# sandip2_and_nb17_project_output

April 30, 2022

## 1 Training and testing Multi-label Image Classifier and using pre-trained scene classifier and a heat map generator

[ ]:
```
from google.colab import drive
drive.mount('/content/gdrive')
import os
os.chdir("gdrive/My Drive/Project")
```

```
Mounted at /content/gdrive
```

### 1.1 Downloading and formatting SUN datasets

[ ]:
```
# downloading data from SUN dataset
import os
synset_url = 'http://cs.brown.edu/~gmpatter/Attributes/SUNAttributeDB.tar.gz'
os.system('wget ' + synset_url)
synset_url = 'http://cs.brown.edu/~gmpatter/Attributes/SUNAttributeDB_Images.
 ↪tar.gz'
os.system('wget ' + synset_url)
```

[ ]:
```
2
```

[ ]:
```
import tarfile
def unpack_gz(filename):
  # open file
  file = tarfile.open(filename)

  # print file names
  print(file.getnames())

  # extract files
  file.extractall('./')
  # file.extract('sample.txt', './Destination_FolderName')

  # close file
  file.close()
```

```
#unpacking data from SUN DATASET
unpack_gz('SUNAttributeDB_Images.tar.gz')

#unpacking images from SUN DATASET
unpack_gz('SUNAttributeDB.tar.gz')
```

### 1.2 Importing necessary libraries

[ ]:
```
import scipy.io
import os
import numpy as np
import torch
import torch.nn as nn
import torchvision

from torchvision import transforms
from sklearn.metrics import average_precision_score
from PIL import Image, ImageDraw
import matplotlib.pyplot as plt
from sun_dataloader import SunDataset, SUN_CLASSES

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

[ ]:
```
# declare what device to use: gpu/cpu
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
```

### 1.3 Reading SUN Dataset

#### 1.3.1 Loading Training Data

In the following cell we will load the training data and also apply some transforms to the data.

[ ]:
```
# 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.Resize(227),
            transforms.CenterCrop(227),
            transforms.ToTensor(),
            normalize
        ])
```

[ ]:
```
ds_train = SunDataset('images/','train',train_transform)
```

### 1.3.2 Loading Validation Data

Loading the validation data for the SUN dataset.

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

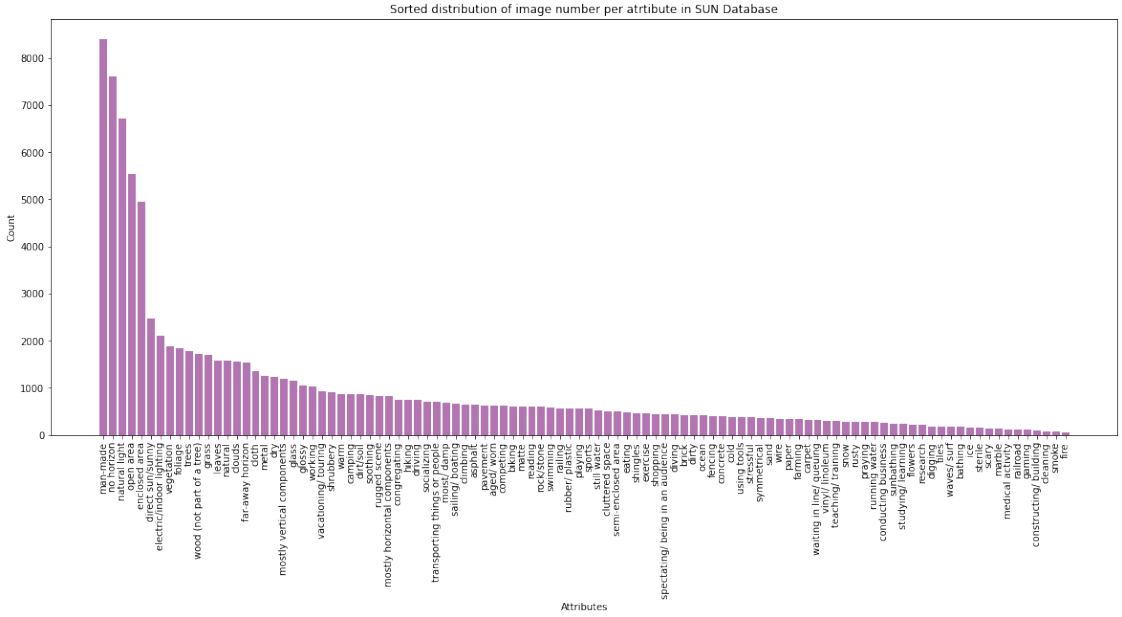
[ ]:
```
ds_val = SunDataset('images/','val',test_transform)
```

### 1.3.3 Visualizing the Data

### 1.3.4 Displaying the sorted distribution of image number per attribute in SUN Database

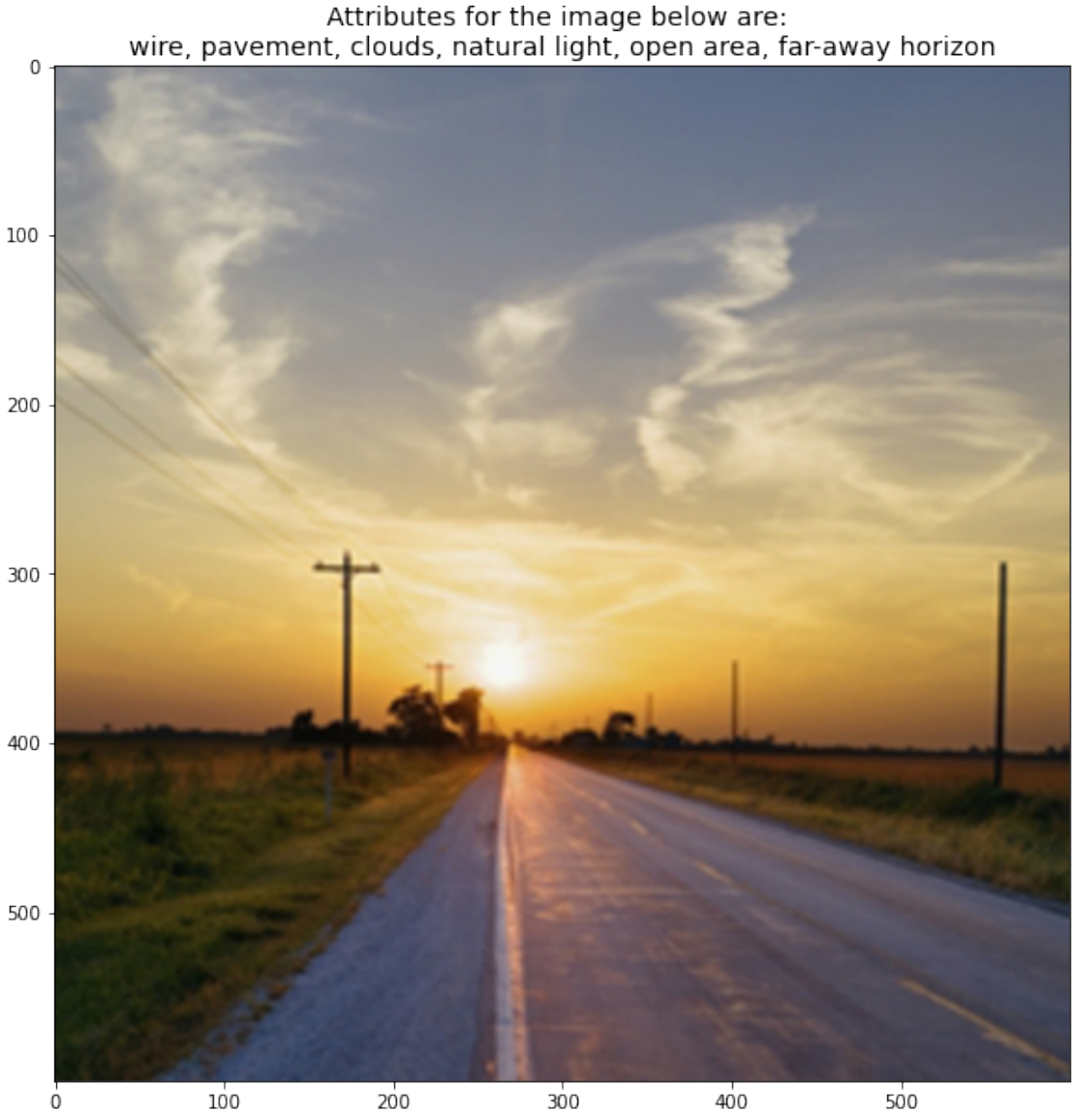
[ ]:
```
labels_mat = scipy.io.loadmat('./SUNAttributeDB/attributeLabels_continuous.mat')
attrib_presence = labels_mat['labels_cv']  # 14340 images x 102 attributes
attrib_presence = (attrib_presence > 1/3).astype(int)   # if two out of three␣
↪voted that there is an attribute in the image, we will consider that this is␣
↪true
```

[ ]:
```
attribute_numbers = np.sum(attrib_presence, axis = 0)
indices = np.argsort(attribute_numbers)[::-1]
height = [attribute_numbers[i] for i in indices]
bars = [SUN_CLASSES[i] for i in indices]
x_pos = np.arange(len(bars))

