

# Assignment 3 : Multi-label Image Classification

In [20]:

```
#!/sh download_data.sh
```

In [21]:

```
#!/sudo pip install sklearn
```

In [22]:

```
import os
import numpy as np
import torch
import torch.nn as nn
from torchvision import transforms
from sklearn.metrics import average_precision_score
from PIL import Image, ImageDraw
import matplotlib.pyplot as plt
from kaggle_submission import output_submission_csv
from classifier import Classifier
from voc_dataloader import VocDataset, VOC_CLASSES

%matplotlib inline
%load_ext autoreload
%autoreload 2
```

The autoreload extension is already loaded. To reload it, use:  
%reload\_ext autoreload

In this assignment, you train a classifier to do multi-label classification on the PASCAL VOC 2007 dataset. The dataset has 20 different classes which can appear in any given image. Your classifier will predict whether each class appears in an image. This task is slightly different from exclusive multiclass classification like the ImageNet competition where only a single most appropriate class is predicted for an image.

## Reading Pascal Data

### Loading Training Data

In the following cell we will load the training data and also apply some transforms to the data. Feel free to apply more [transforms](#) for data augmentation which can lead to better performance.

In [23]:

```
# Transforms applied to the training data
normalize = transforms.Normalize(mean=[0.485, 0.456, 0.406],
                                std=[0.229, 0.224, 0.225])

train_transform = transforms.Compose([
    transforms.RandomResizedCrop(227),
    transforms.RandomHorizontalFlip(),
    transforms.ToTensor(),
    normalize
])
```

In [24]:

```
ds_train = VocDataset('VOCdevkit_2007/VOC2007/', 'train', train_transform)
```

### Loading Validation Data

## Loading validation data

We will load the test data for the PASCAL VOC 2007 dataset. Do **NOT** add data augmentation transforms to validation data.

In [25]:

```
# Transforms applied to the testing data
test_transform = transforms.Compose([
    transforms.Resize(227),
    transforms.CenterCrop(227),
    transforms.ToTensor(),
    normalize
])
```

In [26]:

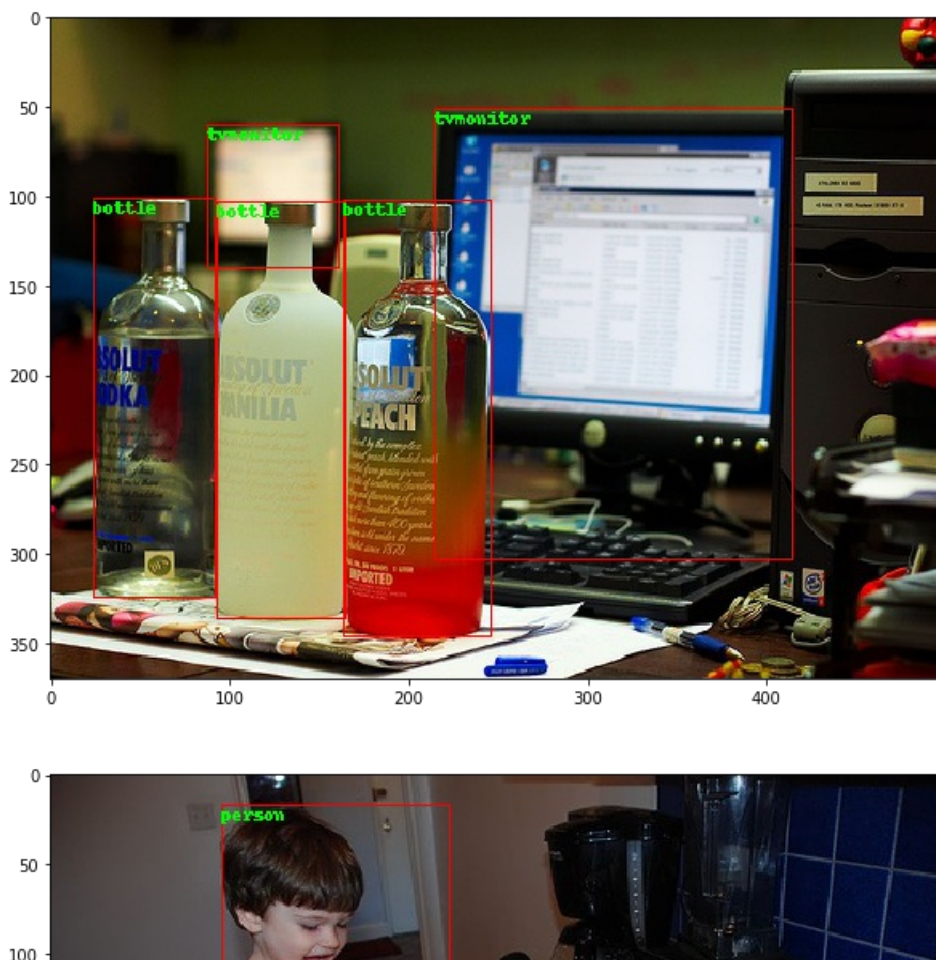
```
ds_val = VocDataset('VOCdevkit_2007/VOC2007/', 'val', test_transform)
```

## Visualizing the Data

PASCAL VOC has bounding box annotations in addition to class labels. Use the following code to visualize some random examples and corresponding annotations from the train set.

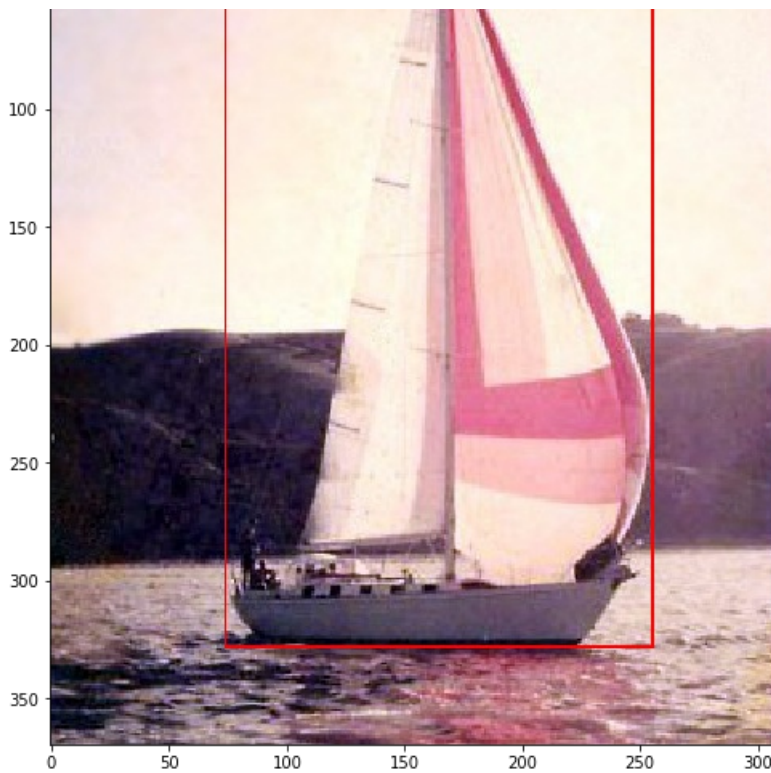
In [27]:

```
for i in range(5):
    idx = np.random.randint(0, len(ds_train.names)+1)
    _imgpath = os.path.join('VOCdevkit_2007/VOC2007/', 'JPEGImages', ds_train.names[idx]+'.jpg')
    img = Image.open(_imgpath).convert('RGB')
    draw = ImageDraw.Draw(img)
    for j in range(len(ds_train.box_indices[idx])):
        obj = ds_train.box_indices[idx][j]
        draw.rectangle(list(obj), outline=(255,0,0))
        draw.text(list(obj[0:2]), ds_train.classes[ds_train.label_order[idx][j]], fill=(0,255,0))
    plt.figure(figsize = (10,10))
    plt.imshow(np.array(img))
```









