CMPT412 Assignment3

Use of 1 free late day.

• Part 1:

o List of the configs and modifications that you used.

```
model_zoo.get_config_file("COCO-Detection/faster_rcnn_X_101_32x8d_FPN_3x.yaml")
cfg.SOLVER.BASE_LR = 0.005
cfg.SOLVER.MAX_ITER = 400
```

o Factors which helped improve the performance. Explain each factor in 2-3 lines.

Adjust model:

```
model_zoo.get_config_file("COCO-Detection/faster_rcnn_X_101_32x8d_FPN_3x.yaml")
```

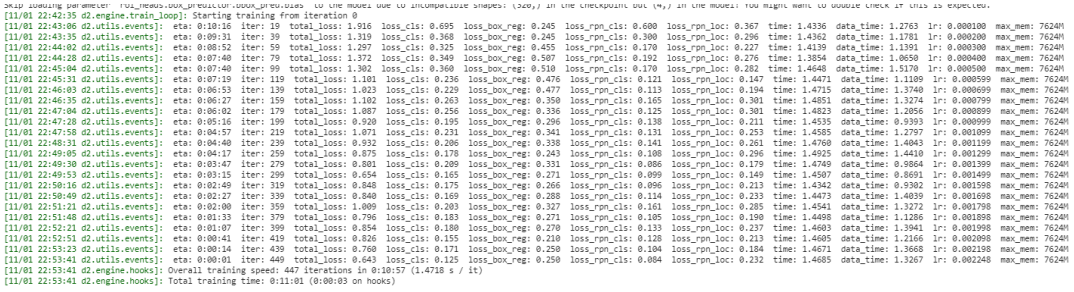
Generally, faster RCNN can perform better and I should choose the deeper model 101 instead of 50. Also, based on our images, although they are high-resolution, the objects (plane) are small. Feature pyramid networks (FPN) are effective at detecting small objects.

Adjust learning rate:

```
cfg.SOLVER.BASE_LR = 0.005
cfg.SOLVER.MAX_ITER = 400
```

The original learning rate is quite small, 0.00025. Small learning rate require more training epochs and may cause the process get stuck, but high learning rate require less epochs and may cause my model converge too quickly so the model can not learn enough. I make the balance between those parts, setting learning rate higher than 0.00025 but cannot too high. I also set epochs lower due to the increase of learning rate.

