This Assignment was done by :

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RSNA Pneumonia Detection

1- The dataset provided in two folder:

- train_images.zip
- test_images.zip.

2- train.csv:

- the training set. Contains patientIds and bounding box / target information.
- patientId :- A patientId. Each patientId corresponds to a unique image.
- x :- the upper-left x coordinate of the bounding box.
- y :- the upper-left y coordinate of the bounding box.
- width :-the width of the bounding box.
- height :- the height of the bounding box.
- Target :- the binary Target, indicating whether this sample has evidence of pneumonia

First we view the data

In [ ]:
```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import pydicom
from PIL import Image
import os
from ultralytics import YOLO
```

In [ ]:
```
df = pd.read_csv('dataset/train_labels.csv')
df.head()
```

Out[ ]:

	patientId	x	y	width	height	Target
0	0004cfab-14fd-4e49-80ba-63a80b6bddd6	NaN	NaN	NaN	NaN	0
1	00313ee0-9eaa-42f4-b0ab-c148ed3241cd	NaN	NaN	NaN	NaN	0
2	00322d4d-1c29-4943-afc9-b6754be640eb	NaN	NaN	NaN	NaN	0
3	003d8fa0-6bf1-40ed-b54c-ac657f8495c5	NaN	NaN	NaN	NaN	0
4	00436515-870c-4b36-a041-de91049b9ab4	264.0	152.0	213.0	379.0	1

In [ ]:
```
# replace nans with 0
df.fillna(0, inplace=True)
df.head()
```

Out[ ]:

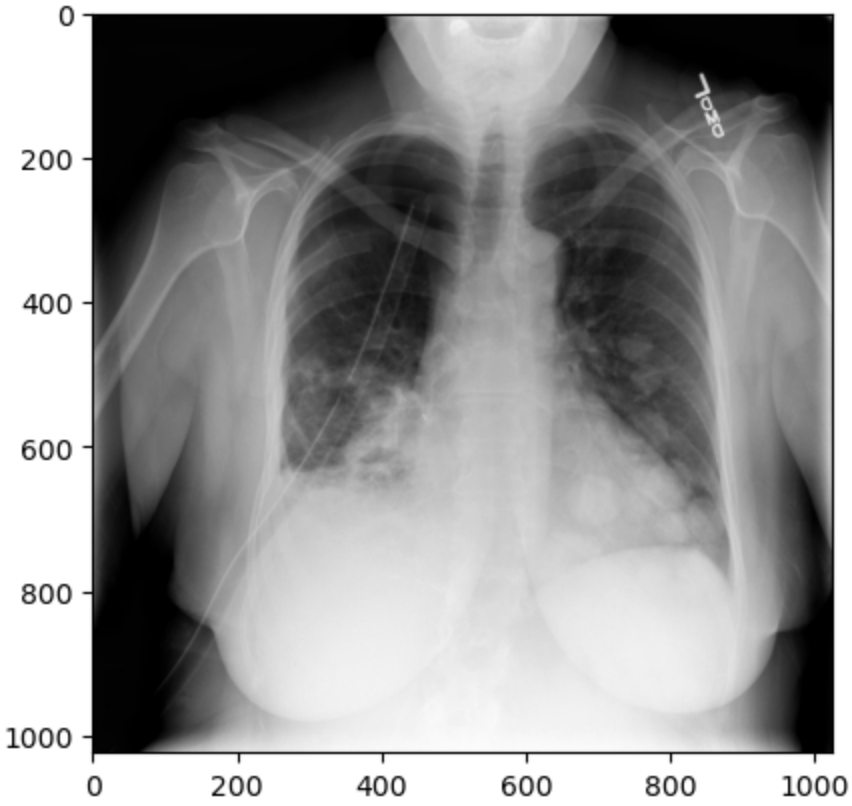
	patientId	x	y	width	height	Target
0	0004cfab-14fd-4e49-80ba-63a80b6bddd6	0.0	0.0	0.0	0.0	0
1	00313ee0-9eaa-42f4-b0ab-c148ed3241cd	0.0	0.0	0.0	0.0	0
2	00322d4d-1c29-4943-afc9-b6754be640eb	0.0	0.0	0.0	0.0	0
3	003d8fa0-6bf1-40ed-b54c-ac657f8495c5	0.0	0.0	0.0	0.0	0
4	00436515-870c-4b36-a041-de91049b9ab4	264.0	152.0	213.0	379.0	1