## Classification

In [28]:

```
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
```

In [29]:

```
train_loader = torch.utils.data.DataLoader(dataset=ds_train,
                                             batch_size=30,
                                             shuffle=True,
                                             num_workers=1)
```

In [30]:

```
val_loader = torch.utils.data.DataLoader(dataset=ds_val,
                                           batch_size=30,
                                           shuffle=True,
                                           num_workers=1)
```

In [31]:

```
def train_classifier(train_loader, classifier, criterion, optimizer):
    classifier.train()
    loss_ = 0.0
    losses = []
    for i, (images, labels, _) in enumerate(train_loader):
        images, labels = images.to(device), labels.to(device)
        optimizer.zero_grad()
        logits = classifier(images)
        loss = criterion(logits, labels)
        loss.backward()
        optimizer.step()
        losses.append(loss)
    return torch.stack(losses).mean().item()
```

In [32]:

```
def test_classifier(test_loader, classifier, criterion, print_ind_classes=True):
    classifier.eval()
    losses = []
```

```

with torch.no_grad():
    y_true = np.zeros((0,21))
    y_score = np.zeros((0,21))
    for i, (images, labels, _) in enumerate(test_loader):
        images, labels = images.to(device), labels.to(device)
        logits = classifier(images)
        y_true = np.concatenate((y_true, labels.cpu().numpy()), axis=0)
        y_score = np.concatenate((y_score, logits.cpu().numpy()), axis=0)
        loss = criterion(logits, labels)
        losses.append(loss)

    aps = []
    # ignore first class which is background
    for i in range(1, y_true.shape[1]):
        ap = average_precision_score(y_true[:, i], y_score[:, i])
        if print_ind_classes:
            print('----- Class: {:<12}      AP: {:>8.4f} -----'.format(VOC_CLASSES[i], ap))
        aps.append(ap)

    mAP = np.mean(aps)
    test_loss = np.mean(losses)
    print('mAP: {0:.4f}'.format(mAP))
    print('Avg loss: {}'.format(test_loss))

return mAP, test_loss, aps

```

## Modifying the network

The network you are given as is will allow you to reach around 0.15-0.2 mAP. To meet the benchmark for this assignment you will need to improve the network. There are a variety of different approaches you should try:

- Network architecture changes
  - Number of layers: try adding layers to make your network deeper
  - Batch normalization: adding batch norm between layers will likely give you a significant performance increase
  - Residual connections: as you increase the depth of your network, you will find that having residual connections like those in ResNet architectures will be helpful
- Optimizer: Instead of plain SGD, you may want to add a learning rate schedule, add momentum, or use one of the other optimizers you have learned about like Adam. Check the `torch.optim` package for other optimizers
- Data augmentation: You should use the `torchvision.transforms` module to try adding random resized crops and horizontal flips of the input data. Check `transforms.RandomResizedCrop` and `transforms.RandomHorizontalFlip` for this
- Epochs: Once you have found a generally good hyperparameter setting try training for more epochs
- Loss function: You might want to add weighting to the `MultiLabelSoftMarginLoss` for classes that are less well represented or experiment with a different loss function

In [33]:

```

classifier = Classifier().to(device)
# You can use this function to reload a network you have already saved previously
# classifier.load_state_dict(torch.load('voc_classifier.pth'))

```

In [34]:

```

criterion = nn.MultiLabelSoftMarginLoss()
# optimizer = torch.optim.SGD(classifier.parameters(), lr=0.01, momentum=0.9)
optimizer = torch.optim.Adam(classifier.parameters(), lr=0.001)

```

In [35]:

```

# Training the Classifier
NUM_EPOCHS = 200
TEST_FREQUENCY = 10

for epoch in range(1, NUM_EPOCHS+1):
    if epoch == 100:
        optimizer = torch.optim.Adam(classifier.parameters(), lr=0.0001)
    print("Starting epoch number " + str(epoch))
    train_loss = train_classifier(train_loader, classifier, criterion, optimizer)
    print("Loss for Training on Epoch " + str(epoch) + " is " + str(train_loss))
    if (epoch%TEST_FREQUENCY==0):

```

```
mAP_val, val_loss, _ = test_classifier(val_loader, classifier, criterion)
print('Evaluating classifier')
print("Mean Precision Score for Testing on Epoch " +str(epoch) + " is "+ str(mAP_val))
```

```
Starting epoch number 1
Loss for Training on Epoch 1 is 0.25038424134254456
Starting epoch number 2
Loss for Training on Epoch 2 is 0.22546131908893585
Starting epoch number 3
Loss for Training on Epoch 3 is 0.22079363465309143
Starting epoch number 4
Loss for Training on Epoch 4 is 0.21614404022693634
Starting epoch number 5
Loss for Training on Epoch 5 is 0.21501779556274414
Starting epoch number 6
Loss for Training on Epoch 6 is 0.21029822528362274
Starting epoch number 7
Loss for Training on Epoch 7 is 0.21012337505817413
Starting epoch number 8
Loss for Training on Epoch 8 is 0.2074798196554184
Starting epoch number 9
Loss for Training on Epoch 9 is 0.20645663142204285
Starting epoch number 10
Loss for Training on Epoch 10 is 0.2052452266216278
----- Class: aeroplane      AP: 0.4656 -----
----- Class: bicycle       AP: 0.1001 -----
----- Class: bird          AP: 0.1593 -----
----- Class: boat          AP: 0.1782 -----
----- Class: bottle        AP: 0.1154 -----
----- Class: bus           AP: 0.1242 -----
----- Class: car           AP: 0.4818 -----
----- Class: cat           AP: 0.2832 -----
----- Class: chair         AP: 0.3940 -----
----- Class: cow           AP: 0.0997 -----
----- Class: diningtable   AP: 0.2834 -----
----- Class: dog           AP: 0.2112 -----
----- Class: horse         AP: 0.2693 -----
----- Class: motorbike     AP: 0.1887 -----
----- Class: person        AP: 0.5825 -----
----- Class: pottedplant   AP: 0.1373 -----
----- Class: sheep         AP: 0.1085 -----
----- Class: sofa          AP: 0.2378 -----
----- Class: train         AP: 0.3320 -----
----- Class: tvmonitor     AP: 0.2217 -----
mAP: 0.2487
Avg loss: 0.2000521868467331
Evaluating classifier
Mean Precision Score for Testing on Epoch 10 is 0.24869810791949773
Starting epoch number 11
Loss for Training on Epoch 11 is 0.20279057323932648
Starting epoch number 12
Loss for Training on Epoch 12 is 0.20237715542316437
Starting epoch number 13
Loss for Training on Epoch 13 is 0.2008308470249176
Starting epoch number 14
Loss for Training on Epoch 14 is 0.19761714339256287
Starting epoch number 15
Loss for Training on Epoch 15 is 0.19817550480365753
Starting epoch number 16
Loss for Training on Epoch 16 is 0.19660347700119019
Starting epoch number 17
Loss for Training on Epoch 17 is 0.1950855255126953
Starting epoch number 18
Loss for Training on Epoch 18 is 0.19470101594924927
Starting epoch number 19
Loss for Training on Epoch 19 is 0.19361375272274017
Starting epoch number 20
Loss for Training on Epoch 20 is 0.19427911937236786
----- Class: aeroplane      AP: 0.5392 -----
----- Class: bicycle       AP: 0.1313 -----
----- Class: bird          AP: 0.1705 -----
----- Class: boat          AP: 0.3167 -----
----- Class: bottle        AP: 0.1511 -----
----- Class: bus           AP: 0.2012 -----
----- Class: car           AP: 0.5526 -----
----- Class: cat           AP: 0.3644 -----
```

```
Class: cat AP: 0.3011 -----
----- Class: chair AP: 0.4391 -----
----- Class: cow AP: 0.1663 -----
----- Class: diningtable AP: 0.2537 -----
----- Class: dog AP: 0.2605 -----
----- Class: horse AP: 0.4006 -----
----- Class: motorbike AP: 0.2790 -----
----- Class: person AP: 0.6929 -----
----- Class: pottedplant AP: 0.1770 -----
----- Class: sheep AP: 0.1771 -----
----- Class: sofa AP: 0.2871 -----
----- Class: train AP: 0.4883 -----
----- Class: tvmonitor AP: 0.3861 -----
```