o Final plot for total training loss and accuracy. This would have been auto-generated by the notebook.



```
[11/01 22:42:35 d2.engine.train_loop]: Starting training from iteration 0
[11/01 22:43:06 d2.utils.events]:  eta: 0:10:16  iter: 19  total_loss: 1.916  loss_cls: 0.695  loss_box_reg: 0.245  loss_rpn_cls: 0.600  loss_rpn_loc: 0.367  time: 1.4336  data_time: 1.2763  lr: 0.000100  max_mem: 7624M
[11/01 22:43:35 d2.utils.events]:  eta: 0:09:31  iter: 39  total_loss: 1.319  loss_cls: 0.368  loss_box_reg: 0.245  loss_rpn_cls: 0.300  loss_rpn_loc: 0.296  time: 1.4362  data_time: 1.1781  lr: 0.000200  max_mem: 7624M
[11/01 22:44:02 d2.utils.events]:  eta: 0:08:52  iter: 59  total_loss: 1.297  loss_cls: 0.325  loss_box_reg: 0.455  loss_rpn_cls: 0.170  loss_rpn_loc: 0.227  time: 1.4139  data_time: 1.1391  lr: 0.000300  max_mem: 7624M
[11/01 22:44:28 d2.utils.events]:  eta: 0:07:40  iter: 79  total_loss: 1.372  loss_cls: 0.349  loss_box_reg: 0.507  loss_rpn_cls: 0.192  loss_rpn_loc: 0.276  time: 1.3854  data_time: 1.0650  lr: 0.000400  max_mem: 7624M
[11/01 22:45:04 d2.utils.events]:  eta: 0:07:40  iter: 99  total_loss: 1.302  loss_cls: 0.360  loss_box_reg: 0.510  loss_rpn_cls: 0.170  loss_rpn_loc: 0.282  time: 1.4648  data_time: 1.5170  lr: 0.000500  max_mem: 7624M
[11/01 22:45:31 d2.utils.events]:  eta: 0:07:19  iter: 119  total_loss: 1.101  loss_cls: 0.236  loss_box_reg: 0.476  loss_rpn_cls: 0.121  loss_rpn_loc: 0.147  time: 1.4471  data_time: 1.1189  lr: 0.000599  max_mem: 7624M
[11/01 22:46:03 d2.utils.events]:  eta: 0:06:53  iter: 139  total_loss: 1.023  loss_cls: 0.229  loss_box_reg: 0.477  loss_rpn_cls: 0.113  loss_rpn_loc: 0.194  time: 1.4715  data_time: 1.3740  lr: 0.000699  max_mem: 7624M
[11/01 22:46:35 d2.utils.events]:  eta: 0:06:27  iter: 159  total_loss: 1.102  loss_cls: 0.263  loss_box_reg: 0.350  loss_rpn_cls: 0.165  loss_rpn_loc: 0.301  time: 1.4851  data_time: 1.3274  lr: 0.000799  max_mem: 7624M
[11/01 22:47:04 d2.utils.events]:  eta: 0:06:02  iter: 179  total_loss: 1.087  loss_cls: 0.256  loss_box_reg: 0.336  loss_rpn_cls: 0.125  loss_rpn_loc: 0.301  time: 1.4823  data_time: 1.2056  lr: 0.000899  max_mem: 7624M
[11/01 22:47:28 d2.utils.events]:  eta: 0:05:16  iter: 199  total_loss: 0.920  loss_cls: 0.195  loss_box_reg: 0.296  loss_rpn_cls: 0.138  loss_rpn_loc: 0.211  time: 1.4535  data_time: 0.9393  lr: 0.000999  max_mem: 7624M
[11/01 22:47:58 d2.utils.events]:  eta: 0:04:57  iter: 219  total_loss: 1.071  loss_cls: 0.231  loss_box_reg: 0.341  loss_rpn_cls: 0.131  loss_rpn_loc: 0.253  time: 1.4585  data_time: 1.2797  lr: 0.001099  max_mem: 7624M
[11/01 22:48:31 d2.utils.events]:  eta: 0:04:40  iter: 239  total_loss: 0.932  loss_cls: 0.206  loss_box_reg: 0.338  loss_rpn_cls: 0.141  loss_rpn_loc: 0.261  time: 1.4760  data_time: 1.4043  lr: 0.001199  max_mem: 7624M
[11/01 22:49:05 d2.utils.events]:  eta: 0:04:17  iter: 259  total_loss: 0.875  loss_cls: 0.178  loss_box_reg: 0.243  loss_rpn_cls: 0.108  loss_rpn_loc: 0.296  time: 1.4925  data_time: 1.4410  lr: 0.001299  max_mem: 7624M
[11/01 22:49:30 d2.utils.events]:  eta: 0:03:47  iter: 279  total_loss: 0.801  loss_cls: 0.209  loss_box_reg: 0.331  loss_rpn_cls: 0.086  loss_rpn_loc: 0.179  time: 1.4749  data_time: 0.9864  lr: 0.001399  max_mem: 7624M
[11/01 22:49:53 d2.utils.events]:  eta: 0:03:15  iter: 299  total_loss: 0.654  loss_cls: 0.165  loss_box_reg: 0.271  loss_rpn_cls: 0.099  loss_rpn_loc: 0.149  time: 1.4507  data_time: 0.8691  lr: 0.001499  max_mem: 7624M
[11/01 22:50:16 d2.utils.events]:  eta: 0:02:49  iter: 319  total_loss: 0.848  loss_cls: 0.175  loss_box_reg: 0.266  loss_rpn_cls: 0.096  loss_rpn_loc: 0.213  time: 1.4342  data_time: 0.9302  lr: 0.001598  max_mem: 7624M
[11/01 22:50:49 d2.utils.events]:  eta: 0:02:27  iter: 339  total_loss: 0.840  loss_cls: 0.169  loss_box_reg: 0.288  loss_rpn_cls: 0.114  loss_rpn_loc: 0.233  time: 1.4473  data_time: 1.4039  lr: 0.001698  max_mem: 7624M
[11/01 22:51:21 d2.utils.events]:  eta: 0:02:00  iter: 359  total_loss: 1.009  loss_cls: 0.203  loss_box_reg: 0.327  loss_rpn_cls: 0.161  loss_rpn_loc: 0.285  time: 1.4541  data_time: 1.3272  lr: 0.001798  max_mem: 7624M
[11/01 22:51:48 d2.utils.events]:  eta: 0:01:33  iter: 379  total_loss: 0.796  loss_cls: 0.183  loss_box_reg: 0.271  loss_rpn_cls: 0.105  loss_rpn_loc: 0.190  time: 1.4498  data_time: 1.1286  lr: 0.001898  max_mem: 7624M
[11/01 22:52:21 d2.utils.events]:  eta: 0:01:07  iter: 399  total_loss: 0.854  loss_cls: 0.180  loss_box_reg: 0.270  loss_rpn_cls: 0.133  loss_rpn_loc: 0.237  time: 1.4603  data_time: 1.3941  lr: 0.001998  max_mem: 7624M
[11/01 22:52:51 d2.utils.events]:  eta: 0:00:41  iter: 419  total_loss: 0.826  loss_cls: 0.155  loss_box_reg: 0.210  loss_rpn_cls: 0.128  loss_rpn_loc: 0.213  time: 1.4605  data_time: 1.2166  lr: 0.002098  max_mem: 7624M
[11/01 22:53:23 d2.utils.events]:  eta: 0:00:14  iter: 439  total_loss: 0.760  loss_cls: 0.171  loss_box_reg: 0.250  loss_rpn_cls: 0.104  loss_rpn_loc: 0.184  time: 1.4671  data_time: 1.3668  lr: 0.002198  max_mem: 7624M
[11/01 22:53:41 d2.utils.events]:  eta: 0:00:01  iter: 449  total_loss: 0.643  loss_cls: 0.125  loss_box_reg: 0.250  loss_rpn_cls: 0.084  loss_rpn_loc: 0.232  time: 1.4685  data_time: 1.3267  lr: 0.002248  max_mem: 7624M
[11/01 22:53:41 d2.engine.hooks]: Overall training speed: 447 iterations in 0:10:57 (1.4718 s / it)
[11/01 22:53:41 d2.engine.hooks]: Total training time: 0:11:01 (0:00:03 on hooks)
```

```
[11/01 22:56:32 d2.evaluation.coco_evaluation]: Evaluating predictions ...
Loading and preparing results...
DONE (t=0.02s)
creating index...
index created!
Running per image evaluation...
Evaluate annotation type *bbox*
COCOeval_opt.evaluate() finished in 0.26 seconds.
Accumulating evaluation results...
COCOeval_opt.accumulate() finished in 0.02 seconds.
 Average Precision  (AP) @[ IoU=0.50:0.95 | area=   all | maxDets=100 ] = 0.282
 Average Precision  (AP) @[ IoU=0.50      | area=   all | maxDets=100 ] = 0.561
 Average Precision  (AP) @[ IoU=0.75      | area=   all | maxDets=100 ] = 0.243
 Average Precision  (AP) @[ IoU=0.50:0.95 | area= small | maxDets=100 ] = 0.202
 Average Precision  (AP) @[ IoU=0.50:0.95 | area=medium | maxDets=100 ] = 0.346
 Average Precision  (AP) @[ IoU=0.50:0.95 | area= large | maxDets=100 ] = 0.527
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets=  1 ] = 0.014
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets= 10 ] = 0.114
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets=100 ] = 0.329
 Average Recall     (AR) @[ IoU=0.50:0.95 | area= small | maxDets=100 ] = 0.218
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=medium | maxDets=100 ] = 0.404
 Average Recall     (AR) @[ IoU=0.50:0.95 | area= large | maxDets=100 ] = 0.641
[11/01 22:56:32 d2.evaluation.coco_evaluation]: Evaluation results for bbox:
|   AP   |  AP50  |  AP75  |  APs   |  APm   |  AP1   |
|:------:|:------:|:------:|:------:|:------:|:------:|
| 28.215 | 56.058 | 24.322 | 20.173 | 34.608 | 52.723 |
OrderedDict([('bbox', {'AP': 28.21481763069922, 'AP50': 56.057851635798286, 'AP75': 24.322153788500852, 'Al
```