# Create bars and choose color
plt.figure(figsize=(20, 8))
plt.bar(x_pos, height, color = (0.5,0.1,0.5,0.6))

# Add title and axis names
plt.title('Sorted distribution of image number per atrtibute in SUN Database')
plt.xlabel('Attributes')
plt.ylabel('Count')

# Create names on the x axis
plt.xticks(x_pos, bars, rotation='vertical')

# Show graph
plt.show()
```

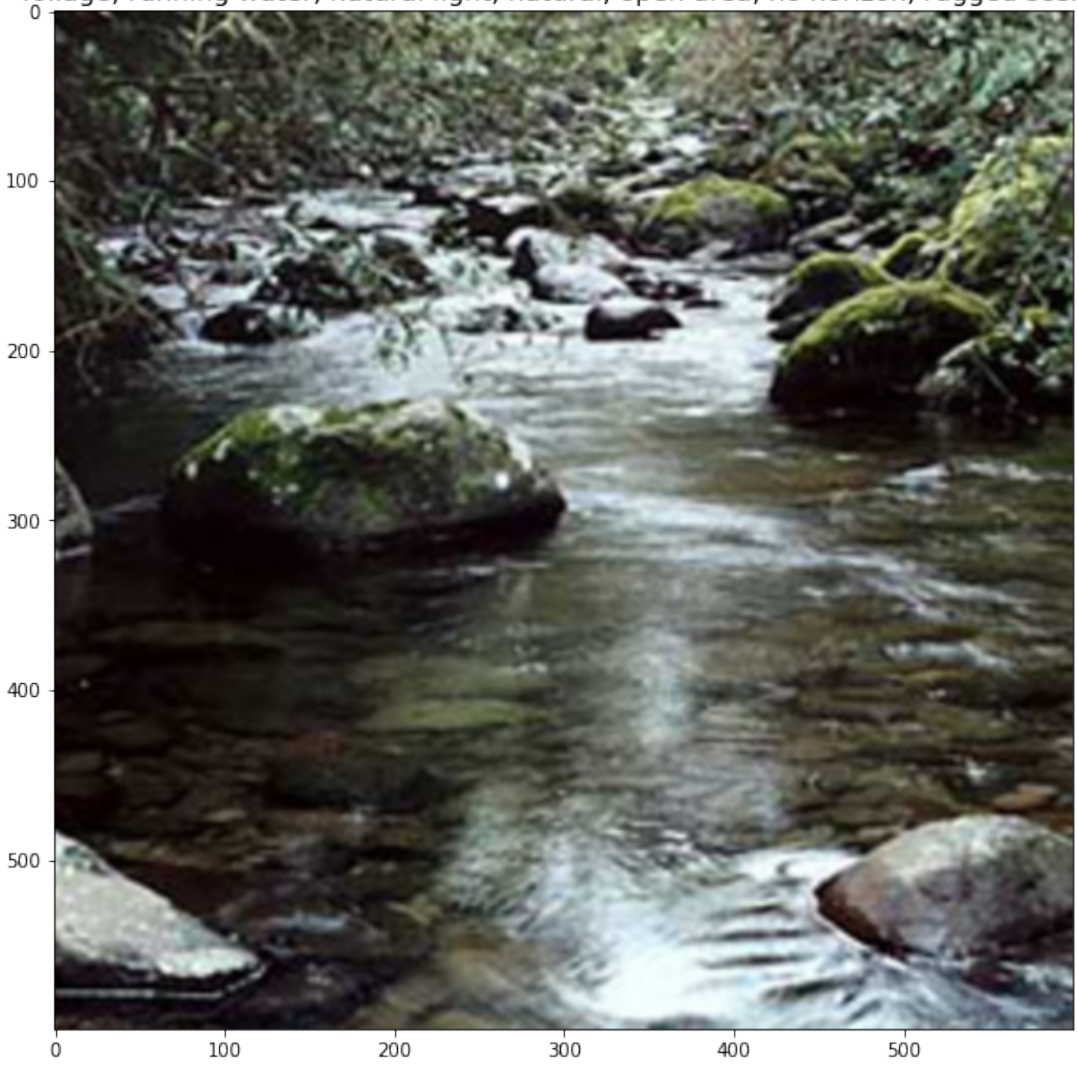



### 1.3.5 Displaying some of the images and the attributes that are present in these images

[ ]:
```
for i in range(5):
    idx = np.random.randint(0, len(ds_train.names)+1)
    _imgpath = os.path.join('images/', ds_train.names[idx])
    img = Image.open(_imgpath).convert('RGB')

    draw = ImageDraw.Draw(img)
    plt.figure(figsize = (10,10))
    plt.imshow(np.array(img))

    attributes = ds_train.labels[idx]
    present_indices = []
    for i, is_present in enumerate(ds_train.labels[idx]):
      if is_present > 0:
        present_indices.append(i)
    plt.title("Attributes for the image below are: \n" + ", ".
↪join([SUN_CLASSES[idx] for idx in present_indices]), pad = 5,␣
↪fontdict={'fontsize': 14})
```


Attributes for the image below are:
wire, pavement, clouds, natural light, open area, far-away horizon
0
100
200
300
400
500
0
100
200
300
400
500

Attributes for the image below are:
foliage, running water, natural light, natural, open area, no horizon, rugged scene




Attributes for the image below are:
shopping, no horizon
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500



## 2 Classification

[ ]:
```
# declare what device to use: gpu/cpu
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
```

[ ]:
```
train_loader = torch.utils.data.DataLoader(dataset=ds_train,
                                           batch_size=50,
                                           shuffle=True,
                                           num_workers=1)
```

[ ]:
```
val_loader = torch.utils.data.DataLoader(dataset=ds_val,
                                           batch_size=50,
                                           shuffle=True,
                                           num_workers=1)
```

[ ]:
```
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()
```

[ ]:
```
def test_classifier(test_loader, classifier, criterion, print_ind_classes=True,␣
↪print_total=True):
    classifier.eval()
    losses = []
    with torch.no_grad():
        y_true = np.zeros((0,102))
        y_score = np.zeros((0,102))
        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.item())
        aps = []
        for i in range(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(SUN_CLASSES[i], ap))
            aps.append(ap)

        mAP = np.mean(aps)
```

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

    return mAP, test_loss, aps
```