mAP: 0.3217

Avg loss: 0.1862042248249054

Evaluating classifier

Mean Precision Score for Testing on Epoch 20 is 0.321743548162765

Starting epoch number 21

Loss for Training on Epoch 21 is 0.1915990263223648

Starting epoch number 22

Loss for Training on Epoch 22 is 0.19224153459072113

Starting epoch number 23

Loss for Training on Epoch 23 is 0.1895395964384079

Starting epoch number 24

Loss for Training on Epoch 24 is 0.1885790079832077

Starting epoch number 25

Loss for Training on Epoch 25 is 0.18980371952056885

Starting epoch number 26

Loss for Training on Epoch 26 is 0.1864825040102005

Starting epoch number 27

Loss for Training on Epoch 27 is 0.18715861439704895

Starting epoch number 28

Loss for Training on Epoch 28 is 0.18828830122947693

Starting epoch number 29

Loss for Training on Epoch 29 is 0.18646582961082458

Starting epoch number 30

Loss for Training on Epoch 30 is 0.18556955456733704

```
----- Class: aeroplane AP: 0.5387 -----
----- Class: bicycle AP: 0.1459 -----
----- Class: bird AP: 0.2400 -----
----- Class: boat AP: 0.4118 -----
----- Class: bottle AP: 0.1815 -----
----- Class: bus AP: 0.2447 -----
----- Class: car AP: 0.5786 -----
----- Class: cat AP: 0.3599 -----
----- Class: chair AP: 0.4703 -----
----- Class: cow AP: 0.1418 -----
----- Class: diningtable AP: 0.2853 -----
----- Class: dog AP: 0.2748 -----
----- Class: horse AP: 0.4834 -----
----- Class: motorbike AP: 0.3707 -----
----- Class: person AP: 0.7339 -----
----- Class: pottedplant AP: 0.1672 -----
----- Class: sheep AP: 0.1374 -----
----- Class: sofa AP: 0.3190 -----
----- Class: train AP: 0.4935 -----
----- Class: tvmonitor AP: 0.3615 -----
```