o The visualization of 3 test samples and the predicted results.

o At least one ablation study to validate the above choices, i.e., a comparison of performance for two variants of a model, one with and one without a certain feature or implementation choice. In addition, provide visualization of a test sample for qualitative comparison.

Old parameter settings:

AP50:32

```
cfg.merge_from_file(model_zoo.get_config_file("COCO-Detection/faster_rcnn_R_50_FPN_3x.yaml"))
cfg.MODEL.WEIGHTS = model_zoo.get_checkpoint_url("COCO-Detection/faster_rcnn_R_50_FPN_3x.yaml"))
cfg.SOLVER.BASE_LR = 0.00025
```

Updated parameter settings:

AP50: 56

```
cfg.merge_from_file(model_zoo.get_config_file("COCO-Detection/faster_rcnn_X_101_32x8d_FPN_3x.yaml"))
cfg.MODEL.WEIGHTS = model_zoo.get_checkpoint_url("COCO-Detection/faster_rcnn_X_101_32x8d_FPN_3x.yaml")
cfg.SOLVER.BASE_LR = 0.005
```

Better result:

• Part 2:
o Report any hyperparameter settings you used (batch_size, learning_rate, num_epochs, optimizer).
num_epochs = 25
batch_size = 4
learning_rate = 0.03
weight_decay = 1e-5
optim = torch.optim.SGD(model.parameters(),lr=learning_rate,weight_decay=weight_decay)

o Report the final architecture of your network including any modification that you have for the layers. Briefly explain the reason for each modification.