[ ]:
```
# plot functions
def plot_losses(train, val, test_frequency, num_epochs):
    plt.plot(train, label="train")
    indices = [i for i in range(num_epochs) if ((i+1)%test_frequency == 0 or i
 ↪==0)]
    plt.plot(indices, val, label="val")
    plt.title("Loss Plot")
    plt.ylabel("Loss")
    plt.xlabel("Epoch")
    plt.legend()
    plt.show()

def plot_mAP(train, val, test_frequency, num_epochs):
    indices = [i for i in range(num_epochs) if ((i+1)%test_frequency == 0 or i
 ↪==0)]
    plt.plot(indices, train, label="train")
    plt.plot(indices, val, label="val")
    plt.title("mAP Plot")
    plt.ylabel("mAP")
    plt.xlabel("Epoch")
    plt.legend()
    plt.show()
```

### 2.1 Training the network

[ ]:
```
def train(classifier, num_epochs, train_loader, val_loader, criterion,
 ↪optimizer, test_frequency=5):
    train_losses = []
    train_mAPs = []
    val_losses = []
    val_mAPs = []

    for epoch in range(1,num_epochs+1):
        print("Starting epoch number " + str(epoch))
        train_loss = train_classifier(train_loader, classifier, criterion,
 ↪optimizer)
        train_losses.append(train_loss)
        print("Loss for Training on Epoch " +str(epoch) + " is "+
 ↪str(train_loss))
```

```
        if(epoch%test_frequency==0 or epoch==1):
            mAP_train, _, _ = test_classifier(train_loader, classifier,␣
 ↪criterion, False, False)
            train_mAPs.append(mAP_train)
            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))
            val_losses.append(val_loss)
            val_mAPs.append(mAP_val)
        scheduler.step()

    return classifier, train_losses, val_losses, train_mAPs, val_mAPs
```

### 2.2 Training with pretrained DenseNet with 201 layers

[ ]:
```
num_epochs = 40
test_frequency = 5

# Load Pretrained DenseNet
classifier = torchvision.models.densenet201(pretrained=True)
classifier.classifier = nn.Linear(1920, 102)
classifier = classifier.to(device)
optimizer = torch.optim.SGD(classifier.parameters(), lr=0.1, momentum=0.9)
decay_rate = 0.97
scheduler = torch.optim.lr_scheduler.ExponentialLR(optimizer=optimizer,␣
 ↪gamma=decay_rate)
criterion = nn.MultiLabelSoftMarginLoss()
```

```
Downloading: "https://download.pytorch.org/models/densenet201-c1103571.pth" to
/root/.cache/torch/hub/checkpoints/densenet201-c1103571.pth

  0%|          | 0.00/77.4M [00:00<?, ?B/s]
```