mAP: 0.3470

Avg loss: 0.18248142302036285

Evaluating classifier

Mean Precision Score for Testing on Epoch 30 is 0.3470092753730277

Starting epoch number 31

Loss for Training on Epoch 31 is 0.18639791011810303

Starting epoch number 32

Loss for Training on Epoch 32 is 0.1844942718744278

Starting epoch number 33

Loss for Training on Epoch 33 is 0.18189343810081482

Starting epoch number 34

Loss for Training on Epoch 34 is 0.18430876731872559

Starting epoch number 35

Loss for Training on Epoch 35 is 0.18486712872982025

Starting epoch number 36

Loss for Training on Epoch 36 is 0.18223576247692108

Starting epoch number 37

Loss for Training on Epoch 37 is 0.18361611664295197

Starting epoch number 38

Loss for Training on Epoch 38 is 0.1831856518983841

Starting epoch number 39

```
Starting epoch number 39
Loss for Training on Epoch 39 is 0.18081548810005188
Starting epoch number 40
Loss for Training on Epoch 40 is 0.18020851910114288
----- Class: aeroplane      AP: 0.6000 -----
----- Class: bicycle        AP: 0.1036 -----
----- Class: bird           AP: 0.2155 -----
----- Class: boat           AP: 0.4145 -----
----- Class: bottle         AP: 0.1348 -----
----- Class: bus            AP: 0.2349 -----
----- Class: car            AP: 0.5875 -----
----- Class: cat            AP: 0.3696 -----
----- Class: chair          AP: 0.4569 -----
----- Class: cow            AP: 0.1517 -----
----- Class: diningtable    AP: 0.3087 -----
----- Class: dog            AP: 0.2976 -----
----- Class: horse          AP: 0.4142 -----
----- Class: motorbike      AP: 0.3002 -----
----- Class: person         AP: 0.6958 -----
----- Class: pottedplant     AP: 0.1112 -----
----- Class: sheep          AP: 0.2078 -----
----- Class: sofa           AP: 0.2650 -----
----- Class: train          AP: 0.5048 -----
----- Class: tvmonitor      AP: 0.3134 -----
mAP: 0.3344
Avg loss: 0.18457111716270447
Evaluating classifier
Mean Precision Score for Testing on Epoch 40 is 0.33437853150294583
Starting epoch number 41
Loss for Training on Epoch 41 is 0.1799742877483368
Starting epoch number 42
Loss for Training on Epoch 42 is 0.17868056893348694
Starting epoch number 43
Loss for Training on Epoch 43 is 0.1791076958179474
Starting epoch number 44
Loss for Training on Epoch 44 is 0.18026688694953918
Starting epoch number 45
Loss for Training on Epoch 45 is 0.1790032684803009
Starting epoch number 46
Loss for Training on Epoch 46 is 0.17878024280071259
Starting epoch number 47
Loss for Training on Epoch 47 is 0.17839744687080383
Starting epoch number 48
Loss for Training on Epoch 48 is 0.17848725616931915
Starting epoch number 49
Loss for Training on Epoch 49 is 0.17712238430976868
Starting epoch number 50
Loss for Training on Epoch 50 is 0.17832061648368835
----- Class: aeroplane      AP: 0.6162 -----
----- Class: bicycle        AP: 0.1358 -----
----- Class: bird           AP: 0.2203 -----
----- Class: boat           AP: 0.4452 -----
----- Class: bottle         AP: 0.1401 -----
----- Class: bus            AP: 0.2528 -----
----- Class: car            AP: 0.6147 -----
----- Class: cat            AP: 0.3706 -----
----- Class: chair          AP: 0.4653 -----
----- Class: cow            AP: 0.1684 -----
----- Class: diningtable    AP: 0.3197 -----
----- Class: dog            AP: 0.3054 -----
----- Class: horse          AP: 0.4367 -----
----- Class: motorbike      AP: 0.3169 -----
----- Class: person         AP: 0.7374 -----
----- Class: pottedplant     AP: 0.1215 -----
----- Class: sheep          AP: 0.2003 -----
----- Class: sofa           AP: 0.3031 -----
----- Class: train          AP: 0.5608 -----
----- Class: tvmonitor      AP: 0.2926 -----
mAP: 0.3512
Avg loss: 0.19242432713508606
Evaluating classifier
Mean Precision Score for Testing on Epoch 50 is 0.3511893363493083
Starting epoch number 51
Loss for Training on Epoch 51 is 0.17571032047271729
Starting epoch number 52
Loss for Training on Epoch 52 is 0.17565502226352692
Starting epoch number 53
Loss for Training on Epoch 53 is 0.1768132448196411
```



```
Loss for Training on Epoch 53 is 0.1700132440190411
Starting epoch number 54
Loss for Training on Epoch 54 is 0.1761883944272995
Starting epoch number 55
Loss for Training on Epoch 55 is 0.17585471272468567
Starting epoch number 56
Loss for Training on Epoch 56 is 0.17354390025138855
Starting epoch number 57
Loss for Training on Epoch 57 is 0.1739850789308548
Starting epoch number 58
Loss for Training on Epoch 58 is 0.17533940076828003
Starting epoch number 59
Loss for Training on Epoch 59 is 0.1728152483701706
Starting epoch number 60
Loss for Training on Epoch 60 is 0.1712528020143509
----- Class: aeroplane      AP: 0.6440 -----
----- Class: bicycle       AP: 0.1788 -----
----- Class: bird          AP: 0.2928 -----
----- Class: boat          AP: 0.4111 -----
----- Class: bottle        AP: 0.1886 -----
----- Class: bus           AP: 0.3554 -----
----- Class: car           AP: 0.6351 -----
----- Class: cat           AP: 0.4008 -----
----- Class: chair         AP: 0.5023 -----
----- Class: cow           AP: 0.1723 -----
----- Class: diningtable    AP: 0.3736 -----
----- Class: dog           AP: 0.2965 -----
----- Class: horse         AP: 0.5319 -----
----- Class: motorbike      AP: 0.5071 -----
----- Class: person        AP: 0.7723 -----
----- Class: pottedplant    AP: 0.1403 -----
----- Class: sheep         AP: 0.1587 -----
----- Class: sofa          AP: 0.3137 -----
----- Class: train         AP: 0.5891 -----
----- Class: tvmonitor      AP: 0.3365 -----
mAP: 0.3900
Avg loss: 0.1731175184249878
Evaluating classifier
Mean Precision Score for Testing on Epoch 60 is 0.3900428847285358
Starting epoch number 61
Loss for Training on Epoch 61 is 0.17265889048576355
Starting epoch number 62
Loss for Training on Epoch 62 is 0.17161405086517334
Starting epoch number 63
Loss for Training on Epoch 63 is 0.17117314040660858
Starting epoch number 64
Loss for Training on Epoch 64 is 0.1722673922777176
Starting epoch number 65
Loss for Training on Epoch 65 is 0.1690593808889389
Starting epoch number 66
Loss for Training on Epoch 66 is 0.16861355304718018
Starting epoch number 67
Loss for Training on Epoch 67 is 0.17092539370059967
Starting epoch number 68
Loss for Training on Epoch 68 is 0.1697646528482437
Starting epoch number 69
Loss for Training on Epoch 69 is 0.17015206813812256
Starting epoch number 70
Loss for Training on Epoch 70 is 0.16946013271808624
----- Class: aeroplane      AP: 0.6620 -----
----- Class: bicycle       AP: 0.1705 -----
----- Class: bird          AP: 0.3376 -----
----- Class: boat          AP: 0.4095 -----
----- Class: bottle        AP: 0.1871 -----
----- Class: bus           AP: 0.3560 -----
----- Class: car           AP: 0.6495 -----
----- Class: cat           AP: 0.4224 -----
----- Class: chair         AP: 0.5389 -----
----- Class: cow           AP: 0.2035 -----
----- Class: diningtable    AP: 0.3744 -----
----- Class: dog           AP: 0.2939 -----
----- Class: horse         AP: 0.5102 -----
----- Class: motorbike      AP: 0.5189 -----
----- Class: person        AP: 0.7888 -----
----- Class: pottedplant    AP: 0.1451 -----
----- Class: sheep         AP: 0.2048 -----
----- Class: sofa          AP: 0.3420 -----
----- Class: train         AP: 0.6067 -----
```

```
----- Class: train AP: 0.6067 -----
----- Class: tvmonitor AP: 0.3384 -----
mAP: 0.4030
Avg loss: 0.17138618230819702
Evaluating classifier
Mean Precision Score for Testing on Epoch 70 is 0.40302373080273685
Starting epoch number 71
Loss for Training on Epoch 71 is 0.1685085892677307
Starting epoch number 72
Loss for Training on Epoch 72 is 0.17213064432144165
Starting epoch number 73
Loss for Training on Epoch 73 is 0.16910326480865479
Starting epoch number 74
Loss for Training on Epoch 74 is 0.16921794414520264
Starting epoch number 75
Loss for Training on Epoch 75 is 0.16843868792057037
Starting epoch number 76
Loss for Training on Epoch 76 is 0.16984401643276215
Starting epoch number 77
Loss for Training on Epoch 77 is 0.16787274181842804
Starting epoch number 78
Loss for Training on Epoch 78 is 0.16812273859977722
Starting epoch number 79
Loss for Training on Epoch 79 is 0.16657796502113342
Starting epoch number 80
Loss for Training on Epoch 80 is 0.167343407869339
----- Class: aeroplane AP: 0.6648 -----
----- Class: bicycle AP: 0.1888 -----
----- Class: bird AP: 0.2902 -----
----- Class: boat AP: 0.4773 -----
----- Class: bottle AP: 0.1949 -----
----- Class: bus AP: 0.3517 -----
----- Class: car AP: 0.6509 -----
----- Class: cat AP: 0.3869 -----
----- Class: chair AP: 0.5197 -----
----- Class: cow AP: 0.2213 -----
----- Class: diningtable AP: 0.3784 -----
----- Class: dog AP: 0.2949 -----
----- Class: horse AP: 0.4979 -----
----- Class: motorbike AP: 0.5030 -----
----- Class: person AP: 0.7752 -----
----- Class: pottedplant AP: 0.1524 -----
----- Class: sheep AP: 0.1966 -----
----- Class: sofa AP: 0.2823 -----
----- Class: train AP: 0.5568 -----
----- Class: tvmonitor AP: 0.3754 -----
mAP: 0.3980
Avg loss: 0.17782050371170044
Evaluating classifier
Mean Precision Score for Testing on Epoch 80 is 0.3979758205761865
Starting epoch number 81
Loss for Training on Epoch 81 is 0.16722387075424194
Starting epoch number 82
Loss for Training on Epoch 82 is 0.1676642745733261
Starting epoch number 83
Loss for Training on Epoch 83 is 0.1677396446466446
Starting epoch number 84
Loss for Training on Epoch 84 is 0.16616350412368774
Starting epoch number 85
Loss for Training on Epoch 85 is 0.16504430770874023
Starting epoch number 86
Loss for Training on Epoch 86 is 0.16647736728191376
Starting epoch number 87
Loss for Training on Epoch 87 is 0.164045512676239
Starting epoch number 88
Loss for Training on Epoch 88 is 0.16500146687030792
Starting epoch number 89
Loss for Training on Epoch 89 is 0.16312409937381744
Starting epoch number 90
Loss for Training on Epoch 90 is 0.16547182202339172
----- Class: aeroplane AP: 0.6505 -----
----- Class: bicycle AP: 0.1973 -----
----- Class: bird AP: 0.3596 -----
----- Class: boat AP: 0.4538 -----
----- Class: bottle AP: 0.1930 -----
----- Class: bus AP: 0.3324 -----
----- Class: car AP: 0.6177 -----
----- Class: cat AP: 0.2866 -----
```

```
----- Class: cat          AP: 0.3866 -----
----- Class: chair        AP: 0.4961 -----
----- Class: cow          AP: 0.1982 -----
----- Class: diningtable  AP: 0.3474 -----
----- Class: dog          AP: 0.3125 -----
----- Class: horse        AP: 0.5391 -----
----- Class: motorbike    AP: 0.4308 -----
----- Class: person       AP: 0.7841 -----
----- Class: pottedplant  AP: 0.1564 -----
----- Class: sheep        AP: 0.1964 -----
----- Class: sofa         AP: 0.2648 -----
----- Class: train        AP: 0.6328 -----
----- Class: tvmonitor    AP: 0.3468 -----
```

