You can modify this report template, and upload your results in PDF format. Reports in other forms/formats will result in ZERO point. Reports written in either Chinese or English are both acceptable. The length of your report should NOT exceed 6 pages (**excluding bonus**).

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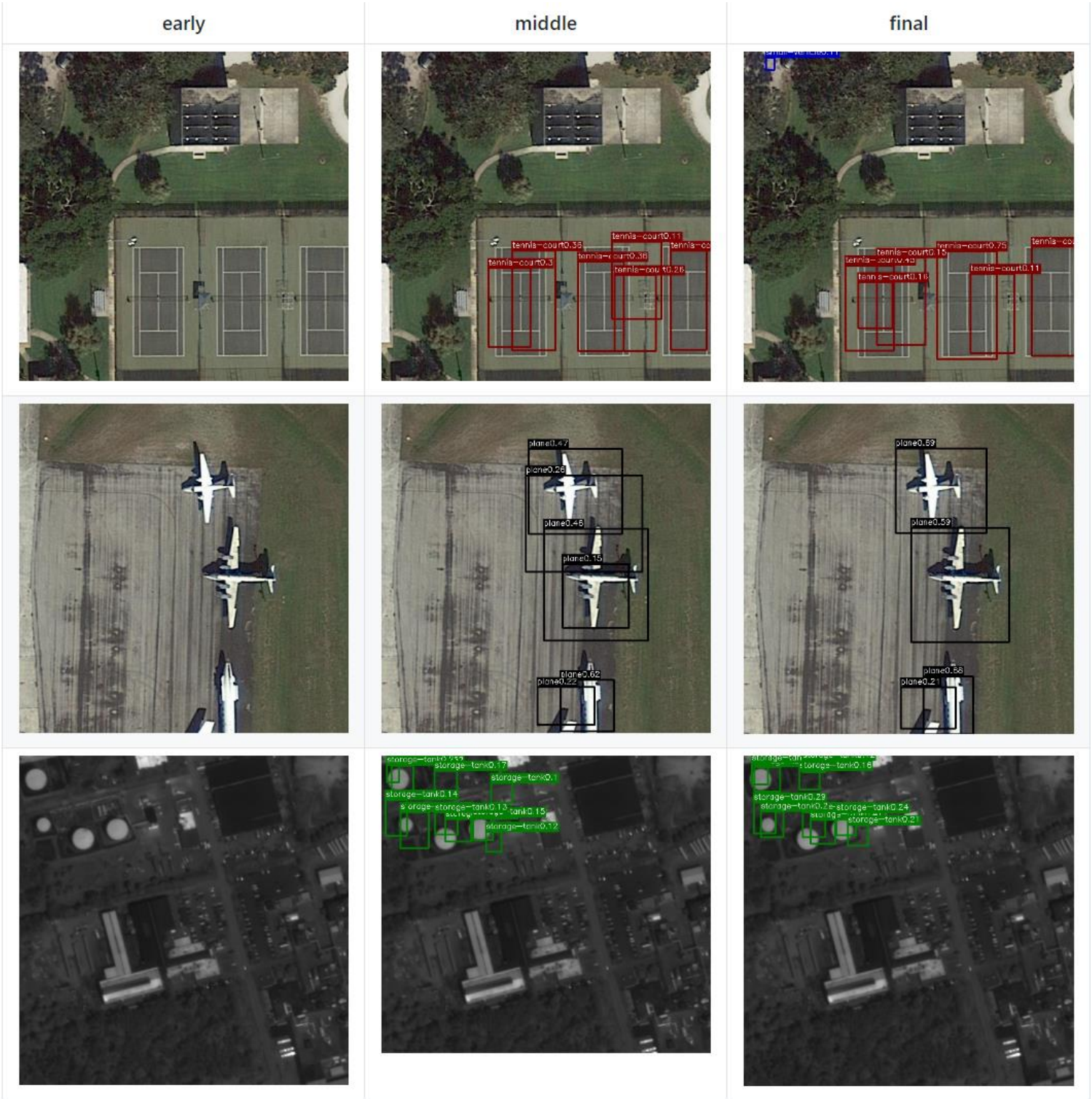
1. (5%) Print the network architecture of your YoloV1-vgg16bn model and describe your training config. (optimizer,batch size….and so on)

```
VGG(
  (features): Sequential(
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1))
    (1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (2): ReLU(inplace)
    (3): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (4): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (5): ReLU(inplace)
    (6): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (7): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (9): ReLU(inplace)
    (10): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (11): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (12): ReLU(inplace)
    (13): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (14): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (15): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (16): ReLU(inplace)
    (17): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (18): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (19): ReLU(inplace)
    (20): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (21): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (22): ReLU(inplace)
    (23): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (24): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (25): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (26): ReLU(inplace)
    (27): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (28): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (29): ReLU(inplace)
    (30): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (31): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (32): ReLU(inplace)
    (33): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (34): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (35): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (36): ReLU(inplace)
    (37): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (38): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (39): ReLU(inplace)
    (40): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (41): BatchNorm2d(512, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (42): ReLU(inplace)
    (43): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  )
  (yolo): Sequential(
    (0): Linear(in_features=25088, out_features=4096, bias=True)
    (1): BatchNorm1d(4096, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1)
    (3): Dropout(p=0.5)
    (4): Linear(in_features=4096, out_features=1274, bias=True)
  )
)
```