[ ]:
```
classifier, train_losses, val_losses, train_mAPs, val_mAPs = train(classifier,␣
 ↪num_epochs, train_loader, val_loader, criterion, optimizer, test_frequency)
```

```
Starting epoch number 1
Loss for Training on Epoch 1 is 0.14774060249328613
-------  Class: driving          AP:   0.7346  -------
-------  Class: biking           AP:   0.6716  -------
-------  Class: transporting things or people     AP:   0.6077  -------
-------  Class: sunbathing       AP:   0.2489  -------
-------  Class: vacationing/ touring     AP:   0.3861  -------
-------  Class: hiking           AP:   0.6272  -------
-------  Class: climbing         AP:   0.6765  -------
-------  Class: camping          AP:   0.7205  -------
```

```
-------  Class: reading          AP:   0.4759  -------
-------  Class: studying/ learning     AP:   0.5221  -------
-------  Class: teaching/ training     AP:   0.3831  -------
-------  Class: research         AP:   0.3135  -------
-------  Class: diving           AP:   0.4898  -------
-------  Class: swimming         AP:   0.7288  -------
-------  Class: bathing          AP:   0.3474  -------
-------  Class: eating           AP:   0.4326  -------
-------  Class: cleaning         AP:   0.5294  -------
-------  Class: socializing      AP:   0.5335  -------
-------  Class: congregating     AP:   0.5500  -------
-------  Class: waiting in line/ queuing     AP:   0.2028  -------
-------  Class: competing        AP:   0.6593  -------
-------  Class: sports           AP:   0.8049  -------
-------  Class: exercise         AP:   0.5664  -------
-------  Class: playing          AP:   0.3964  -------
-------  Class: gaming           AP:   0.0922  -------
-------  Class: spectating/ being in an audience     AP:   0.5305  -------
-------  Class: farming          AP:   0.3594  -------
-------  Class: constructing/ building     AP:   0.2049  -------
-------  Class: shopping         AP:   0.6769  -------
-------  Class: medical activity     AP:   0.1243  -------
-------  Class: working          AP:   0.6204  -------
-------  Class: using tools      AP:   0.4033  -------
-------  Class: digging          AP:   0.2202  -------
-------  Class: conducting business     AP:   0.2451  -------
-------  Class: praying          AP:   0.5746  -------
-------  Class: fencing          AP:   0.1062  -------
-------  Class: railing          AP:   0.3184  -------
-------  Class: wire             AP:   0.2069  -------
-------  Class: railroad         AP:   0.2188  -------
-------  Class: trees            AP:   0.8505  -------
-------  Class: grass            AP:   0.8431  -------
-------  Class: vegetation       AP:   0.7852  -------
-------  Class: shrubbery        AP:   0.4842  -------
-------  Class: foliage          AP:   0.8460  -------
-------  Class: leaves           AP:   0.7054  -------
-------  Class: flowers          AP:   0.5863  -------
-------  Class: asphalt          AP:   0.7567  -------
-------  Class: pavement         AP:   0.3747  -------
-------  Class: shingles         AP:   0.5623  -------
-------  Class: carpet           AP:   0.2586  -------
-------  Class: brick            AP:   0.5231  -------
-------  Class: tiles            AP:   0.0360  -------
-------  Class: concrete         AP:   0.1540  -------
-------  Class: metal            AP:   0.5456  -------
-------  Class: paper            AP:   0.4810  -------
-------  Class: wood (not part of a tree)     AP:   0.6448  -------
```

```
-------  Class: vinyl/ linoleum     AP:   0.1712  -------
-------  Class: rubber/ plastic     AP:   0.3583  -------
-------  Class: cloth            AP:   0.7459  -------
-------  Class: sand             AP:   0.5588  -------
-------  Class: rock/stone       AP:   0.5887  -------
-------  Class: dirt/soil        AP:   0.6467  -------
-------  Class: marble           AP:   0.0693  -------
-------  Class: glass            AP:   0.4315  -------
-------  Class: waves/ surf      AP:   0.5542  -------
-------  Class: ocean            AP:   0.6972  -------
-------  Class: running water     AP:   0.5889  -------
-------  Class: still water      AP:   0.4204  -------
-------  Class: ice              AP:   0.4536  -------
-------  Class: snow             AP:   0.7785  -------
-------  Class: clouds           AP:   0.8693  -------
-------  Class: smoke            AP:   0.0352  -------
-------  Class: fire             AP:   0.0701  -------
-------  Class: natural light     AP:   0.8527  -------
-------  Class: direct sun/sunny     AP:   0.5790  -------
-------  Class: electric/indoor lighting     AP:   0.7176  -------
-------  Class: aged/ worn       AP:   0.3565  -------
-------  Class: glossy           AP:   0.4345  -------
-------  Class: matte            AP:   0.2320  -------
-------  Class: sterile          AP:   0.1390  -------
-------  Class: moist/ damp      AP:   0.3540  -------
-------  Class: dry              AP:   0.6248  -------
-------  Class: dirty            AP:   0.5714  -------
-------  Class: rusty            AP:   0.3162  -------
-------  Class: warm             AP:   0.3168  -------
-------  Class: cold             AP:   0.6433  -------
-------  Class: natural          AP:   0.8861  -------
-------  Class: man-made         AP:   0.8818  -------
-------  Class: open area        AP:   0.9222  -------
-------  Class: semi-enclosed area     AP:   0.2096  -------
-------  Class: enclosed area     AP:   0.9381  -------
-------  Class: far-away horizon     AP:   0.8413  -------
-------  Class: no horizon       AP:   0.8554  -------
-------  Class: rugged scene     AP:   0.7391  -------
-------  Class: mostly vertical components     AP:   0.4756  -------
-------  Class: mostly horizontal components     AP:   0.2845  -------
-------  Class: symmetrical      AP:   0.2231  -------
-------  Class: cluttered space     AP:   0.4256  -------
-------  Class: scary            AP:   0.2851  -------
-------  Class: soothing         AP:   0.2767  -------
-------  Class: stressful        AP:   0.2988  -------
mAP: 0.4918
Avg loss: 0.10844768660849538
Evaluating classifier
```

```
Mean Precision Score for Testing on Epoch 1 is 0.4917565609063136
Starting epoch number 2
Loss for Training on Epoch 2 is 0.10917959362268448
Starting epoch number 3
Loss for Training on Epoch 3 is 0.09801068156957626
Starting epoch number 4
Loss for Training on Epoch 4 is 0.08920326083898544
Starting epoch number 5
Loss for Training on Epoch 5 is 0.08024616539478302
-------  Class: driving          AP:   0.8489  -------
-------  Class: biking           AP:   0.7812  -------
-------  Class: transporting things or people     AP:   0.8865  -------
-------  Class: sunbathing       AP:   0.4251  -------
-------  Class: vacationing/ touring     AP:   0.5732  -------
-------  Class: hiking           AP:   0.7973  -------
-------  Class: climbing         AP:   0.7817  -------
-------  Class: camping          AP:   0.8549  -------
-------  Class: reading          AP:   0.7613  -------
-------  Class: studying/ learning     AP:   0.6200  -------
-------  Class: teaching/ training     AP:   0.6499  -------
-------  Class: research         AP:   0.5928  -------
-------  Class: diving           AP:   0.6734  -------
-------  Class: swimming         AP:   0.8642  -------
-------  Class: bathing          AP:   0.5830  -------
-------  Class: eating           AP:   0.8299  -------
-------  Class: cleaning         AP:   0.6429  -------
-------  Class: socializing      AP:   0.7270  -------
-------  Class: congregating     AP:   0.7814  -------
-------  Class: waiting in line/ queuing     AP:   0.4998  -------
-------  Class: competing        AP:   0.8411  -------
-------  Class: sports           AP:   0.9189  -------
-------  Class: exercise         AP:   0.7180  -------
-------  Class: playing          AP:   0.6711  -------
-------  Class: gaming           AP:   0.5256  -------
-------  Class: spectating/ being in an audience     AP:   0.8828  -------
-------  Class: farming          AP:   0.6970  -------
-------  Class: constructing/ building     AP:   0.4033  -------
-------  Class: shopping         AP:   0.9228  -------
-------  Class: medical activity     AP:   0.5854  -------
-------  Class: working          AP:   0.8747  -------
-------  Class: using tools      AP:   0.7907  -------
-------  Class: digging          AP:   0.6172  -------
-------  Class: conducting business     AP:   0.5732  -------
-------  Class: praying          AP:   0.8030  -------
-------  Class: fencing          AP:   0.4275  -------
-------  Class: railing          AP:   0.7005  -------
-------  Class: wire             AP:   0.6292  -------