mAP: 0.3948

Avg loss: 0.1748254895210266

Evaluating classifier

Mean Precision Score for Testing on Epoch 90 is 0.3948146876447162

Starting epoch number 91

Loss for Training on Epoch 91 is 0.16337820887565613

Starting epoch number 92

Loss for Training on Epoch 92 is 0.1621313840150833

Starting epoch number 93

Loss for Training on Epoch 93 is 0.16416794061660767

Starting epoch number 94

Loss for Training on Epoch 94 is 0.16342508792877197

Starting epoch number 95

Loss for Training on Epoch 95 is 0.16284769773483276

Starting epoch number 96

Loss for Training on Epoch 96 is 0.161908358335495

Starting epoch number 97

Loss for Training on Epoch 97 is 0.16394932568073273

Starting epoch number 98

Loss for Training on Epoch 98 is 0.16192150115966797

Starting epoch number 99

Loss for Training on Epoch 99 is 0.16526946425437927

Starting epoch number 100

Loss for Training on Epoch 100 is 0.1583743840456009

```
----- Class: aeroplane    AP: 0.6673 -----
----- Class: bicycle      AP: 0.2126 -----
----- Class: bird         AP: 0.3758 -----
----- Class: boat         AP: 0.4731 -----
----- Class: bottle       AP: 0.1917 -----
----- Class: bus          AP: 0.3289 -----
----- Class: car          AP: 0.6922 -----
----- Class: cat          AP: 0.3988 -----
----- Class: chair        AP: 0.5410 -----
----- Class: cow          AP: 0.1966 -----
----- Class: diningtable  AP: 0.4275 -----
----- Class: dog          AP: 0.3001 -----
----- Class: horse        AP: 0.5794 -----
----- Class: motorbike    AP: 0.5357 -----
----- Class: person       AP: 0.8024 -----
----- Class: pottedplant  AP: 0.1625 -----
----- Class: sheep        AP: 0.1646 -----
----- Class: sofa         AP: 0.3206 -----
----- Class: train        AP: 0.6691 -----
----- Class: tvmonitor    AP: 0.3994 -----
```