Optimizer: SGD, momentum=0.9, weight_decay=0.00005
Epoch: 100
Batch_size: 25
Learing rate:0.001, decay to 0.0001 at epoch 60

2. (10%) Show the predicted bbox image of “val1500/0076.jpg”, “val1500/0086.jpg”, “val1500/0907.jpg” during the early, middle, and the final stage during the training stage. (For example, results of 1st, 10th, 20th epoch)



3. (10%) Implement an improved model which performs better than your baseline model. Print the network architecture of this model and describe it.

```
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  (features): Sequential(
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(2, 2), padding=(1, 1))
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    (15): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (16): ReLU(inplace)
    (17): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (18): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
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  )
)
```
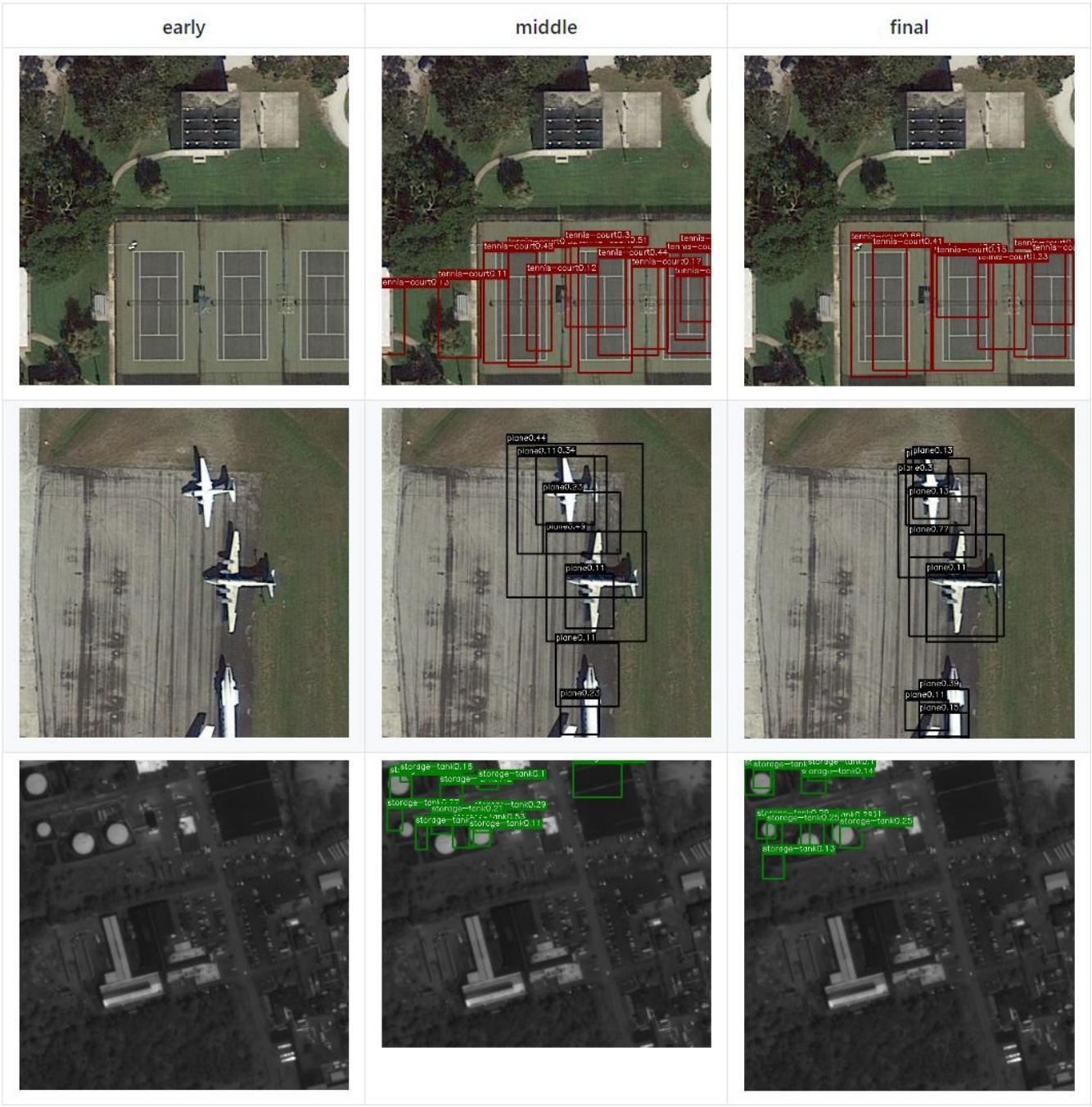

