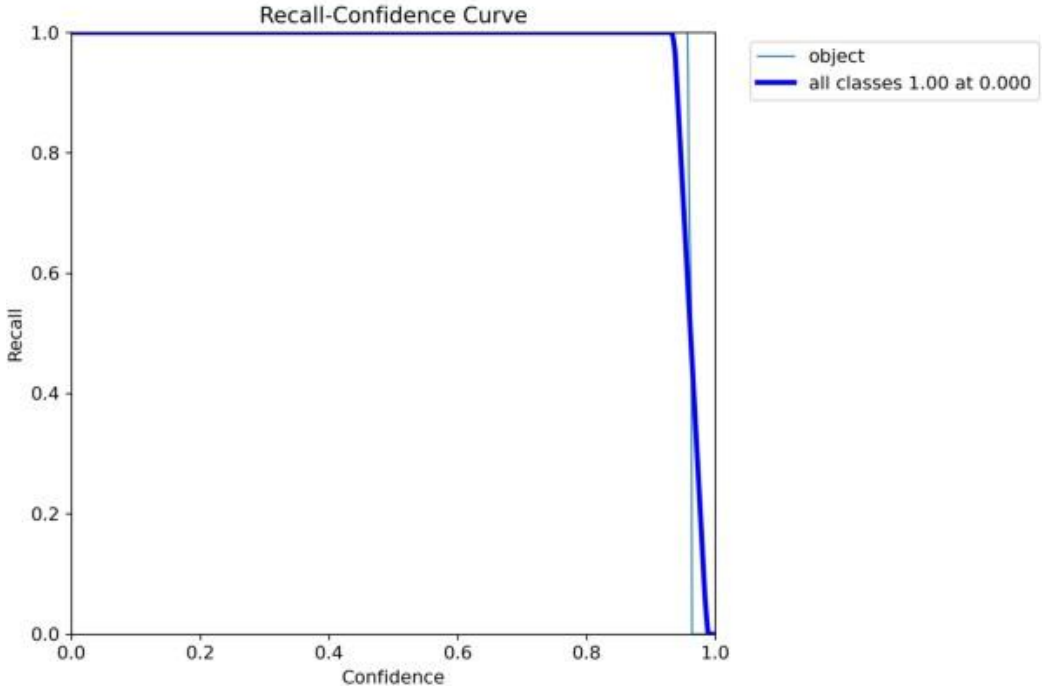
```
Ultralytics 8.3.94 Python-3.11.11 torch-2.6.0+cu124 CUDA:0 (Tesla T4,
15095MiB)
val: Scanning /content/datasets/Sample-
Project-1/valid/labels.cache... 2 images, 0 backgrounds, 0 corrupt:
100%| | 2/2 [00:00<?, ?it/s]
                 Class     Images  Instances      Box(P          R      mAP50
mAP50-95): 100%|  | 1/1 [00:00<00:00,  7.45it/s]
                   all          2          4      0.989          1      0.995
0.995
Speed: 0.4ms preprocess, 42.8ms inference, 0.0ms loss, 1.2ms postprocess per
image
Results saved to runs/detect/val
mAP@0.5: 0.9950
mAP@0.5:0.95: 0.9950
Precision: 0.9894
Recall: 1.0000
F1 Score: 0.9947
```

[ ]:
```
import os
from PIL import Image
import matplotlib.pyplot as plt

# Path to the val3 folder
folder_path = '/content/runs/detect/val'

# List all image files (you can filter for .png, .jpg, etc.)
image_files = [f for f in os.listdir(folder_path) if f.lower().endswith(('.
  spng', '.jpg', '.jpeg'))]

# Loop through and display each image
for img_file in image_files:
    img_path = os.path.join(folder_path, img_file)
    img = Image.open(img_path)

    plt.figure(figsize=(8, 8))
    plt.imshow(img)
    plt.title(img_file)
    plt.axis('off')
    plt.show()
```