mAP: 0.4220

Avg loss: 0.16472144424915314

Evaluating classifier

Mean Precision Score for Testing on Epoch 100 is 0.4219737053211981

Starting epoch number 101

Loss for Training on Epoch 101 is 0.15665848553180695

Starting epoch number 102

Loss for Training on Epoch 102 is 0.1547895073890686

Starting epoch number 103

Loss for Training on Epoch 103 is 0.15465447306632996

Starting epoch number 104

Loss for Training on Epoch 104 is 0.15502145886421204

Starting epoch number 105

Loss for Training on Epoch 105 is 0.15565261244773865

Starting epoch number 106

Loss for Training on Epoch 106 is 0.15504136681556702

Starting epoch number 107

Loss for Training on Epoch 107 is 0.1544770747423172

Starting epoch number 108

Loss for Training on Epoch 108 is 0.15475547313690186

Starting epoch number 109

```
Starting epoch number 109
Loss for Training on Epoch 109 is 0.15389768779277802
Starting epoch number 110
Loss for Training on Epoch 110 is 0.15717513859272003
----- Class: aeroplane      AP: 0.6691 -----
----- Class: bicycle        AP: 0.2276 -----
----- Class: bird           AP: 0.3925 -----
----- Class: boat           AP: 0.4769 -----
----- Class: bottle         AP: 0.1870 -----
----- Class: bus            AP: 0.3438 -----
----- Class: car            AP: 0.6923 -----
----- Class: cat            AP: 0.4026 -----
----- Class: chair          AP: 0.5430 -----
----- Class: cow            AP: 0.2184 -----
----- Class: diningtable    AP: 0.4141 -----
----- Class: dog            AP: 0.3172 -----
----- Class: horse          AP: 0.5706 -----
----- Class: motorbike      AP: 0.5531 -----
----- Class: person         AP: 0.8074 -----
----- Class: pottedplant    AP: 0.1525 -----
----- Class: sheep          AP: 0.1857 -----
----- Class: sofa           AP: 0.3433 -----
----- Class: train          AP: 0.6765 -----
----- Class: tvmonitor      AP: 0.3926 -----
mAP: 0.4283
Avg loss: 0.16441360116004944
Evaluating classifier
Mean Precision Score for Testing on Epoch 110 is 0.42831538038275757
Starting epoch number 111
Loss for Training on Epoch 111 is 0.15529121458530426
Starting epoch number 112
Loss for Training on Epoch 112 is 0.15251155197620392
Starting epoch number 113
Loss for Training on Epoch 113 is 0.15250222384929657
Starting epoch number 114
Loss for Training on Epoch 114 is 0.15317581593990326
Starting epoch number 115
Loss for Training on Epoch 115 is 0.1512976586818695
Starting epoch number 116
Loss for Training on Epoch 116 is 0.15356719493865967
Starting epoch number 117
Loss for Training on Epoch 117 is 0.15250003337860107
Starting epoch number 118
Loss for Training on Epoch 118 is 0.1513049304485321
Starting epoch number 119
Loss for Training on Epoch 119 is 0.1522090882062912
Starting epoch number 120
Loss for Training on Epoch 120 is 0.15408453345298767
----- Class: aeroplane      AP: 0.6742 -----
----- Class: bicycle        AP: 0.2150 -----
----- Class: bird           AP: 0.4031 -----
----- Class: boat           AP: 0.4838 -----
----- Class: bottle         AP: 0.1837 -----
----- Class: bus            AP: 0.3303 -----
----- Class: car            AP: 0.6917 -----
----- Class: cat            AP: 0.4153 -----
----- Class: chair          AP: 0.5388 -----
----- Class: cow            AP: 0.2151 -----
----- Class: diningtable    AP: 0.4155 -----
----- Class: dog            AP: 0.3127 -----
----- Class: horse          AP: 0.5811 -----
----- Class: motorbike      AP: 0.5441 -----
----- Class: person         AP: 0.8029 -----
----- Class: pottedplant    AP: 0.1562 -----
----- Class: sheep          AP: 0.1874 -----
----- Class: sofa           AP: 0.3359 -----
----- Class: train          AP: 0.6805 -----
----- Class: tvmonitor      AP: 0.3950 -----
mAP: 0.4281
Avg loss: 0.16473893821239471
Evaluating classifier
Mean Precision Score for Testing on Epoch 120 is 0.4281166262952844
Starting epoch number 121
Loss for Training on Epoch 121 is 0.15346375107765198
Starting epoch number 122
Loss for Training on Epoch 122 is 0.1540905386209488
Starting epoch number 123
----- Class: aeroplane      AP: 0.6742 -----
----- Class: bicycle        AP: 0.2150 -----
----- Class: bird           AP: 0.4031 -----
----- Class: boat           AP: 0.4838 -----
----- Class: bottle         AP: 0.1837 -----
----- Class: bus            AP: 0.3303 -----
----- Class: car            AP: 0.6917 -----
----- Class: cat            AP: 0.4153 -----
----- Class: chair          AP: 0.5388 -----
----- Class: cow            AP: 0.2151 -----
----- Class: diningtable    AP: 0.4155 -----
----- Class: dog            AP: 0.3127 -----
----- Class: horse          AP: 0.5811 -----
----- Class: motorbike      AP: 0.5441 -----
----- Class: person         AP: 0.8029 -----
----- Class: pottedplant    AP: 0.1562 -----
----- Class: sheep          AP: 0.1874 -----
----- Class: sofa           AP: 0.3359 -----
----- Class: train          AP: 0.6805 -----
----- Class: tvmonitor      AP: 0.3950 -----
mAP: 0.4281
Avg loss: 0.16473893821239471
Evaluating classifier
Mean Precision Score for Testing on Epoch 120 is 0.4281166262952844
```

```
Loss for Training on Epoch 123 is 0.15239037573337555
Starting epoch number 124
Loss for Training on Epoch 124 is 0.15238556265830994
Starting epoch number 125
Loss for Training on Epoch 125 is 0.1522916704416275
Starting epoch number 126
Loss for Training on Epoch 126 is 0.15386918187141418
Starting epoch number 127
Loss for Training on Epoch 127 is 0.15308254957199097
Starting epoch number 128
Loss for Training on Epoch 128 is 0.15351559221744537
Starting epoch number 129
Loss for Training on Epoch 129 is 0.15435409545898438
Starting epoch number 130
Loss for Training on Epoch 130 is 0.1536034792661667
----- Class: aeroplane      AP: 0.6827 -----
----- Class: bicycle        AP: 0.2053 -----
----- Class: bird           AP: 0.3874 -----
----- Class: boat           AP: 0.4777 -----
----- Class: bottle         AP: 0.1893 -----
----- Class: bus            AP: 0.3347 -----
----- Class: car            AP: 0.6931 -----
----- Class: cat            AP: 0.4137 -----
----- Class: chair          AP: 0.5433 -----
----- Class: cow            AP: 0.2241 -----
----- Class: diningtable    AP: 0.4200 -----
----- Class: dog            AP: 0.3289 -----
----- Class: horse          AP: 0.5758 -----
----- Class: motorbike      AP: 0.5353 -----
----- Class: person         AP: 0.8094 -----
----- Class: pottedplant    AP: 0.1501 -----
----- Class: sheep          AP: 0.2022 -----
----- Class: sofa           AP: 0.3339 -----
----- Class: train          AP: 0.6748 -----
----- Class: tvmonitor      AP: 0.3934 -----
mAP: 0.4288
Avg loss: 0.1652134209871292
Evaluating classifier
Mean Precision Score for Testing on Epoch 130 is 0.42875510459628224
Starting epoch number 131
Loss for Training on Epoch 131 is 0.15211255848407745
Starting epoch number 132
Loss for Training on Epoch 132 is 0.15175393223762512
Starting epoch number 133
Loss for Training on Epoch 133 is 0.1513964980840683
Starting epoch number 134
Loss for Training on Epoch 134 is 0.14937300980091095
Starting epoch number 135
Loss for Training on Epoch 135 is 0.15231230854988098
Starting epoch number 136
Loss for Training on Epoch 136 is 0.15173013508319855
Starting epoch number 137
Loss for Training on Epoch 137 is 0.15147608518600464
Starting epoch number 138
Loss for Training on Epoch 138 is 0.15237018465995789
Starting epoch number 139
Loss for Training on Epoch 139 is 0.14892001450061798
Starting epoch number 140
Loss for Training on Epoch 140 is 0.15440352261066437
----- Class: aeroplane      AP: 0.6792 -----
----- Class: bicycle        AP: 0.1995 -----
----- Class: bird           AP: 0.3997 -----
----- Class: boat           AP: 0.4741 -----
----- Class: bottle         AP: 0.1927 -----
----- Class: bus            AP: 0.3266 -----
----- Class: car            AP: 0.6986 -----
----- Class: cat            AP: 0.4192 -----
----- Class: chair          AP: 0.5387 -----
----- Class: cow            AP: 0.2087 -----
----- Class: diningtable    AP: 0.4081 -----
----- Class: dog            AP: 0.3268 -----
----- Class: horse          AP: 0.5831 -----
----- Class: motorbike      AP: 0.5488 -----
----- Class: person         AP: 0.8072 -----
----- Class: pottedplant    AP: 0.1517 -----
----- Class: sheep          AP: 0.1898 -----
----- Class: sofa           AP: 0.3333 -----
```



```
----- Class: train          AP: 0.6762 -----
----- Class: tvmonitor      AP: 0.3905 -----
mAP: 0.4276
Avg loss: 0.16498538851737976
Evaluating classifier
Mean Precision Score for Testing on Epoch 140 is 0.4276322479772429
Starting epoch number 141
Loss for Training on Epoch 141 is 0.15248262882232666
Starting epoch number 142
Loss for Training on Epoch 142 is 0.15029862523078918
Starting epoch number 143
Loss for Training on Epoch 143 is 0.15202544629573822
Starting epoch number 144
Loss for Training on Epoch 144 is 0.15124580264091492
Starting epoch number 145
Loss for Training on Epoch 145 is 0.150699645280838
Starting epoch number 146
Loss for Training on Epoch 146 is 0.1526777446269989
Starting epoch number 147
Loss for Training on Epoch 147 is 0.15157215297222137
Starting epoch number 148
Loss for Training on Epoch 148 is 0.15128281712532043
Starting epoch number 149
Loss for Training on Epoch 149 is 0.15061035752296448
Starting epoch number 150
Loss for Training on Epoch 150 is 0.153216153383255
----- Class: aeroplane      AP: 0.6779 -----
----- Class: bicycle        AP: 0.2069 -----
----- Class: bird           AP: 0.4031 -----
----- Class: boat           AP: 0.4725 -----
----- Class: bottle         AP: 0.1964 -----
----- Class: bus            AP: 0.3256 -----
----- Class: car            AP: 0.6955 -----
----- Class: cat            AP: 0.4158 -----
----- Class: chair          AP: 0.5391 -----
----- Class: cow            AP: 0.2118 -----
----- Class: diningtable    AP: 0.4051 -----