I have added more layers to increase the accuracy. In convolution module, when activation is needed, there are 4 other combinations of convolution layers, normalization and LeakyRelu layers added, so the deep network can go deeper to extract mode information from the image.
When activation sets to false, I added one normalization layer after convolutions layers and also add to the down module. Normalizing the output from convolution layers can stabilize the learning process and reduce epochs to train deep network.

Layer No	Layer Type	Kernel Size	Input|Outp	Input|Out dimension
1	conv2d	3	3|64	128|128
2	normalization			128|128
3	LeakyRelu			128|128
4	conv2d	3	64|64	128|128
5	normalization			128|128
6	LeakyRelu			128|128
7	conv2d	3	64|128	128|128
9	normalization			128|128
10	LeakyRelu			128|128
11	conv2d	3	128|64	128|128
12	normalization			128|128
13	LeakyRelu			128|128
14	conv2d	3	64|4	128|128
15	normalization			128|128
16	LeakyRelu			128|128
17	conv2d	3	4|64	128|128
18	normalization			128|128
19	LeakyRelu			128|128
20	conv2d	3	64|64	128|128
21	normalization			128|128
22	LeakyRelu			128|128
23	conv2d	3	64|128	128|128
24	normalization			128|128
25	LeakyRelu			128|128
26	conv2d	3	128|64	128|128
27	normalization			128|128
28	LeakyRelu			128|128
29	conv2d	3	64|8	128|128
30	normalization			128|128
31	LeakyRelu			128|128
32	normalization			128|128
33	Maxpooling			128|64
34	LeakyRelu			64|64
35	upsample		8|16	64|128
36	conv2d	3	16|64	128|128
37	normalization			128|128
38	LeakyRelu			128|128
39	conv2d	3	64|64	128|128
40	normalization			128|128
41	LeakyRelu			128|128
42	conv2d	3	64|128	128|128
43	normalization			128|128
44	LeakyRelu			128|128
45	conv2d	3	128|64	128|128
46	normalization			128|128
47	LeakyRelu			128|128
48	conv2d	3	64|4	128|128
49	normalization			128|128
50	LeakyRelu			128|128
51	conv2d	3	4|1	128|128
52	normalization			128|128

o Report the loss functions that you used and the plot the total training loss of the training procedure

```
100% 1995/1995 [11:33<00:00, 2.88it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:24: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:25: UserWarning

Epoch: 0, Loss: 0.31015148758888245
100% 1995/1995 [10:34<00:00, 3.14it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning

Epoch: 1, Loss: 0.26569339632987976
100% 1995/1995 [09:36<00:00, 3.46it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning

Epoch: 2, Loss: 0.25129127502441406
100% 1995/1995 [08:38<00:00, 3.85it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarning

Epoch: 3, Loss: 0.24125079810619354
```

```
Epoch: 4, Loss: 0.23474687337875366
100% 1995/1995 [06:43<00:00, 4.95it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW

Epoch: 5, Loss: 0.23020599782466888
100% 1995/1995 [05:46<00:00, 5.77it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW

Epoch: 6, Loss: 0.2279159426689148
100% 1995/1995 [04:48<00:00, 6.92it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW

Epoch: 7, Loss: 0.22398623824119568
100% 1995/1995 [03:50<00:00, 8.64it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW

Epoch: 8, Loss: 0.22139872610569
100% 1995/1995 [01:54<00:00, 17.35it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserW
```

```
Epoch: 9, Loss: 0.21894574165344238
100% 1995/1995 [01:55<
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc

Epoch: 10, Loss: 0.21721374988555908
100% 1995/1995 [00:57<
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc

Epoch: 11, Loss: 0.21532082557678223
100% 1995/1995 [00:57<
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc

Epoch: 12, Loss: 0.2144259661436081
100% 1995/1995 [12:29<
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc

Epoch: 13, Loss: 0.21358530223369598
100% 1995/1995 [11:31<
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc
/usr/local/lib/python3.6/dist-packages/ipykernel_launc

Epoch: 14, Loss: 0.21110987663269043
```

```
Epoch: 15, Loss: 0.21040597558021545
100% 1995/1995 [0
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l

Epoch: 16, Loss: 0.2092978060245514
100% 1995/1995 [0
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l

Epoch: 17, Loss: 0.2081814557313919
100% 1995/1995 [0
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l

Epoch: 18, Loss: 0.20725101232528687
100% 1995/1995 [0
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l

Epoch: 19, Loss: 0.20686404407024384
100% 1995/1995 [0
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l
/usr/local/lib/python3.6/dist-packages/ipykernel_l

Epoch: 20, Loss: 0.20486223697662354
```

```
Epoch: 19, Loss: 0.20686404407024384
100% 1995/1995 [02:
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau

Epoch: 20, Loss: 0.20486223697662354
100% 1995/1995 [04:
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau

Epoch: 21, Loss: 0.2042093127965927
100% 1995/1995 [03:
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau

Epoch: 22, Loss: 0.20380237698554993
100% 1995/1995 [02:
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau

Epoch: 23, Loss: 0.20405738055706024
100% 1995/1995 [01:
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau
/usr/local/lib/python3.6/dist-packages/ipykernel_lau

Epoch: 24, Loss: 0.20264242589473724
```