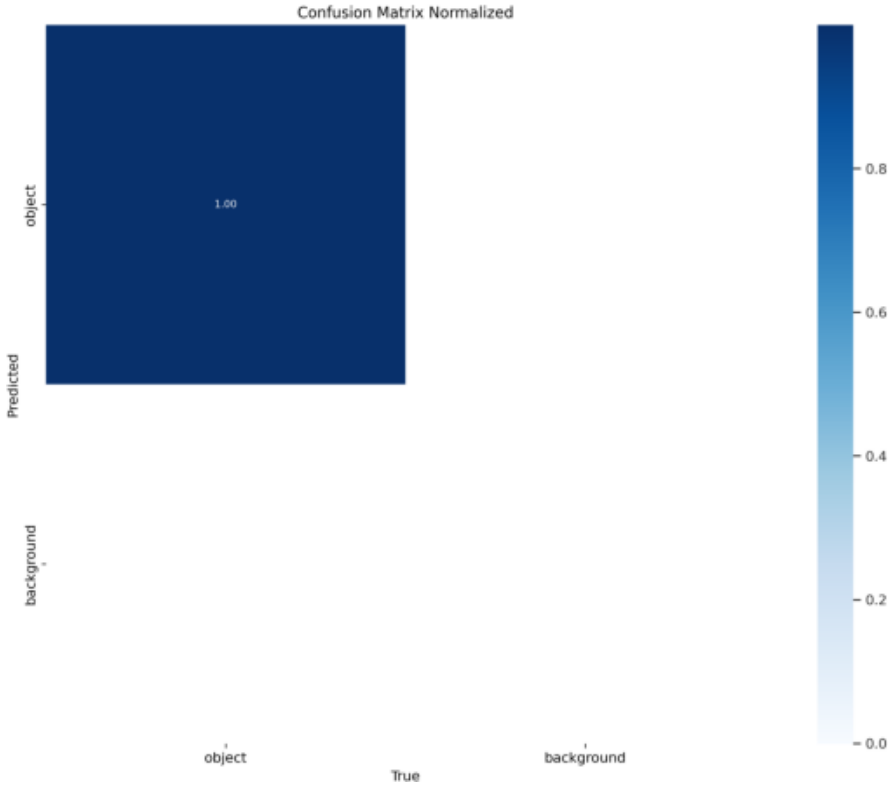
val_batch0_pred.jpg



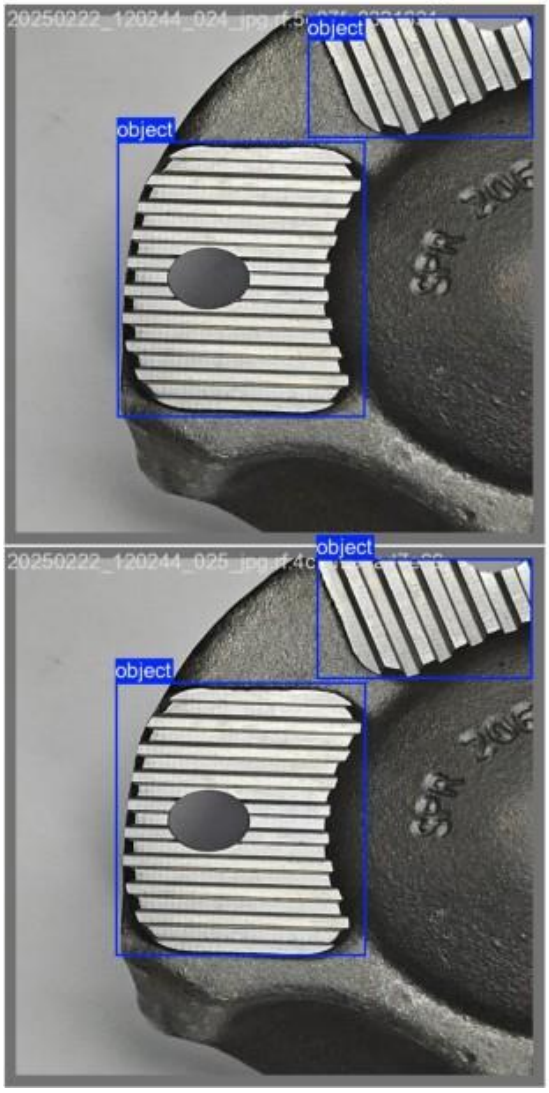
R_curve.png

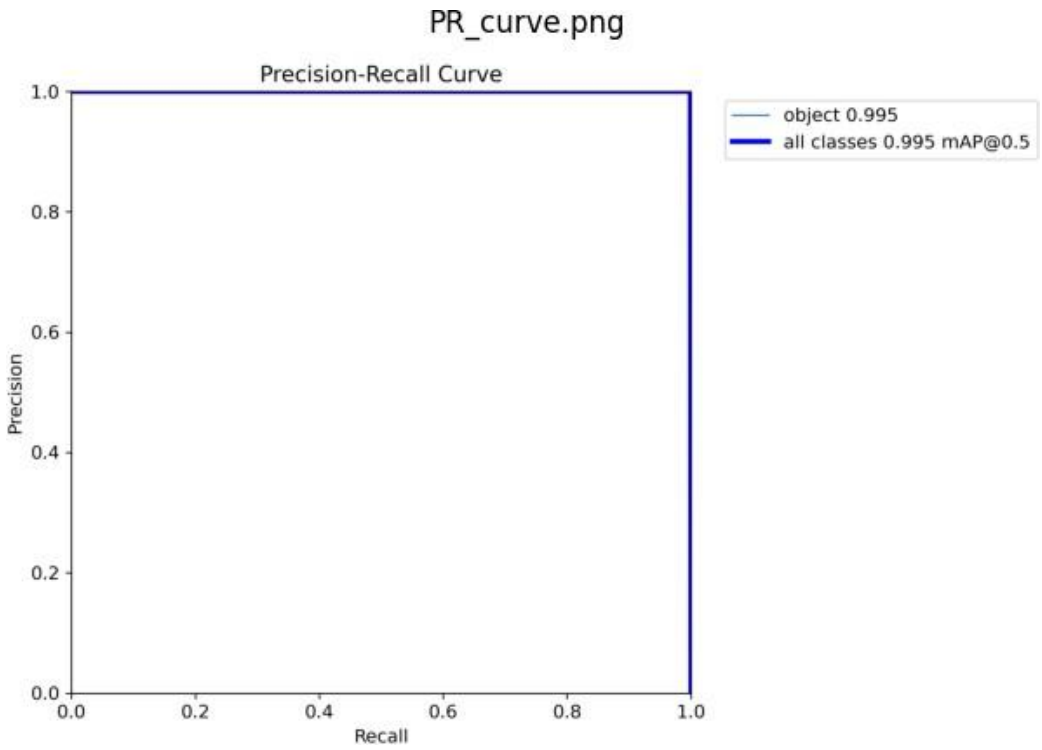

Recall-Confidence Curve
Recall
Confidence
0.0
0.2
0.4
0.6
0.8
1.0
object
all classes 1.00 at 0.000