----- Class: dog            AP: 0.3252 -----
----- Class: horse          AP: 0.5869 -----
----- Class: motorbike      AP: 0.5492 -----
----- Class: person         AP: 0.8048 -----
----- Class: pottedplant    AP: 0.1550 -----
----- Class: sheep          AP: 0.1883 -----
----- Class: sofa           AP: 0.3367 -----
----- Class: train          AP: 0.6894 -----
----- Class: tvmonitor      AP: 0.3922 -----
mAP: 0.4289
Avg loss: 0.1641746461391449
Evaluating classifier
Mean Precision Score for Testing on Epoch 150 is 0.4288687751935888
Starting epoch number 151
Loss for Training on Epoch 151 is 0.15195302665233612
Starting epoch number 152
Loss for Training on Epoch 152 is 0.15036597847938538
Starting epoch number 153
Loss for Training on Epoch 153 is 0.15052859485149384
Starting epoch number 154
Loss for Training on Epoch 154 is 0.15149398148059845
Starting epoch number 155
Loss for Training on Epoch 155 is 0.1467011570930481
Starting epoch number 156
Loss for Training on Epoch 156 is 0.15144550800323486
Starting epoch number 157
Loss for Training on Epoch 157 is 0.15298870205879211
Starting epoch number 158
Loss for Training on Epoch 158 is 0.15036819875240326
Starting epoch number 159
Loss for Training on Epoch 159 is 0.1526784896850586
Starting epoch number 160
Loss for Training on Epoch 160 is 0.15063047409057617
----- Class: aeroplane      AP: 0.6838 -----
----- Class: bicycle        AP: 0.2162 -----
----- Class: bird           AP: 0.4089 -----
----- Class: boat           AP: 0.4790 -----
----- Class: bottle         AP: 0.1974 -----
----- Class: bus            AP: 0.3382 -----
----- Class: car            AP: 0.6947 -----
```

```
----- Class: cat                AP: 0.4156 -----
----- Class: chair              AP: 0.5413 -----
----- Class: cow                AP: 0.2117 -----
----- Class: diningtable        AP: 0.4137 -----
----- Class: dog                AP: 0.3279 -----
----- Class: horse              AP: 0.5980 -----
----- Class: motorbike          AP: 0.5486 -----
----- Class: person             AP: 0.8065 -----
----- Class: pottedplant         AP: 0.1483 -----
----- Class: sheep              AP: 0.1834 -----
----- Class: sofa               AP: 0.3420 -----
----- Class: train              AP: 0.6740 -----
----- Class: tvmonitor          AP: 0.3904 -----
mAP: 0.4310
Avg loss: 0.16465646028518677
Evaluating classifier
Mean Precision Score for Testing on Epoch 160 is 0.4309941063151624
Starting epoch number 161
Loss for Training on Epoch 161 is 0.14975480735301971
Starting epoch number 162
Loss for Training on Epoch 162 is 0.15210506319999695
Starting epoch number 163
Loss for Training on Epoch 163 is 0.1495804488658905
Starting epoch number 164
Loss for Training on Epoch 164 is 0.152412548661232
Starting epoch number 165
Loss for Training on Epoch 165 is 0.1493864804506302
Starting epoch number 166
Loss for Training on Epoch 166 is 0.15140031278133392
Starting epoch number 167
Loss for Training on Epoch 167 is 0.15067270398139954
Starting epoch number 168
Loss for Training on Epoch 168 is 0.15252888202667236
Starting epoch number 169
Loss for Training on Epoch 169 is 0.14947311580181122
Starting epoch number 170
Loss for Training on Epoch 170 is 0.1521836370229721
----- Class: aeroplane          AP: 0.6749 -----
----- Class: bicycle            AP: 0.2208 -----
----- Class: bird               AP: 0.4178 -----
----- Class: boat               AP: 0.4733 -----
----- Class: bottle             AP: 0.1920 -----
----- Class: bus                AP: 0.3368 -----
----- Class: car                AP: 0.6961 -----
----- Class: cat                AP: 0.4268 -----
----- Class: chair              AP: 0.5379 -----
----- Class: cow                AP: 0.2275 -----
----- Class: diningtable        AP: 0.4101 -----
----- Class: dog                AP: 0.3361 -----
----- Class: horse              AP: 0.5827 -----
----- Class: motorbike          AP: 0.5441 -----
----- Class: person             AP: 0.8107 -----
----- Class: pottedplant         AP: 0.1408 -----
----- Class: sheep              AP: 0.1971 -----
----- Class: sofa               AP: 0.3303 -----
----- Class: train              AP: 0.6867 -----
----- Class: tvmonitor          AP: 0.3874 -----
mAP: 0.4315
Avg loss: 0.1650475263595581
Evaluating classifier
Mean Precision Score for Testing on Epoch 170 is 0.43148699570111726
Starting epoch number 171
Loss for Training on Epoch 171 is 0.15116846561431885
Starting epoch number 172
Loss for Training on Epoch 172 is 0.15009495615959167
Starting epoch number 173
Loss for Training on Epoch 173 is 0.1504458785057068
Starting epoch number 174
Loss for Training on Epoch 174 is 0.1480901837348938
Starting epoch number 175
Loss for Training on Epoch 175 is 0.14953596889972687
Starting epoch number 176
Loss for Training on Epoch 176 is 0.1490035206079483
Starting epoch number 177
Loss for Training on Epoch 177 is 0.1509813815355301
Starting epoch number 178
Loss for Training on Epoch 178 is 0.14866124093532562
```

```
Starting epoch number 179
Loss for Training on Epoch 179 is 0.14897258579730988
Starting epoch number 180
Loss for Training on Epoch 180 is 0.15114887058734894
----- Class: aeroplane      AP: 0.6842 -----
----- Class: bicycle        AP: 0.2197 -----
----- Class: bird           AP: 0.4165 -----
----- Class: boat           AP: 0.4884 -----
----- Class: bottle         AP: 0.1931 -----
----- Class: bus            AP: 0.3505 -----
----- Class: car            AP: 0.6958 -----
----- Class: cat            AP: 0.4303 -----
----- Class: chair          AP: 0.5421 -----
----- Class: cow            AP: 0.2240 -----
----- Class: diningtable    AP: 0.4256 -----
----- Class: dog            AP: 0.3329 -----
----- Class: horse          AP: 0.5887 -----
----- Class: motorbike      AP: 0.5624 -----
----- Class: person         AP: 0.8097 -----
----- Class: pottedplant     AP: 0.1434 -----
----- Class: sheep          AP: 0.1969 -----
----- Class: sofa           AP: 0.3328 -----
----- Class: train          AP: 0.6887 -----
----- Class: tvmonitor      AP: 0.3934 -----
mAP: 0.4360
Avg loss: 0.16436082124710083
Evaluating classifier
Mean Precision Score for Testing on Epoch 180 is 0.43596439802449777
Starting epoch number 181
Loss for Training on Epoch 181 is 0.14941897988319397
Starting epoch number 182
Loss for Training on Epoch 182 is 0.1514900028705597
Starting epoch number 183
Loss for Training on Epoch 183 is 0.14736992120742798
Starting epoch number 184
Loss for Training on Epoch 184 is 0.15135148167610168
Starting epoch number 185
Loss for Training on Epoch 185 is 0.14961577951908112
Starting epoch number 186
Loss for Training on Epoch 186 is 0.15136156976222992
Starting epoch number 187
Loss for Training on Epoch 187 is 0.1503935158252716
Starting epoch number 188
Loss for Training on Epoch 188 is 0.1518031358718872
Starting epoch number 189
Loss for Training on Epoch 189 is 0.14810748398303986
Starting epoch number 190
Loss for Training on Epoch 190 is 0.15134872496128082
----- Class: aeroplane      AP: 0.6850 -----
----- Class: bicycle        AP: 0.2160 -----
----- Class: bird           AP: 0.4343 -----
----- Class: boat           AP: 0.4925 -----
----- Class: bottle         AP: 0.2081 -----
----- Class: bus            AP: 0.3253 -----
----- Class: car            AP: 0.6988 -----
----- Class: cat            AP: 0.4230 -----
----- Class: chair          AP: 0.5437 -----
----- Class: cow            AP: 0.2157 -----
----- Class: diningtable    AP: 0.4123 -----
----- Class: dog            AP: 0.3331 -----
----- Class: horse          AP: 0.5881 -----
----- Class: motorbike      AP: 0.5492 -----
----- Class: person         AP: 0.8075 -----
----- Class: pottedplant     AP: 0.1432 -----
----- Class: sheep          AP: 0.1805 -----
----- Class: sofa           AP: 0.3363 -----
----- Class: train          AP: 0.6936 -----
----- Class: tvmonitor      AP: 0.3828 -----
mAP: 0.4335
Avg loss: 0.16429083049297333
Evaluating classifier
Mean Precision Score for Testing on Epoch 190 is 0.4334512860211984
Starting epoch number 191
Loss for Training on Epoch 191 is 0.1490975171327591
Starting epoch number 192
Loss for Training on Epoch 192 is 0.14857253432273865
Starting epoch number 193
```

```

Loss for Training on Epoch 193 is 0.1480739712715149
Starting epoch number 194
Loss for Training on Epoch 194 is 0.15080976486206055
Starting epoch number 195
Loss for Training on Epoch 195 is 0.14563266932964325
Starting epoch number 196
Loss for Training on Epoch 196 is 0.14710521697998047
Starting epoch number 197
Loss for Training on Epoch 197 is 0.15084022283554077
Starting epoch number 198
Loss for Training on Epoch 198 is 0.14885543286800385
Starting epoch number 199
Loss for Training on Epoch 199 is 0.14938214421272278
Starting epoch number 200
Loss for Training on Epoch 200 is 0.14862383902072906
----- Class: aeroplane      AP: 0.6843 -----
----- Class: bicycle       AP: 0.2081 -----
----- Class: bird          AP: 0.4087 -----
----- Class: boat          AP: 0.4797 -----
----- Class: bottle        AP: 0.2132 -----
----- Class: bus           AP: 0.3318 -----
----- Class: car           AP: 0.7020 -----
----- Class: cat           AP: 0.4277 -----
----- Class: chair         AP: 0.5449 -----
----- Class: cow           AP: 0.2265 -----
----- Class: diningtable   AP: 0.4103 -----
----- Class: dog           AP: 0.3382 -----
----- Class: horse         AP: 0.5915 -----
----- Class: motorbike     AP: 0.5510 -----
----- Class: person        AP: 0.8083 -----
----- Class: pottedplant   AP: 0.1471 -----
----- Class: sheep         AP: 0.1907 -----
----- Class: sofa          AP: 0.3399 -----
----- Class: train         AP: 0.6897 -----
----- Class: tvmonitor     AP: 0.3792 -----
mAP: 0.4336
Avg loss: 0.16414828598499298
Evaluating classifier
Mean Precision Score for Testing on Epoch 200 is 0.43363475835793047