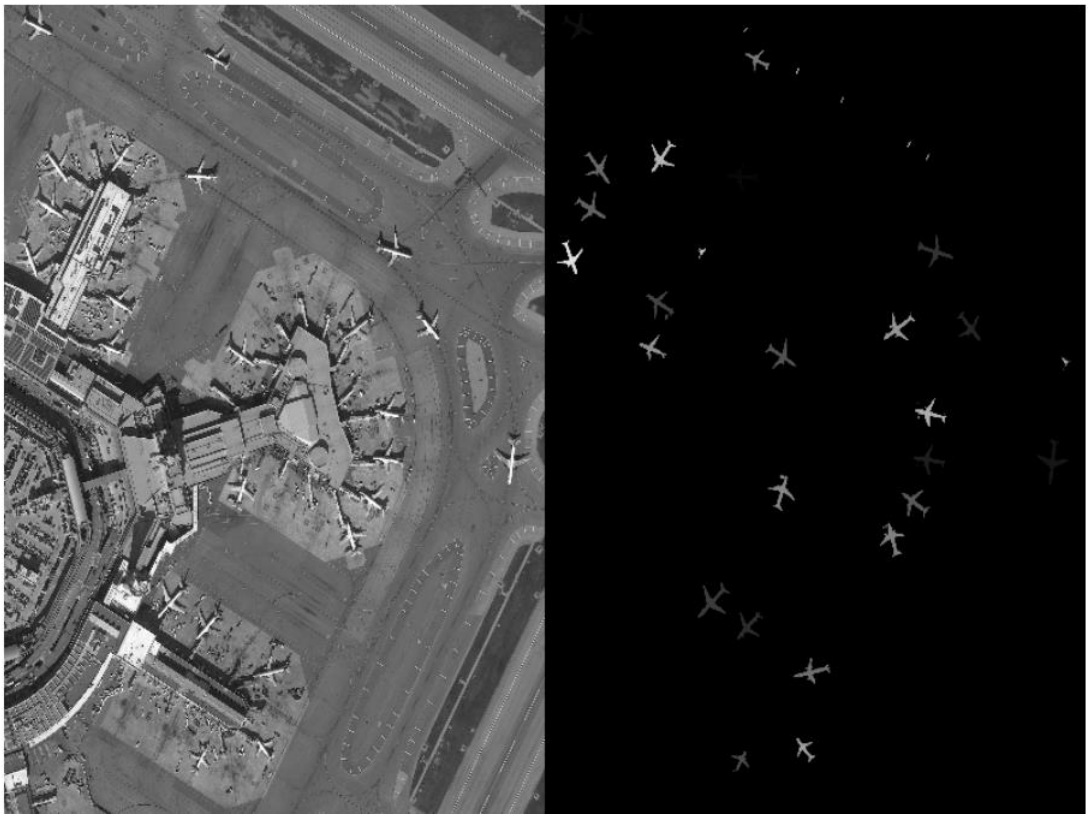
o Report the final mean IoU of your model.