-------  Class: railroad         AP:   0.7969  -------
```

```
-------  Class: trees            AP:   0.9398  -------
-------  Class: grass            AP:   0.9383  -------
-------  Class: vegetation       AP:   0.8461  -------
-------  Class: shrubbery        AP:   0.7161  -------
-------  Class: foliage          AP:   0.9429  -------
-------  Class: leaves           AP:   0.7941  -------
-------  Class: flowers          AP:   0.9490  -------
-------  Class: asphalt          AP:   0.8517  -------
-------  Class: pavement         AP:   0.5975  -------
-------  Class: shingles         AP:   0.8356  -------
-------  Class: carpet           AP:   0.5631  -------
-------  Class: brick            AP:   0.7334  -------
-------  Class: tiles            AP:   0.3264  -------
-------  Class: concrete         AP:   0.4674  -------
-------  Class: metal            AP:   0.7856  -------
-------  Class: paper            AP:   0.6800  -------
-------  Class: wood (not part of a tree)     AP:   0.8291  -------
-------  Class: vinyl/ linoleum     AP:   0.3766  -------
-------  Class: rubber/ plastic     AP:   0.6008  -------
-------  Class: cloth            AP:   0.9055  -------
-------  Class: sand             AP:   0.7515  -------
-------  Class: rock/stone       AP:   0.8150  -------
-------  Class: dirt/soil        AP:   0.7936  -------
-------  Class: marble           AP:   0.1366  -------
-------  Class: glass            AP:   0.7540  -------
-------  Class: waves/ surf      AP:   0.7413  -------
-------  Class: ocean            AP:   0.8881  -------
-------  Class: running water     AP:   0.8282  -------
-------  Class: still water      AP:   0.7196  -------
-------  Class: ice              AP:   0.7088  -------
-------  Class: snow             AP:   0.9945  -------
-------  Class: clouds           AP:   0.9655  -------
-------  Class: smoke            AP:   0.8333  -------
-------  Class: fire             AP:   0.9429  -------
-------  Class: natural light     AP:   0.9214  -------
-------  Class: direct sun/sunny     AP:   0.7806  -------
-------  Class: electric/indoor lighting     AP:   0.9131  -------
-------  Class: aged/ worn       AP:   0.5983  -------
-------  Class: glossy           AP:   0.6775  -------
-------  Class: matte            AP:   0.4483  -------
-------  Class: sterile          AP:   0.4631  -------
-------  Class: moist/ damp      AP:   0.6340  -------
-------  Class: dry              AP:   0.7246  -------
-------  Class: dirty            AP:   0.7934  -------
-------  Class: rusty            AP:   0.6297  -------
-------  Class: warm             AP:   0.5557  -------
-------  Class: cold             AP:   0.8823  -------
-------  Class: natural          AP:   0.9574  -------
```

```
-------  Class: man-made         AP:   0.9449  -------
-------  Class: open area        AP:   0.9558  -------
-------  Class: semi-enclosed area     AP:   0.5720  -------
-------  Class: enclosed area     AP:   0.9725  -------
-------  Class: far-away horizon     AP:   0.9432  -------
-------  Class: no horizon       AP:   0.9239  -------
-------  Class: rugged scene     AP:   0.8452  -------
-------  Class: mostly vertical components     AP:   0.7119  -------
-------  Class: mostly horizontal components     AP:   0.5627  -------
-------  Class: symmetrical      AP:   0.5587  -------
-------  Class: cluttered space     AP:   0.7025  -------
-------  Class: scary            AP:   0.5453  -------
-------  Class: soothing         AP:   0.6147  -------
-------  Class: stressful        AP:   0.5353  -------
mAP: 0.7275
Avg loss: 0.07482510278451032
Evaluating classifier
Mean Precision Score for Testing on Epoch 5 is 0.7274553257253299
Starting epoch number 6
Loss for Training on Epoch 6 is 0.0714421272277832
Starting epoch number 7
Loss for Training on Epoch 7 is 0.06306614726781845
Starting epoch number 8
Loss for Training on Epoch 8 is 0.05546502023935318
Starting epoch number 9
Loss for Training on Epoch 9 is 0.048265427350997925
Starting epoch number 10
Loss for Training on Epoch 10 is 0.04157853126525879
-------  Class: driving          AP:   0.8712  -------
-------  Class: biking           AP:   0.8727  -------
-------  Class: transporting things or people     AP:   0.9211  -------
-------  Class: sunbathing       AP:   0.5685  -------
-------  Class: vacationing/ touring     AP:   0.7748  -------
-------  Class: hiking           AP:   0.9057  -------
-------  Class: climbing         AP:   0.8787  -------
-------  Class: camping          AP:   0.8867  -------
-------  Class: reading          AP:   0.8753  -------
-------  Class: studying/ learning     AP:   0.6971  -------
-------  Class: teaching/ training     AP:   0.8141  -------
-------  Class: research         AP:   0.7937  -------
-------  Class: diving           AP:   0.6989  -------
-------  Class: swimming         AP:   0.9211  -------
-------  Class: bathing          AP:   0.6248  -------
-------  Class: eating           AP:   0.9191  -------
-------  Class: cleaning         AP:   0.7500  -------
-------  Class: socializing      AP:   0.8598  -------
-------  Class: congregating     AP:   0.8577  -------
-------  Class: waiting in line/ queuing     AP:   0.6977  -------
```

```
-------  Class: competing        AP:   0.8806  -------
-------  Class: sports           AP:   0.9459  -------
-------  Class: exercise         AP:   0.8177  -------
-------  Class: playing          AP:   0.8366  -------
-------  Class: gaming           AP:   0.6864  -------
-------  Class: spectating/ being in an audience     AP:   0.9244  -------
-------  Class: farming          AP:   0.8312  -------
-------  Class: constructing/ building     AP:   0.7145  -------
-------  Class: shopping         AP:   0.9527  -------
-------  Class: medical activity     AP:   0.6938  -------
-------  Class: working          AP:   0.9208  -------
-------  Class: using tools      AP:   0.8970  -------
-------  Class: digging          AP:   0.6738  -------
-------  Class: conducting business     AP:   0.7619  -------
-------  Class: praying          AP:   0.9247  -------
-------  Class: fencing          AP:   0.5466  -------
-------  Class: railing          AP:   0.8681  -------
-------  Class: wire             AP:   0.8739  -------
-------  Class: railroad         AP:   0.7987  -------
-------  Class: trees            AP:   0.9654  -------
-------  Class: grass            AP:   0.9716  -------
-------  Class: vegetation       AP:   0.9376  -------
-------  Class: shrubbery        AP:   0.8694  -------
-------  Class: foliage          AP:   0.9604  -------
-------  Class: leaves           AP:   0.9045  -------
-------  Class: flowers          AP:   1.0000  -------
-------  Class: asphalt          AP:   0.9380  -------
-------  Class: pavement         AP:   0.7898  -------
-------  Class: shingles         AP:   0.9035  -------
-------  Class: carpet           AP:   0.7645  -------
-------  Class: brick            AP:   0.8853  -------
-------  Class: tiles            AP:   0.6592  -------
-------  Class: concrete         AP:   0.7764  -------
-------  Class: metal            AP:   0.9330  -------
-------  Class: paper            AP:   0.8142  -------
-------  Class: wood (not part of a tree)     AP:   0.8915  -------
-------  Class: vinyl/ linoleum     AP:   0.7021  -------
-------  Class: rubber/ plastic     AP:   0.8889  -------
-------  Class: cloth            AP:   0.9712  -------
-------  Class: sand             AP:   0.7985  -------
-------  Class: rock/stone       AP:   0.9168  -------
-------  Class: dirt/soil        AP:   0.9020  -------
-------  Class: marble           AP:   0.4038  -------
-------  Class: glass            AP:   0.9254  -------
-------  Class: waves/ surf      AP:   0.8602  -------
-------  Class: ocean            AP:   0.9110  -------
-------  Class: running water     AP:   0.9354  -------
-------  Class: still water      AP:   0.8128  -------
```

```
-------  Class: ice              AP:   0.7737  -------
-------  Class: snow             AP:   0.9561  -------
-------  Class: clouds           AP:   0.9904  -------
-------  Class: smoke            AP:   1.0000  -------
-------  Class: fire             AP:   0.9250  -------
-------  Class: natural light     AP:   0.9675  -------
-------  Class: direct sun/sunny     AP:   0.9158  -------
-------  Class: electric/indoor lighting     AP:   0.9589  -------
-------  Class: aged/ worn       AP:   0.7729  -------
-------  Class: glossy           AP:   0.8332  -------
-------  Class: matte            AP:   0.7139  -------
-------  Class: sterile          AP:   0.8321  -------
-------  Class: moist/ damp      AP:   0.8131  -------