```

In [36]:

```

# Save the classifier network
# Suggestion: you can save checkpoints of your network during training and reload them later
torch.save(classifier.state_dict(), './voc_classifier.pth')

```

## Evaluate on test set

In [37]:

```

ds_test = VocDataset('VOCdevkit_2007/VOC2007test/', 'test', test_transform)

test_loader = torch.utils.data.DataLoader(dataset=ds_test,
                                           batch_size=50,
                                           shuffle=False,
                                           num_workers=1)

mAP_test, test_loss, test_aps = test_classifier(test_loader, classifier, criterion)

```

```

----- Class: aeroplane      AP: 0.6390 -----
----- Class: bicycle       AP: 0.3146 -----
----- Class: bird          AP: 0.3750 -----
----- Class: boat          AP: 0.4965 -----
----- Class: bottle        AP: 0.1677 -----
----- Class: bus           AP: 0.3890 -----
----- Class: car           AP: 0.7050 -----
----- Class: cat           AP: 0.3938 -----
----- Class: chair         AP: 0.4819 -----
----- Class: cow           AP: 0.2215 -----
----- Class: diningtable   AP: 0.3371 -----
----- Class: dog           AP: 0.3447 -----
----- Class: horse         AP: 0.6578 -----
----- Class: motorbike     AP: 0.5455 -----

```

```
----- Class: motorcycle AP: 0.8100 -----  
----- Class: person AP: 0.8093 -----  
----- Class: pottedplant AP: 0.2146 -----  
----- Class: sheep AP: 0.2632 -----  
----- Class: sofa AP: 0.3488 -----  
----- Class: train AP: 0.6065 -----  
----- Class: tvmonitor AP: 0.3402 -----  
mAP: 0.4326  
Avg loss: 0.1630074828863144
```

In [38]:

```
output_submission_csv('my_solution.csv', test_aps)
```