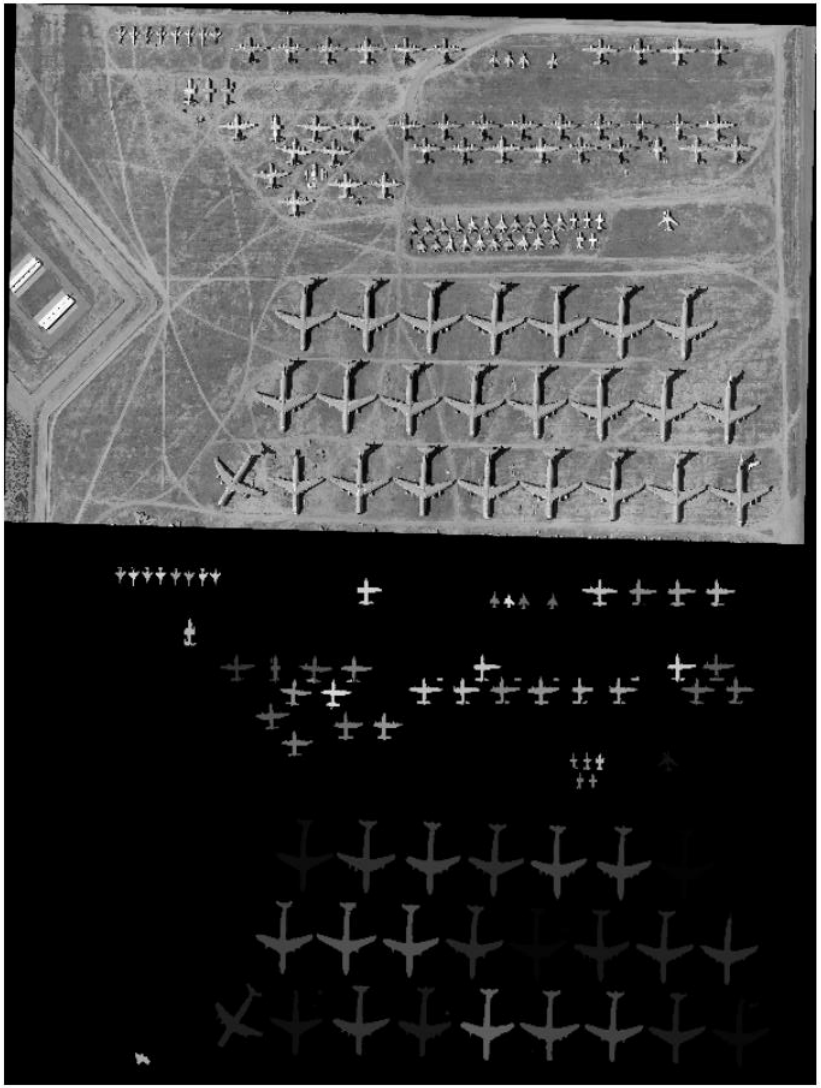
```
100% 998/998 [03:12<00:00, 5.17it/s]
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarn
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarn
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarn
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:31: UserWarn


#images: 7980, Mean IoU: 0.7189520586657695
```

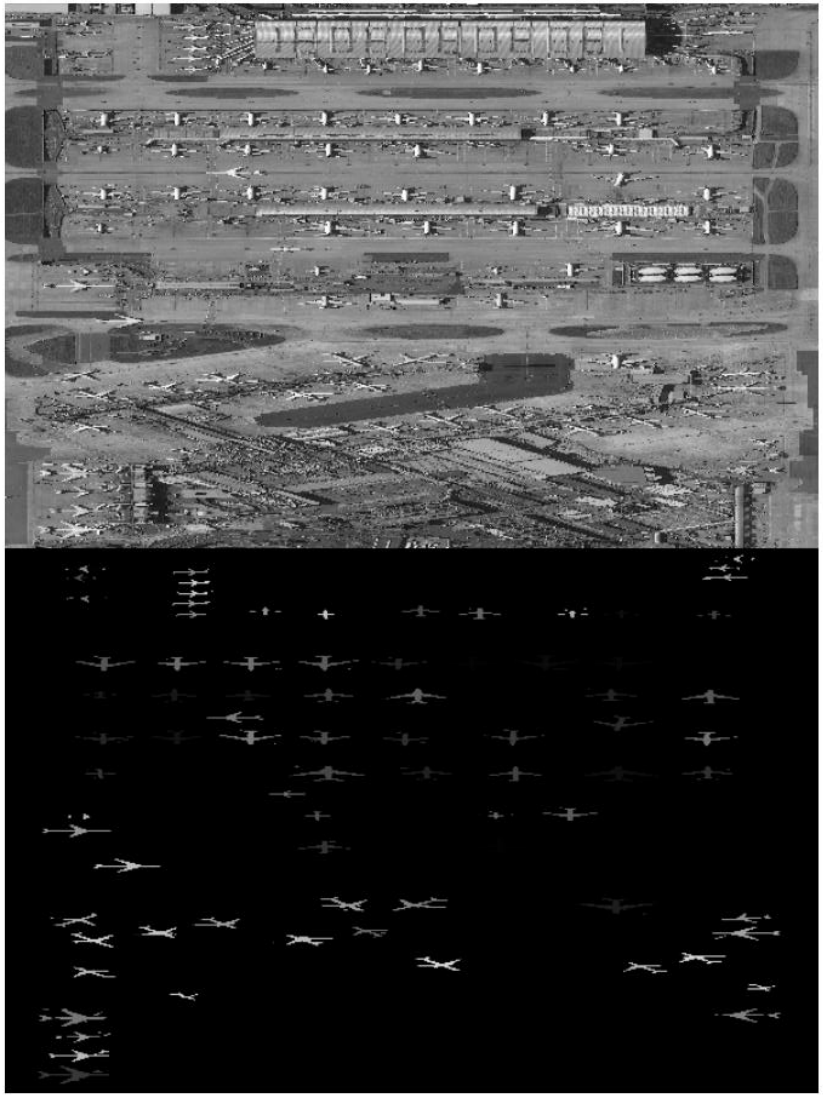
o Visualize 3 test images and the corresponding predicted masks.