In [ ]:
```
df.describe()
```

Out[ ]:

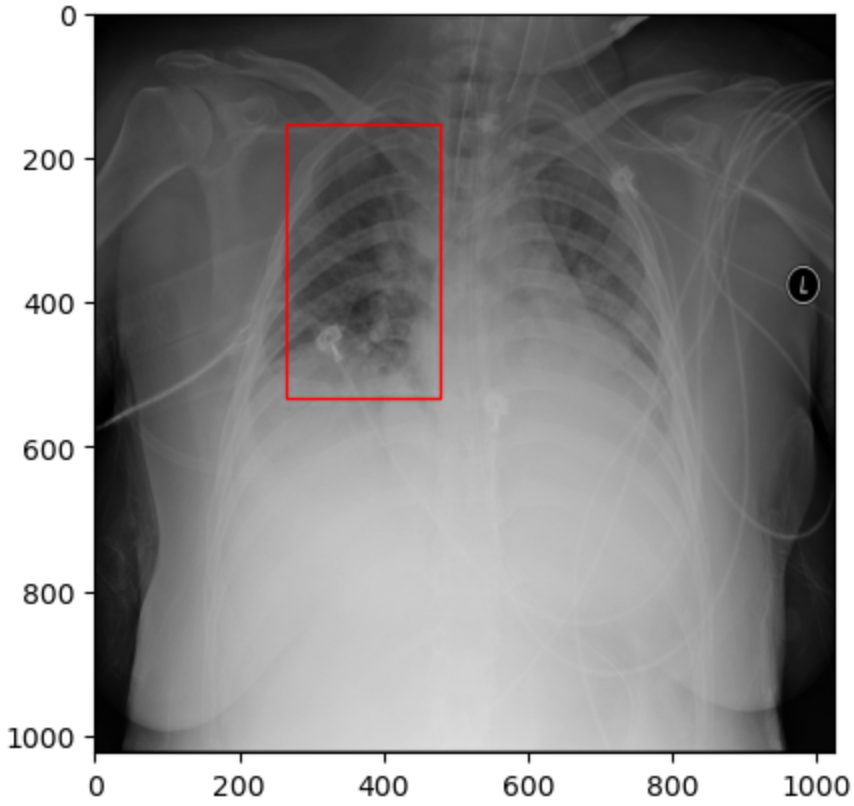
	x	y	width	height	Target
count	30227.000000	30227.000000	30227.000000	30227.000000	30227.000000
mean	124.561683	115.960962	69.060575	104.084825	0.316108
std	216.326397	190.012883	106.910496	176.932152	0.464963
min	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.000000	0.000000	0.000000	0.000000	0.000000
50%	0.000000	0.000000	0.000000	0.000000	0.000000
75%	193.000000	231.000000	169.000000	188.000000	1.000000
max	835.000000	881.000000	528.000000	942.000000	1.000000

In [ ]:
```
# Plotting the first image

path_to_image = df['patientId'][0]

# Load the .dcm image
ds = pydicom.dcmread(f'dataset/train_images/{path_to_image}.dcm')

# Access image data
image = ds.pixel_array

# Display the image
plt.imshow(image, cmap='gray')
plt.show()
```