confusion_matrix_normalized.png

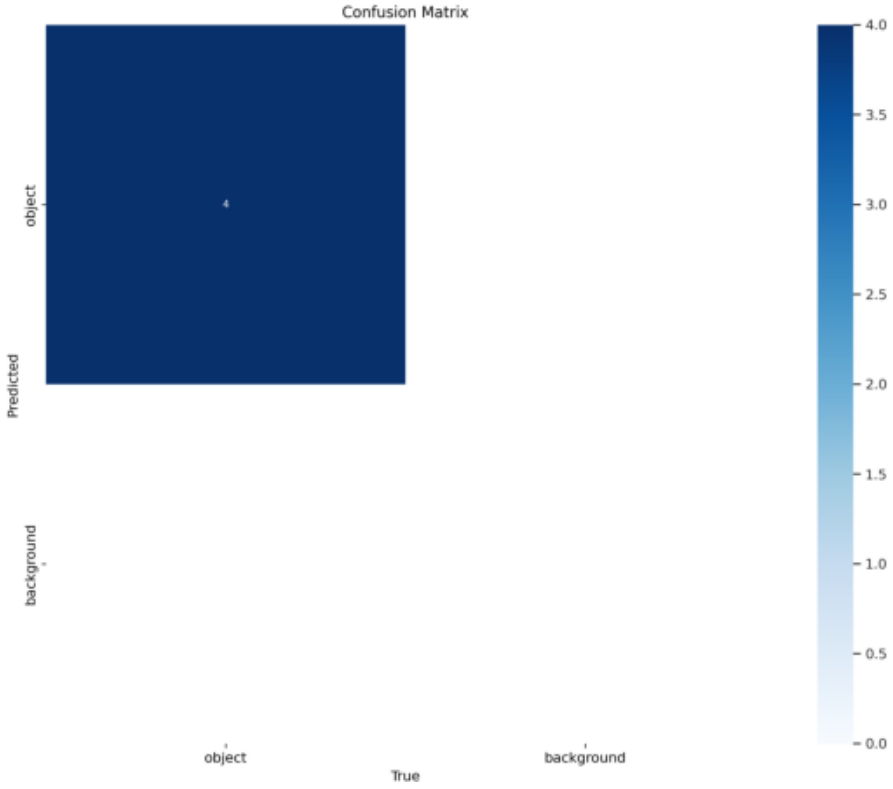


val_batch0_labels.jpg

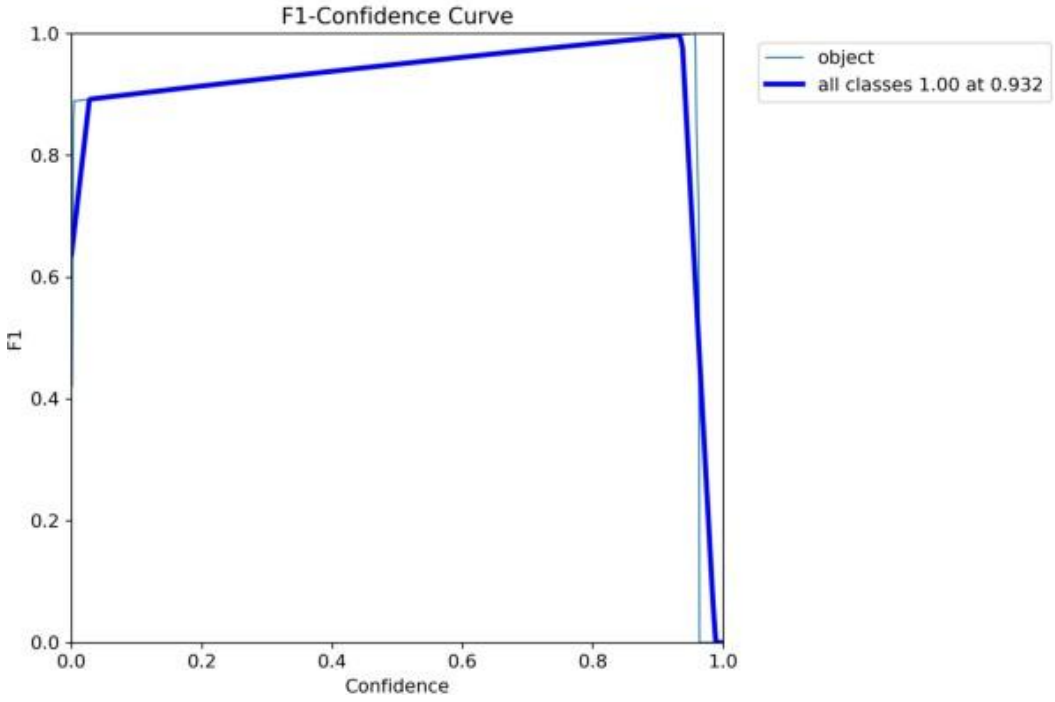



PR_curve.png
Precision-Recall Curve
Precision
Recall
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
object 0.995
all classes 0.995 mAP@0.5

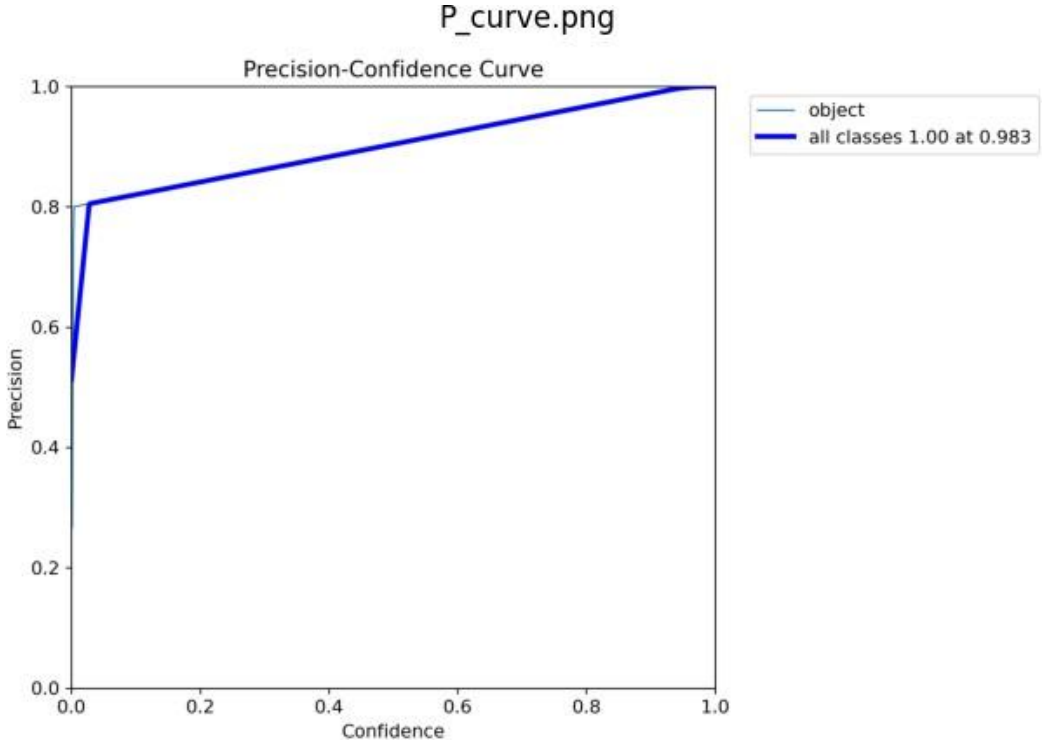
confusion_matrix.png



F1_curve.png



P_curve.png



Declaration

I, Md Yaseen Alam, confirm that the work submitted in this assignment is my own and has been completed following academic integrity guidelines. The code is uploaded on my GitHub repository account, and the repository link is provided below:

Signature: Md Yaseen Alam