-------  Class: dry              AP:   0.8962  -------
-------  Class: dirty            AP:   0.8199  -------
-------  Class: rusty            AP:   0.7482  -------
-------  Class: warm             AP:   0.8165  -------
-------  Class: cold             AP:   0.9385  -------
-------  Class: natural          AP:   0.9760  -------
-------  Class: man-made         AP:   0.9762  -------
-------  Class: open area        AP:   0.9784  -------
-------  Class: semi-enclosed area     AP:   0.8820  -------
-------  Class: enclosed area     AP:   0.9786  -------
-------  Class: far-away horizon     AP:   0.9715  -------
-------  Class: no horizon       AP:   0.9602  -------
-------  Class: rugged scene     AP:   0.8974  -------
-------  Class: mostly vertical components     AP:   0.8949  -------
-------  Class: mostly horizontal components     AP:   0.8267  -------
-------  Class: symmetrical      AP:   0.7883  -------
-------  Class: cluttered space     AP:   0.8964  -------
-------  Class: scary            AP:   0.6709  -------
-------  Class: soothing         AP:   0.8574  -------
-------  Class: stressful        AP:   0.7713  -------
mAP: 0.8488
Avg loss: 0.05157194800417999
Evaluating classifier
Mean Precision Score for Testing on Epoch 10 is 0.8488024385133978
Starting epoch number 11
Loss for Training on Epoch 11 is 0.0361127108335495
Starting epoch number 12
Loss for Training on Epoch 12 is 0.03120662085711956
Starting epoch number 13
Loss for Training on Epoch 13 is 0.027179595082998276
Starting epoch number 14
Loss for Training on Epoch 14 is 0.023117564618587494
Starting epoch number 15
Loss for Training on Epoch 15 is 0.020076945424079895
-------  Class: driving          AP:   0.9181  -------
```

```
-------  Class: biking           AP:   0.9207  -------
-------  Class: transporting things or people     AP:   0.9249  -------
-------  Class: sunbathing       AP:   0.7588  -------
-------  Class: vacationing/ touring     AP:   0.8249  -------
-------  Class: hiking           AP:   0.9376  -------
-------  Class: climbing         AP:   0.9050  -------
-------  Class: camping          AP:   0.9241  -------
-------  Class: reading          AP:   0.8637  -------
-------  Class: studying/ learning     AP:   0.8178  -------
-------  Class: teaching/ training     AP:   0.9465  -------
-------  Class: research         AP:   0.8971  -------
-------  Class: diving           AP:   0.8536  -------
-------  Class: swimming         AP:   0.9488  -------
-------  Class: bathing          AP:   0.6691  -------
-------  Class: eating           AP:   0.9353  -------
-------  Class: cleaning         AP:   1.0000  -------
-------  Class: socializing      AP:   0.8873  -------
-------  Class: congregating     AP:   0.9167  -------
-------  Class: waiting in line/ queuing     AP:   0.8363  -------
-------  Class: competing        AP:   0.9358  -------
-------  Class: sports           AP:   0.9621  -------
-------  Class: exercise         AP:   0.8672  -------
-------  Class: playing          AP:   0.9038  -------
-------  Class: gaming           AP:   0.8230  -------
-------  Class: spectating/ being in an audience     AP:   0.9436  -------
-------  Class: farming          AP:   0.8680  -------
-------  Class: constructing/ building     AP:   0.8200  -------
-------  Class: shopping         AP:   0.9707  -------
-------  Class: medical activity     AP:   0.8036  -------
-------  Class: working          AP:   0.9440  -------
-------  Class: using tools      AP:   0.9184  -------
-------  Class: digging          AP:   0.8282  -------
-------  Class: conducting business     AP:   0.8489  -------
-------  Class: praying          AP:   0.8777  -------
-------  Class: fencing          AP:   0.6532  -------
-------  Class: railing          AP:   0.8538  -------
-------  Class: wire             AP:   0.9709  -------
-------  Class: railroad         AP:   0.8818  -------
-------  Class: trees            AP:   0.9832  -------
-------  Class: grass            AP:   0.9707  -------
-------  Class: vegetation       AP:   0.9667  -------
-------  Class: shrubbery        AP:   0.9313  -------
-------  Class: foliage          AP:   0.9795  -------
-------  Class: leaves           AP:   0.9493  -------
-------  Class: flowers          AP:   1.0000  -------
-------  Class: asphalt          AP:   0.9610  -------
-------  Class: pavement         AP:   0.8824  -------
-------  Class: shingles         AP:   0.9209  -------
```

```
-------  Class: carpet           AP:   0.8577  -------
-------  Class: brick            AP:   0.9302  -------
-------  Class: tiles            AP:   0.6853  -------
-------  Class: concrete         AP:   0.8484  -------
-------  Class: metal            AP:   0.9563  -------
-------  Class: paper            AP:   0.8831  -------
-------  Class: wood (not part of a tree)     AP:   0.9007  -------
-------  Class: vinyl/ linoleum     AP:   0.8429  -------
-------  Class: rubber/ plastic     AP:   0.9333  -------
-------  Class: cloth            AP:   0.9814  -------
-------  Class: sand             AP:   0.9231  -------
-------  Class: rock/stone       AP:   0.9662  -------
-------  Class: dirt/soil        AP:   0.9405  -------
-------  Class: marble           AP:   0.7589  -------
-------  Class: glass            AP:   0.9405  -------
-------  Class: waves/ surf      AP:   0.8557  -------
-------  Class: ocean            AP:   0.9345  -------
-------  Class: running water     AP:   0.9717  -------
-------  Class: still water      AP:   0.8655  -------
-------  Class: ice              AP:   0.7482  -------
-------  Class: snow             AP:   1.0000  -------
-------  Class: clouds           AP:   0.9954  -------
-------  Class: smoke            AP:   1.0000  -------
-------  Class: fire             AP:   1.0000  -------
-------  Class: natural light     AP:   0.9706  -------
-------  Class: direct sun/sunny     AP:   0.9541  -------
-------  Class: electric/indoor lighting     AP:   0.9794  -------
-------  Class: aged/ worn       AP:   0.8205  -------
-------  Class: glossy           AP:   0.8885  -------
-------  Class: matte            AP:   0.8050  -------
-------  Class: sterile          AP:   0.7978  -------
-------  Class: moist/ damp      AP:   0.9239  -------
-------  Class: dry              AP:   0.9311  -------
-------  Class: dirty            AP:   0.8991  -------
-------  Class: rusty            AP:   0.7963  -------
-------  Class: warm             AP:   0.8891  -------
-------  Class: cold             AP:   0.9792  -------
-------  Class: natural          AP:   0.9859  -------
-------  Class: man-made         AP:   0.9730  -------
-------  Class: open area        AP:   0.9819  -------
-------  Class: semi-enclosed area     AP:   0.8579  -------
-------  Class: enclosed area     AP:   0.9792  -------
-------  Class: far-away horizon     AP:   0.9656  -------
-------  Class: no horizon       AP:   0.9711  -------
-------  Class: rugged scene     AP:   0.9344  -------
-------  Class: mostly vertical components     AP:   0.9127  -------
-------  Class: mostly horizontal components     AP:   0.8717  -------
-------  Class: symmetrical      AP:   0.8839  -------
```

```
-------  Class: cluttered space     AP:   0.9194  -------
-------  Class: scary            AP:   0.8924  -------
-------  Class: soothing         AP:   0.9035  -------
-------  Class: stressful        AP:   0.8709  -------
mAP: 0.9026
Avg loss: 0.040300142212674535
Evaluating classifier
Mean Precision Score for Testing on Epoch 15 is 0.9026054632505955
Starting epoch number 16
Loss for Training on Epoch 16 is 0.016973763704299927
Starting epoch number 17
Loss for Training on Epoch 17 is 0.014170930720865726
Starting epoch number 18
Loss for Training on Epoch 18 is 0.012336528860032558
Starting epoch number 19
Loss for Training on Epoch 19 is 0.010685698129236698
Starting epoch number 20
Loss for Training on Epoch 20 is 0.008981846272945404
-------  Class: driving          AP:   0.9343  -------
-------  Class: biking           AP:   0.9344  -------
-------  Class: transporting things or people     AP:   0.9284  -------
-------  Class: sunbathing       AP:   0.9481  -------
-------  Class: vacationing/ touring     AP:   0.8469  -------
-------  Class: hiking           AP:   0.9575  -------
-------  Class: climbing         AP:   0.9221  -------
-------  Class: camping          AP:   0.9480  -------
-------  Class: reading          AP:   0.8973  -------
-------  Class: studying/ learning     AP:   0.8544  -------
-------  Class: teaching/ training     AP:   0.9460  -------