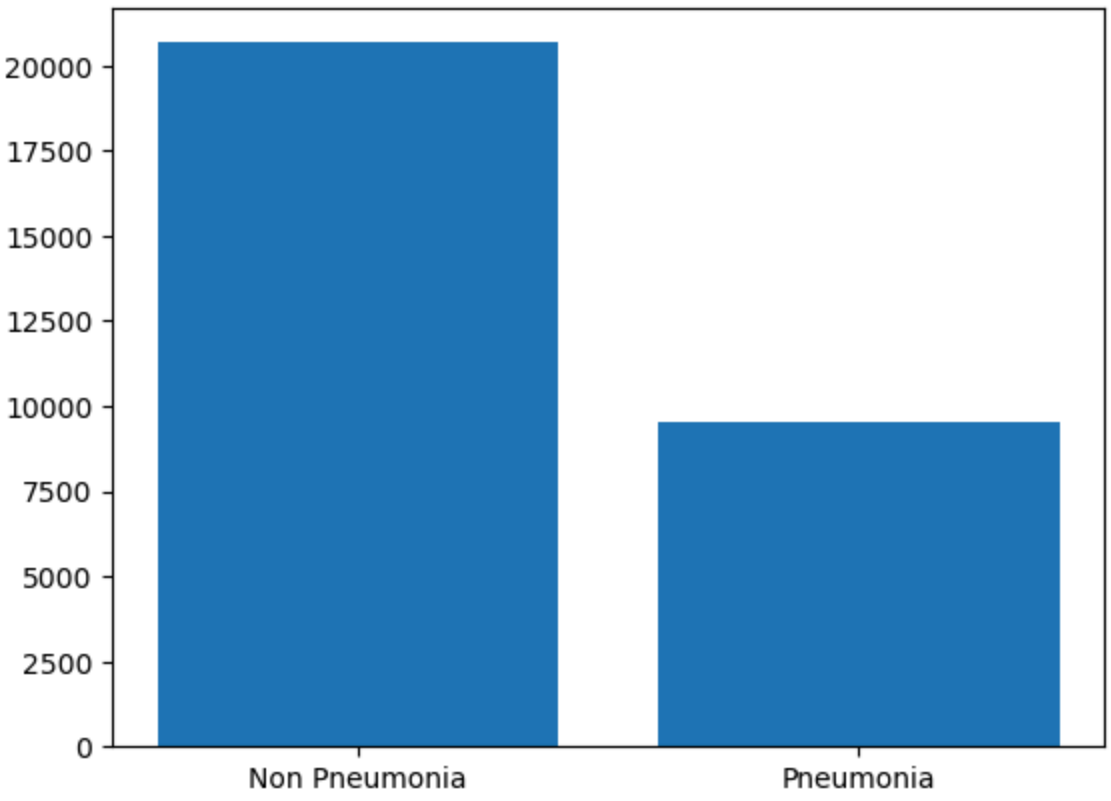
In [ ]:

```
# Plotting the first image with bounding box

# Load the .dcm image
path_to_image = df['patientId'][4]
ds = pydicom.dcmread(f'dataset/train_images/{path_to_image}.dcm')

# Access image data
image = ds.pixel_array

# Display the image
plt.imshow(image, cmap='gray')

# Add bounding box

# Get the target values
x = df['x'][4]
y = df['y'][4]
width = df['width'][4]
height = df['height'][4]

# Create a Rectangle patch

rect = plt.Rectangle((x, y), width, height, edgecolor='r', facecolor='none')

# Add the patch to the Axes
plt.gca().add_patch(rect)

plt.show()
```



In [ ]:
```
# compare between the number of images with pneumonia and without pneumonia
print(df['Target'].value_counts())
plt.bar(['Non Pneumonia', 'Pneumonia'], df['Target'].value_counts());
```

```
Target
0    20672
1     9555
Name: count, dtype: int64
```



In [ ]:
```
# count the .dcm files in the dataset/train_images folder
print(len(os.listdir('dataset/train_images')))
```

```
26684
```

In [ ]:
```
# check if any of the patientId in the train_labels.csv file are in the dataset/test_ima
test_images = os.listdir('dataset/test_images')

for patientId in df['patientId']:
    if f'{patientId}.dcm' in test_images:
        print(patientId)
```

In [ ]:
```
df.shape
```

Out[ ]:
```
(30227, 6)
```

In [ ]:
```
# count the number of unique patients
df['patientId'].nunique()
```

Out[ ]:
```
26684
```

In [ ]:
```
print(len(os.listdir('dataset/test_images')))
```

```
3000
```

- Nan values are replaced with zeros
- number of images with non-pneumonia are double the images with pneumonia (imbalanced data)
- number of unique patients in the dataframe is equal to the number of training images (no redundancy)