Improved model 跟 baseline 的 backbone 一樣，但是改掉了 loss function。由於觀察到 class imbalance，發現某些類別的樣本數較少，mAP 較低，所以把 loss function 改成 class weighted loss，其中的 weight 與**該 class 在整個 dataset 裡的樣本數**成**反比**。

然而如果單純這麼做，會使 training 不穩定，所以更進一步的，將 weight 改成與**該 class 在每個 batch 裡的樣本數**成**反比**，也就是，在每個 batch 根據 sample 到各個 class 的樣本數，重新計算每個 class weight，稱其為 batch-wise weighted loss。

4. (10%) Show the predicted bbox image of "val1500/0076.jpg", "val1500/0086.jpg", "val1500/0907.jpg" during the early, middle, and the final stage during the training process of this improved model.

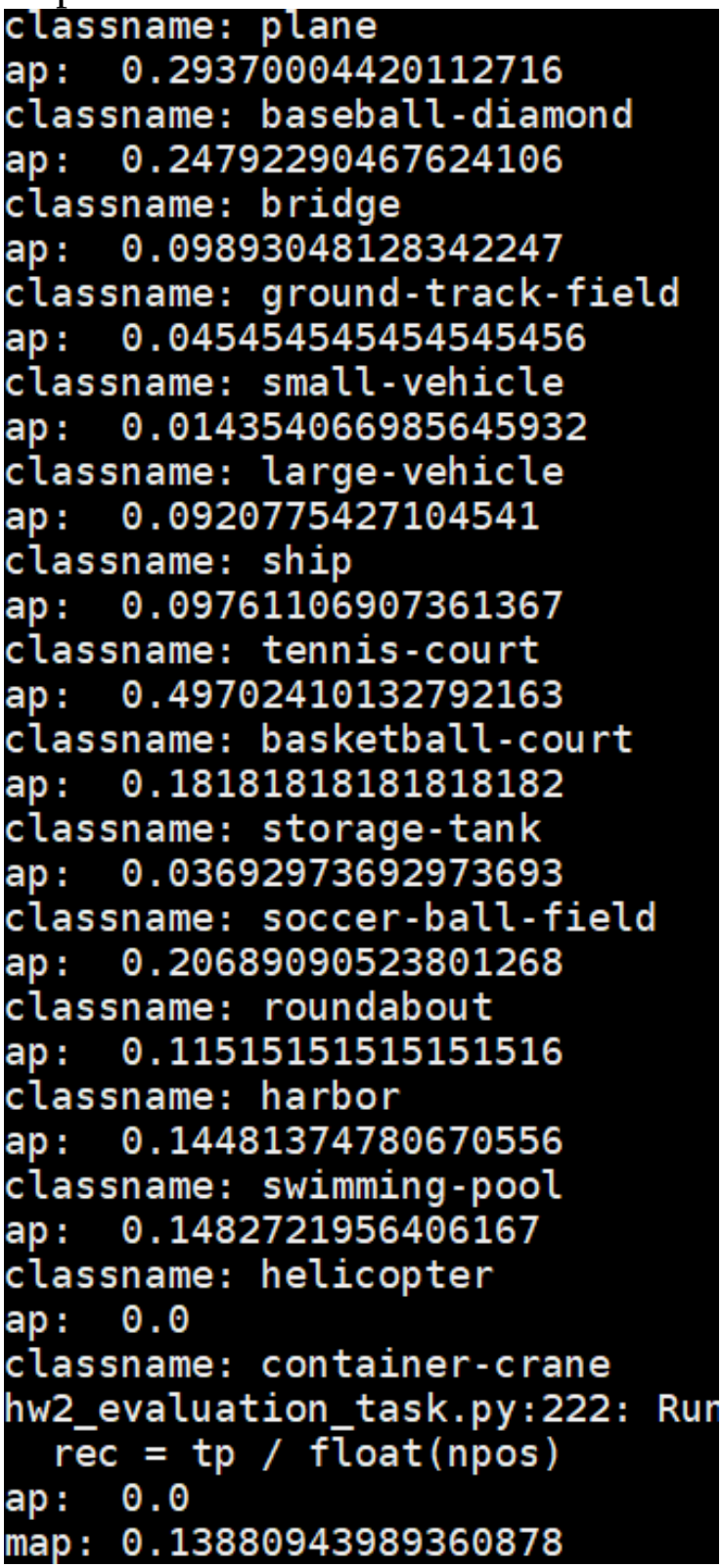


5. (15%) Report mAP score of both models on the validation set. Discuss the reason why the improved model performs better than the baseline one. You may conduct some experiments and show some evidences to support your reasoning.

Baseline model: **10.5%**

```
classname: plane
ap:  0.277790251330766 74
classname: baseball-diamond
ap:  0.090909090909091
classname: bridge
ap:  0.090909090909091
classname: ground-track-field
ap:  0.0454545454545456
classname: small-vehicle