-------  Class: research         AP:   0.9403  -------
-------  Class: diving           AP:   0.8970  -------
-------  Class: swimming         AP:   0.9621  -------
-------  Class: bathing          AP:   0.7781  -------
-------  Class: eating           AP:   0.9433  -------
-------  Class: cleaning         AP:   1.0000  -------
-------  Class: socializing      AP:   0.9265  -------
-------  Class: congregating     AP:   0.9253  -------
-------  Class: waiting in line/ queuing     AP:   0.8491  -------
-------  Class: competing        AP:   0.9322  -------
-------  Class: sports           AP:   0.9748  -------
-------  Class: exercise         AP:   0.8930  -------
-------  Class: playing          AP:   0.9300  -------
-------  Class: gaming           AP:   0.8650  -------
-------  Class: spectating/ being in an audience     AP:   0.9516  -------
-------  Class: farming          AP:   0.9031  -------
-------  Class: constructing/ building     AP:   0.7990  -------
-------  Class: shopping         AP:   0.9540  -------
-------  Class: medical activity     AP:   0.8545  -------
```

```
-------  Class: working          AP:   0.9493  -------
-------  Class: using tools      AP:   0.9260  -------
-------  Class: digging          AP:   0.8467  -------
-------  Class: conducting business     AP:   0.9003  -------
-------  Class: praying          AP:   0.9197  -------
-------  Class: fencing          AP:   0.7281  -------
-------  Class: railing          AP:   0.8332  -------
-------  Class: wire             AP:   0.9766  -------
-------  Class: railroad         AP:   0.8920  -------
-------  Class: trees            AP:   0.9813  -------
-------  Class: grass            AP:   0.9764  -------
-------  Class: vegetation       AP:   0.9781  -------
-------  Class: shrubbery        AP:   0.9671  -------
-------  Class: foliage          AP:   0.9794  -------
-------  Class: leaves           AP:   0.9607  -------
-------  Class: flowers          AP:   1.0000  -------
-------  Class: asphalt          AP:   0.9643  -------
-------  Class: pavement         AP:   0.8944  -------
-------  Class: shingles         AP:   0.9356  -------
-------  Class: carpet           AP:   0.9060  -------
-------  Class: brick            AP:   0.9173  -------
-------  Class: tiles            AP:   0.7546  -------
-------  Class: concrete         AP:   0.8533  -------
-------  Class: metal            AP:   0.9662  -------
-------  Class: paper            AP:   0.9096  -------
-------  Class: wood (not part of a tree)     AP:   0.9286  -------
-------  Class: vinyl/ linoleum     AP:   0.9108  -------
-------  Class: rubber/ plastic     AP:   0.9376  -------
-------  Class: cloth            AP:   0.9837  -------
-------  Class: sand             AP:   0.9363  -------
-------  Class: rock/stone       AP:   0.9869  -------
-------  Class: dirt/soil        AP:   0.9394  -------
-------  Class: marble           AP:   0.7744  -------
-------  Class: glass            AP:   0.9461  -------
-------  Class: waves/ surf      AP:   0.9531  -------
-------  Class: ocean            AP:   0.9572  -------
-------  Class: running water     AP:   0.9910  -------
-------  Class: still water      AP:   0.9360  -------
-------  Class: ice              AP:   0.8034  -------
-------  Class: snow             AP:   0.9952  -------
-------  Class: clouds           AP:   0.9943  -------
-------  Class: smoke            AP:   1.0000  -------
-------  Class: fire             AP:   0.9667  -------
-------  Class: natural light     AP:   0.9732  -------
-------  Class: direct sun/sunny     AP:   0.9560  -------
-------  Class: electric/indoor lighting     AP:   0.9790  -------
-------  Class: aged/ worn       AP:   0.8792  -------
-------  Class: glossy           AP:   0.9069  -------
```

```
-------  Class: matte            AP:   0.8290  -------
-------  Class: sterile          AP:   0.8624  -------
-------  Class: moist/ damp      AP:   0.9203  -------
-------  Class: dry              AP:   0.9393  -------
-------  Class: dirty            AP:   0.9238  -------
-------  Class: rusty            AP:   0.8239  -------
-------  Class: warm             AP:   0.9406  -------
-------  Class: cold             AP:   0.9857  -------
-------  Class: natural          AP:   0.9854  -------
-------  Class: man-made         AP:   0.9810  -------
-------  Class: open area        AP:   0.9874  -------
-------  Class: semi-enclosed area     AP:   0.9279  -------
-------  Class: enclosed area     AP:   0.9838  -------
-------  Class: far-away horizon     AP:   0.9685  -------
-------  Class: no horizon       AP:   0.9713  -------
-------  Class: rugged scene     AP:   0.9425  -------
-------  Class: mostly vertical components     AP:   0.9367  -------
-------  Class: mostly horizontal components     AP:   0.8730  -------
-------  Class: symmetrical      AP:   0.9101  -------
-------  Class: cluttered space     AP:   0.9294  -------
-------  Class: scary            AP:   0.9075  -------
-------  Class: soothing         AP:   0.9377  -------
-------  Class: stressful        AP:   0.8915  -------
mAP: 0.9238
Avg loss: 0.03712121859706681
Evaluating classifier
Mean Precision Score for Testing on Epoch 20 is 0.9238226933886258
Starting epoch number 21
Loss for Training on Epoch 21 is 0.007741714362055063
Starting epoch number 22
Loss for Training on Epoch 22 is 0.006721013225615025
Starting epoch number 23
Loss for Training on Epoch 23 is 0.006086838431656361
Starting epoch number 24
Loss for Training on Epoch 24 is 0.005285778548568487
Starting epoch number 25
Loss for Training on Epoch 25 is 0.004733097739517689
-------  Class: driving          AP:   0.9485  -------
-------  Class: biking           AP:   0.9352  -------
-------  Class: transporting things or people     AP:   0.9308  -------
-------  Class: sunbathing       AP:   0.9712  -------
-------  Class: vacationing/ touring     AP:   0.8729  -------
-------  Class: hiking           AP:   0.9606  -------
-------  Class: climbing         AP:   0.9220  -------
-------  Class: camping          AP:   0.9595  -------
-------  Class: reading          AP:   0.9010  -------
-------  Class: studying/ learning     AP:   0.8754  -------
-------  Class: teaching/ training     AP:   0.9677  -------
```

```
-------  Class: research         AP:   0.9502  -------
-------  Class: diving           AP:   0.9160  -------
-------  Class: swimming         AP:   0.9689  -------
-------  Class: bathing          AP:   0.8263  -------
-------  Class: eating           AP:   0.9559  -------
-------  Class: cleaning         AP:   1.0000  -------
-------  Class: socializing      AP:   0.9253  -------
-------  Class: congregating     AP:   0.9279  -------
-------  Class: waiting in line/ queuing     AP:   0.8802  -------
-------  Class: competing        AP:   0.9488  -------
-------  Class: sports           AP:   0.9708  -------
-------  Class: exercise         AP:   0.9077  -------
-------  Class: playing          AP:   0.9256  -------
-------  Class: gaming           AP:   0.8979  -------
-------  Class: spectating/ being in an audience     AP:   0.9543  -------
-------  Class: farming          AP:   0.9030  -------
-------  Class: constructing/ building     AP:   0.7978  -------
-------  Class: shopping         AP:   0.9590  -------
-------  Class: medical activity     AP:   0.8684  -------
-------  Class: working          AP:   0.9568  -------
-------  Class: using tools      AP:   0.9191  -------
-------  Class: digging          AP:   0.8576  -------
-------  Class: conducting business     AP:   0.9082  -------
-------  Class: praying          AP:   0.9312  -------
-------  Class: fencing          AP:   0.7834  -------
-------  Class: railing          AP:   0.8716  -------
-------  Class: wire             AP:   0.9861  -------
-------  Class: railroad         AP:   0.8932  -------
-------  Class: trees            AP:   0.9850  -------
-------  Class: grass            AP:   0.9843  -------
-------  Class: vegetation       AP:   0.9824  -------
-------  Class: shrubbery        AP:   0.9629  -------
-------  Class: foliage          AP:   0.9831  -------
-------  Class: leaves           AP:   0.9732  -------
-------  Class: flowers          AP:   1.0000  -------
-------  Class: asphalt          AP:   0.9718  -------
-------  Class: pavement         AP:   0.9066  -------
-------  Class: shingles         AP:   0.9492  -------
-------  Class: carpet           AP:   0.9125  -------
-------  Class: brick            AP:   0.9745  -------
-------  Class: tiles            AP:   0.7381  -------
-------  Class: concrete         AP:   0.8660  -------