Convert the .dcm images to a format that YOLOv8 can work with

- First, we extract the image data from .dcm file
- Second, we will Normalize the pixel values to be from 0 - 255 (leading to faster convergence)
- we then convert it to jpg format

In [ ]:
```
# convert the .dcm files to .jpg files

def convert_dcm_to_jpg(input_folder, output_folder):
    for file in os.listdir(input_folder):
        if os.path.isfile(f'{output_folder}/{file.split(".")[0]}.jpg'):
            continue
        ds = pydicom.dcmread(f'{input_folder}/{file}')
        img = ds.pixel_array
        # Normalize the pixel values to the range [0, 255]
        image_normalized = (img - np.min(img)) / (np.max(img) - np.min(img)) * 255
        image_normalized = image_normalized.astype(np.uint8)  # Convert to unsigned 8-bi

        # Convert the numpy array to a PIL image
        image = Image.fromarray(image_normalized)

        filename = file.split('.')[0]
        image.save(f'{output_folder}/{filename}.jpg')
```

In [ ]:
```
convert_dcm_to_jpg('dataset/train_images', 'dataset/images/train')
```

In [ ]:
```
convert_dcm_to_jpg('dataset/test_images', 'dataset/images/test')
```

Normalizing the labels (YOLO Format)

In [ ]:
```python
def normalize_bboxs(df):
    img_size = 1024

    # normalize the bounding boxes
    df['width'] = df['width'] / img_size
    df['height'] = df['height'] / img_size
    # Centering X , Y coordinates and normalize them
    df['x'] = df['x'] / img_size + df['width'] / 2
    df['y'] = df['y'] / img_size + df['height'] / 2


def denormalize_bbox(rx, ry, rw, rh):
    img_size = 1024

    x = (rx-rw/2)*img_size
    y = (ry-rh/2)*img_size
    w = rw*img_size
    h = rh*img_size

    return x, y, w, h
```

In [ ]:
```python
normalize_bboxs(df)

df.head()
```

Out[ ]:

	patientId	x	y	width	height	Target
0	0004cfab-14fd-4e49-80ba-63a80b6bddd6	0.000000	0.000000	0.000000	0.000000	0
1	00313ee0-9eaa-42f4-b0ab-c148ed3241cd	0.000000	0.000000	0.000000	0.000000	0
2	00322d4d-1c29-4943-afc9-b6754be640eb	0.000000	0.000000	0.000000	0.000000	0
3	003d8fa0-6bf1-40ed-b54c-ac657f8495c5	0.000000	0.000000	0.000000	0.000000	0
4	00436515-870c-4b36-a041-de91049b9ab4	0.361816	0.333496	0.208008	0.370117	1

Preparing The labels folder

In [ ]:
```python
# Converting the df to .txt files per patientId each patientId in separate file (as ther

def convert_df_to_txt_files(df, output_folder):
    if not os.path.exists(output_folder):
        os.makedirs(output_folder)
    for patientId in df['patientId'].unique():
        patient_df = df[df['patientId'] == patientId].copy()
        if patient_df['Target'].values[0] == 0:
            # if the patient doesn't have pneumonia, output empty txt file
            with open(f'{output_folder}/{patientId}.txt', 'w') as f:
                f.close()
            continue
        patient_df.drop(columns='patientId', inplace=True)
        # getting the target column to the first column
        cols = patient_df.columns.tolist()
        cols = cols[-1:] + cols[:-1]
        patient_df = patient_df[cols]
```

```
        patient_df['Target'] = 0
        patient_df.to_csv(f'{output_folder}/{patientId}.txt', index=False, header=False,
```

In [ ]:
```
convert_df_to_txt_files(df, 'dataset/labels/train')
```

Splitting the data into train_1 , train_2 , train_3 and validation (Hardware constraints)