ap:  0.024118738404452 69
classname: large-vehicle
ap:  0.100509934939335 34
classname: ship
ap:  0.099023636887155 46
classname: tennis-court
ap:  0.449041541915685 57
classname: basketball-court
ap:  0.1590909090909091
classname: storage-tank
ap:  0.067338051170386 49
classname: soccer-ball-field
ap:  0.0454545454545456
classname: roundabout
ap:  0.0
classname: harbor
ap:  0.125063891931361 8
classname: swimming-pool
ap:  0.110139860139860 13
classname: helicopter
ap:  0.0
classname: container-crane
ap:  0.0
map: 0.105302755533574 13
```

Improved model: **13.8%**



可以觀察到樣本數較少的 baseball-diamond、roundabout 跟 soccer-ball-field 都有顯著的進步，證實 batch-wise class weighted loss 對 class imbalance 有幫助。

6. **bonus (5%)** Which classes prediction perform worse than others? Why? You should describe and analyze it.

8723
515
2114
621
100000
23746
34585
3279
661
5199
590
537
7457
1977
434
136

上圖為每個 class 的樣本數(from plane to container-crane)，可以發現 baseline model 在樣本數較少的 class(baseball-diamond、roundabout、soccer-ball-field、helicopter and container-crane)表現特別差，明顯為 class imbalance。