• Part 3:
Kaggle name: Carina Zhao
Score: 0.1742
Visualize 3 random test samples.

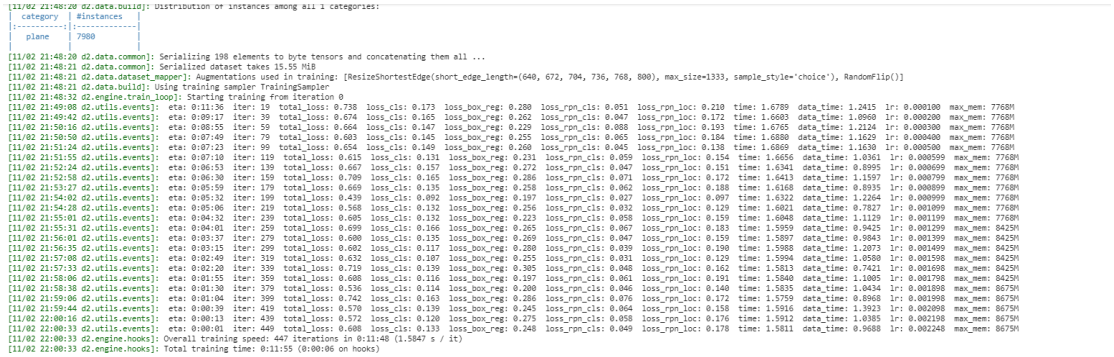






• Part 4:

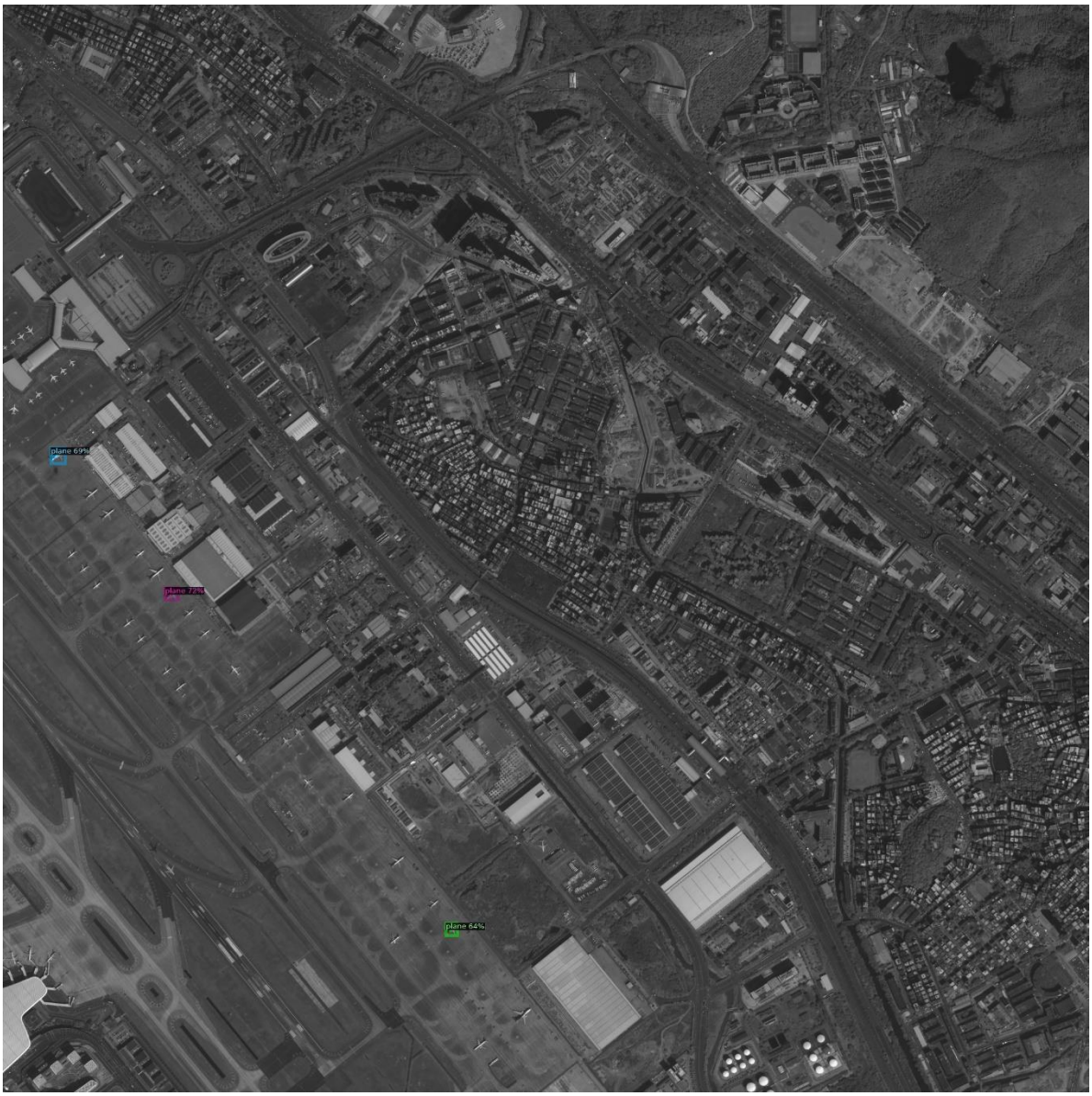
o The visualisation and the evaluation results similar to Part 1.




```
COCOeval_opt.accumulate() finished in 0.03 seconds.
 Average Precision  (AP) @[ IoU=0.50:0.95 | area=   all | maxDets=100 ] = 0.310
 Average Precision  (AP) @[ IoU=0.50       | area=   all | maxDets=100 ] = 0.552
 Average Precision  (AP) @[ IoU=0.75       | area=   all | maxDets=100 ] = 0.333
 Average Precision  (AP) @[ IoU=0.50:0.95 | area= small | maxDets=100 ] = 0.216
 Average Precision  (AP) @[ IoU=0.50:0.95 | area=medium | maxDets=100 ] = 0.394
 Average Precision  (AP) @[ IoU=0.50:0.95 | area= large | maxDets=100 ] = 0.563
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets=  1 ] = 0.015
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets= 10 ] = 0.124
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets=100 ] = 0.351
 Average Recall     (AR) @[ IoU=0.50:0.95 | area= small | maxDets=100 ] = 0.225
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=medium | maxDets=100 ] = 0.439
 Average Recall     (AR) @[ IoU=0.50:0.95 | area= large | maxDets=100 ] = 0.687
[11/03 06:27:54 d2.evaluation.coco_evaluation]: Evaluation results for bbox:
|   AP   |  AP50  |  AP75  |  APs   |  APm   |  APl   |
|:------:|:------:|:------:|:------:|:------:|:------:|
| 31.033 | 55.180 | 33.292 | 21.600 | 39.421 | 56.282 |
```

```
COCOeval_opt.accumulate() finished in 0.03 seconds.
 Average Precision  (AP) @[ IoU=0.50:0.95 | area=   all | maxDets=100 ] = 0.097
 Average Precision  (AP) @[ IoU=0.50       | area=   all | maxDets=100 ] = 0.323
 Average Precision  (AP) @[ IoU=0.75       | area=   all | maxDets=100 ] = 0.022
 Average Precision  (AP) @[ IoU=0.50:0.95 | area= small | maxDets=100 ] = 0.047
 Average Precision  (AP) @[ IoU=0.50:0.95 | area=medium | maxDets=100 ] = 0.112
 Average Precision  (AP) @[ IoU=0.50:0.95 | area= large | maxDets=100 ] = 0.385
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets=  1 ] = 0.008
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets= 10 ] = 0.061
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=   all | maxDets=100 ] = 0.134
 Average Recall     (AR) @[ IoU=0.50:0.95 | area= small | maxDets=100 ] = 0.068
 Average Recall     (AR) @[ IoU=0.50:0.95 | area=medium | maxDets=100 ] = 0.164
 Average Recall     (AR) @[ IoU=0.50:0.95 | area= large | maxDets=100 ] = 0.431
[11/03 06:27:56 d2.evaluation.coco_evaluation]: Evaluation results for segm:
|  AP   |  AP50  |  AP75  |  APs  |  APm   |  APl   |
|:-----:|:------:|:------:|:-----:|:------:|:------:|
| 9.674 | 32.298 | 2.188  | 4.694 | 11.248 | 38.505 |
```


plane 95%
plane 97%
plane 96%



o Explain the differences.

Part4 use mask R-CNN to detect the objects and part1 use faster R-CNN for detection. Compared to faster R-CNN, mask R-CNN has one more branch for predicting an object mask paralleling to classification and localization. Faster R-CNN is fast to predict the regions. However, faster R-CNN only can predict bounding box location. The quality of mask R-CNN's mask is poor.

Based on AP50 from part1 and part4, faster R-CNN and mask R-CNN has similar performance at predicting bounding box location, but mask R-CNN takes longer time for training. I think faster R-CNN is better. The accuracy of faster R-CNN and mask R-CNN are roughly same, but faster R-CNN has shorter training time.

Compared to the part 3's IoU, 0.71, mask R-CNN's AP50 is 0.32. There are 32% mask predicted true when set IoU threshold to 0.5, using mask R-CNN.