In [ ]:
```
## split the data into train_1 , train_2 , train_3 and validation sets and without shuff

# get the unique patientIds
patientIds = df['patientId'].unique()

train_1 = patientIds[:9000]
train_2 = patientIds[9000:18000]
train_3 = patientIds[18000:24000]
validation = patientIds[24000:]

# get the patientIds for each set
train_1_df = df[df['patientId'].isin(train_1)].copy()
train_2_df = df[df['patientId'].isin(train_2)].copy()
train_3_df = df[df['patientId'].isin(train_3)].copy()
validation_df = df[df['patientId'].isin(validation)].copy()


# convert the train_1_df, train_2_df, train_3_df and validation_df to .txt files
# convert_df_to_txt_files(train_1_df, 'dataset/labels/train_1')
# convert_df_to_txt_files(train_2_df, 'dataset/labels/train_2')
# convert_df_to_txt_files(train_3_df, 'dataset/labels/train_3')
# convert_df_to_txt_files(validation_df, 'dataset/labels/validation')

# copy the images to the respective folders
def copy_images_to_folder(df, input_folder, output_folder):
    if not os.path.exists(output_folder):
        os.makedirs(output_folder)
    for patientId in df['patientId'].unique():
        os.system(f'cp {input_folder}/{patientId}.jpg {output_folder}/{patientId}.jpg')

# copy_images_to_folder(train_1_df, 'dataset/images/train', 'dataset/images/train_1')
# copy_images_to_folder(train_2_df, 'dataset/images/train', 'dataset/images/train_2')
# copy_images_to_folder(train_3_df, 'dataset/images/train', 'dataset/images/train_3')
# copy_images_to_folder(validation_df, 'dataset/images/train', 'dataset/images/validatio
```

Training The YOLOv8 Algorithm

- we ran each part `(train_1 , train_2 , train_3)` of the data for two epochs to achieve better results
- at the end of each part we get the `best.pt` from the previous one for the next training session
- that lead to better losses , precision and recall

In [ ]:
```
model = YOLO("dataset/best3.pt")

res = model.train(data="data.yaml", epochs=1) # one final epoch to finish training
```

```
New https://pypi.org/project/ultralytics/8.2.19 available 😃 Update with 'pip install -U
ultralytics'
Ultralytics YOLOv8.2.18 🚀 Python-3.11.5 torch-2.2.2 CUDA:0 (NVIDIA GeForce GTX 1650, 390
4MiB)
engine/trainer: task=detect, mode=train, model=dataset/best3.pt, data=data.yaml, epochs=
1, 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, optimi
zer=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, sav
e_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=Fals
e, agnostic_nms=False, classes=None, retina_masks=False, embed=None, show=False, save_fra
mes=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, wa
rmup_bias_lr=0.1, box=7.5, cls=0.5, dfl=1.5, pose=12.0, kobj=1.0, label_smoothing=0.0, nb
s=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.ya
ml, save_dir=runs/detect/train

                   from  n    params  module                                       argume
nts
  0                  -1  1       464  ultralytics.nn.modules.conv.Conv             [3, 1
6, 3, 2]
  1                  -1  1      4672  ultralytics.nn.modules.conv.Conv             [16, 3
2, 3, 2]
  2                  -1  1      7360  ultralytics.nn.modules.block.C2f             [32, 3
2, 1, True]
  3                  -1  1     18560  ultralytics.nn.modules.conv.Conv             [32, 6
4, 3, 2]
  4                  -1  2     49664  ultralytics.nn.modules.block.C2f             [64, 6
4, 2, True]
  5                  -1  1     73984  ultralytics.nn.modules.conv.Conv             [64, 1
28, 3, 2]
  6                  -1  2    197632  ultralytics.nn.modules.block.C2f             [128,
128, 2, True]
  7                  -1  1    295424  ultralytics.nn.modules.conv.Conv             [128,
256, 3, 2]
  8                  -1  1    460288  ultralytics.nn.modules.block.C2f             [256,
256, 1, True]
  9                  -1  1    164608  ultralytics.nn.modules.block.SPPF            [256,
256, 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    148224  ultralytics.nn.modules.block.C2f             [384,
128, 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     37248  ultralytics.nn.modules.block.C2f             [192,
64, 1]
 16                  -1  1     36992  ultralytics.nn.modules.conv.Conv             [64, 6
4, 3, 2]
 17            [-1, 12]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 18                  -1  1    123648  ultralytics.nn.modules.block.C2f             [192,
128, 1]
 19                  -1  1    147712  ultralytics.nn.modules.conv.Conv             [128,
128, 3, 2]
```

```
 20             [-1, 9]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 21                -1  1    493056  ultralytics.nn.modules.block.C2f             [384,
256, 1]
 22        [15, 18, 21]  1    751507  ultralytics.nn.modules.head.Detect           [1, [6
4, 128, 256]]
Model summary: 225 layers, 3011043 parameters, 3011027 gradients, 8.2 GFLOPs

Transferred 355/355 items from pretrained weights
TensorBoard: Start with 'tensorboard --logdir runs/detect/train', view at http://localhos
t:6006/
Freezing layer 'model.22.dfl.conv.weight'
AMP: running Automatic Mixed Precision (AMP) checks with YOLOv8n...
AMP: checks passed ✅
train: Scanning /media/mahmoud/31A5D0D7034B3BD5/General/FCAI/8th Term/Assignment_1/datase
t/labels/train_1.cache... 9000 images, 6932 backgrounds, 0 corrupt: 100%|██████████| 900
0/9000 [00:00<?, ?it/s]
val: Scanning /media/mahmoud/31A5D0D7034B3BD5/General/FCAI/8th Term/Assignment_1/dataset/
labels/validation.cache... 2684 images, 2079 backgrounds, 0 corrupt: 100%|██████████| 268
4/2684 [00:00<?, ?it/s]
Plotting labels to runs/detect/train/labels.jpg...
optimizer: 'optimizer=auto' found, ignoring 'lr0=0.01' and 'momentum=0.937' and determini
ng best 'optimizer', 'lr0' and 'momentum' automatically...
optimizer: AdamW(lr=0.002, momentum=0.9) with parameter groups 57 weight(decay=0.0), 64 w
eight(decay=0.0005), 63 bias(decay=0.0)
TensorBoard: model graph visualization added ✅
Image sizes 640 train, 640 val
Using 8 dataloader workers
Logging results to runs/detect/train
Starting training for 1 epochs...

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
        1/1      2.31G      2.032      2.694      1.866          1        640: 100%|████
██████| 563/563 [08:51<00:00,  1.06it/s]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95):
100%|██████████| 84/84 [00:59<00:00,  1.42it/s]
                   all       2684        981      0.153      0.243      0.108     0.0331

1 epochs completed in 0.167 hours.
Optimizer stripped from runs/detect/train/weights/last.pt, 6.2MB
Optimizer stripped from runs/detect/train/weights/best.pt, 6.2MB

Validating runs/detect/train/weights/best.pt...
Ultralytics YOLOv8.2.18 🚀 Python-3.11.5 torch-2.2.2 CUDA:0 (NVIDIA GeForce GTX 1650, 390
4MiB)
Model summary (fused): 168 layers, 3005843 parameters, 0 gradients, 8.1 GFLOPs
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95):
100%|██████████| 84/84 [00:51<00:00,  1.62it/s]
                   all       2684        981      0.157      0.224      0.109     0.0337
Speed: 0.4ms preprocess, 17.1ms inference, 0.0ms loss, 0.9ms postprocess per image
Results saved to runs/detect/train
```

Predicting Bounding Boxes

In [ ]:

```python
model = YOLO("best3.pt")
results = model('dataset/images/test',conf=0.1,stream=True)

def get_id_from_path(path):
    return os.path.splitext(os.path.basename(path))[0]
```

```python
for result in results:
    id = get_id_from_path(result.path)
    with open(f'dataset/predictions/{id}.txt', 'w') as f:
        if len(result.xywh) == 0:
            f.write(f'{id}\n')
        else:
            with open(f'dataset/predictions/{id}.txt', 'w') as f:

                x, y, w, h = denormalize_bbox(*result.xywh.tolist())
                confidence = result.conf
                f.write(f'{id} {confidence} {x} {y} {w} {h} \n')
```