-------  Class: metal            AP:   0.9663  -------
-------  Class: paper            AP:   0.9104  -------
-------  Class: wood (not part of a tree)     AP:   0.9118  -------
-------  Class: vinyl/ linoleum     AP:   0.8981  -------
-------  Class: rubber/ plastic     AP:   0.9343  -------
-------  Class: cloth            AP:   0.9802  -------
```

```
-------  Class: sand             AP:   0.9593  -------
-------  Class: rock/stone       AP:   0.9915  -------
-------  Class: dirt/soil        AP:   0.9486  -------
-------  Class: marble           AP:   0.8016  -------
-------  Class: glass            AP:   0.9481  -------
-------  Class: waves/ surf      AP:   0.9764  -------
-------  Class: ocean            AP:   0.9606  -------
-------  Class: running water     AP:   0.9689  -------
-------  Class: still water      AP:   0.9443  -------
-------  Class: ice              AP:   0.7911  -------
-------  Class: snow             AP:   0.9933  -------
-------  Class: clouds           AP:   0.9933  -------
-------  Class: smoke            AP:   1.0000  -------
-------  Class: fire             AP:   1.0000  -------
-------  Class: natural light     AP:   0.9758  -------
-------  Class: direct sun/sunny     AP:   0.9615  -------
-------  Class: electric/indoor lighting     AP:   0.9748  -------
-------  Class: aged/ worn       AP:   0.8862  -------
-------  Class: glossy           AP:   0.9042  -------
-------  Class: matte            AP:   0.8343  -------
-------  Class: sterile          AP:   0.8620  -------
-------  Class: moist/ damp      AP:   0.9409  -------
-------  Class: dry              AP:   0.9393  -------
-------  Class: dirty            AP:   0.9126  -------
-------  Class: rusty            AP:   0.8384  -------
-------  Class: warm             AP:   0.9497  -------
-------  Class: cold             AP:   0.9938  -------
-------  Class: natural          AP:   0.9831  -------
-------  Class: man-made         AP:   0.9862  -------
-------  Class: open area        AP:   0.9870  -------
-------  Class: semi-enclosed area     AP:   0.9312  -------
-------  Class: enclosed area     AP:   0.9841  -------
-------  Class: far-away horizon     AP:   0.9667  -------
-------  Class: no horizon       AP:   0.9700  -------
-------  Class: rugged scene     AP:   0.9526  -------
-------  Class: mostly vertical components     AP:   0.9465  -------
-------  Class: mostly horizontal components     AP:   0.8714  -------
-------  Class: symmetrical      AP:   0.9101  -------
-------  Class: cluttered space     AP:   0.9556  -------
-------  Class: scary            AP:   0.8988  -------
-------  Class: soothing         AP:   0.9472  -------
-------  Class: stressful        AP:   0.8966  -------
mAP: 0.9313
Avg loss: 0.036338181395469044
Evaluating classifier
Mean Precision Score for Testing on Epoch 25 is 0.9313354824456421
Starting epoch number 26
Loss for Training on Epoch 26 is 0.004400004167109728
```

```
Starting epoch number 27
Loss for Training on Epoch 27 is 0.0038972629699856043
Starting epoch number 28
Loss for Training on Epoch 28 is 0.003554541151970625
Starting epoch number 29
Loss for Training on Epoch 29 is 0.0032744365744292736
Starting epoch number 30
Loss for Training on Epoch 30 is 0.00294415932148695
-------  Class: driving          AP:   0.9571  -------
-------  Class: biking           AP:   0.9408  -------
-------  Class: transporting things or people     AP:   0.9338  -------
-------  Class: sunbathing       AP:   0.9826  -------
-------  Class: vacationing/ touring     AP:   0.8805  -------
-------  Class: hiking           AP:   0.9677  -------
-------  Class: climbing         AP:   0.9188  -------
-------  Class: camping          AP:   0.9541  -------
-------  Class: reading          AP:   0.8961  -------
-------  Class: studying/ learning     AP:   0.9009  -------
-------  Class: teaching/ training     AP:   0.9668  -------
-------  Class: research         AP:   0.9480  -------
-------  Class: diving           AP:   0.9111  -------
-------  Class: swimming         AP:   0.9708  -------
-------  Class: bathing          AP:   0.8282  -------
-------  Class: eating           AP:   0.9636  -------
-------  Class: cleaning         AP:   1.0000  -------
-------  Class: socializing      AP:   0.9351  -------
-------  Class: congregating     AP:   0.9302  -------
-------  Class: waiting in line/ queuing     AP:   0.8712  -------
-------  Class: competing        AP:   0.9454  -------
-------  Class: sports           AP:   0.9726  -------
-------  Class: exercise         AP:   0.9271  -------
-------  Class: playing          AP:   0.9141  -------
-------  Class: gaming           AP:   0.9448  -------
-------  Class: spectating/ being in an audience     AP:   0.9504  -------
-------  Class: farming          AP:   0.9121  -------
-------  Class: constructing/ building     AP:   0.8437  -------
-------  Class: shopping         AP:   0.9653  -------
-------  Class: medical activity     AP:   0.8802  -------
-------  Class: working          AP:   0.9566  -------
-------  Class: using tools      AP:   0.9253  -------
-------  Class: digging          AP:   0.8738  -------
-------  Class: conducting business     AP:   0.9217  -------
-------  Class: praying          AP:   0.9155  -------
-------  Class: fencing          AP:   0.7935  -------
-------  Class: railing          AP:   0.8736  -------
-------  Class: wire             AP:   0.9821  -------
-------  Class: railroad         AP:   0.8842  -------
-------  Class: trees            AP:   0.9864  -------
```

```
-------  Class: grass            AP:   0.9829  -------
-------  Class: vegetation       AP:   0.9852  -------
-------  Class: shrubbery        AP:   0.9703  -------
-------  Class: foliage          AP:   0.9885  -------
-------  Class: leaves           AP:   0.9675  -------
-------  Class: flowers          AP:   1.0000  -------
-------  Class: asphalt          AP:   0.9765  -------
-------  Class: pavement         AP:   0.9237  -------
-------  Class: shingles         AP:   0.9436  -------
-------  Class: carpet           AP:   0.9285  -------
-------  Class: brick            AP:   0.9469  -------
-------  Class: tiles            AP:   0.7345  -------
-------  Class: concrete         AP:   0.8697  -------
-------  Class: metal            AP:   0.9672  -------
-------  Class: paper            AP:   0.9109  -------
-------  Class: wood (not part of a tree)     AP:   0.9239  -------
-------  Class: vinyl/ linoleum     AP:   0.9106  -------
-------  Class: rubber/ plastic     AP:   0.9347  -------
-------  Class: cloth            AP:   0.9845  -------
-------  Class: sand             AP:   0.9617  -------
-------  Class: rock/stone       AP:   0.9938  -------
-------  Class: dirt/soil        AP:   0.9488  -------
-------  Class: marble           AP:   0.7826  -------
-------  Class: glass            AP:   0.9497  -------
-------  Class: waves/ surf      AP:   0.9938  -------
-------  Class: ocean            AP:   0.9670  -------
-------  Class: running water     AP:   0.9803  -------
-------  Class: still water      AP:   0.9538  -------
-------  Class: ice              AP:   0.8041  -------
-------  Class: snow             AP:   0.9957  -------
-------  Class: clouds           AP:   0.9965  -------
-------  Class: smoke            AP:   1.0000  -------
-------  Class: fire             AP:   1.0000  -------
-------  Class: natural light     AP:   0.9795  -------
-------  Class: direct sun/sunny     AP:   0.9606  -------
-------  Class: electric/indoor lighting     AP:   0.9823  -------
-------  Class: aged/ worn       AP:   0.8920  -------
-------  Class: glossy           AP:   0.9184  -------
-------  Class: matte            AP:   0.8318  -------
-------  Class: sterile          AP:   0.8871  -------
-------  Class: moist/ damp      AP:   0.9513  -------
-------  Class: dry              AP:   0.9442  -------
-------  Class: dirty            AP:   0.9207  -------
-------  Class: rusty            AP:   0.8414  -------
-------  Class: warm             AP:   0.9551  -------
-------  Class: cold             AP:   0.9973  -------
-------  Class: natural          AP:   0.9897  -------
-------  Class: man-made         AP:   0.9855  -------
```

```
-------  Class: open area        AP:   0.9873  -------
-------  Class: semi-enclosed area     AP:   0.9433  -------
-------  Class: enclosed area     AP:   0.9853  -------
-------  Class: far-away horizon     AP:   0.9751  -------
-------  Class: no horizon       AP:   0.9676  -------
-------  Class: rugged scene     AP:   0.9542  -------
-------  Class: mostly vertical components     AP:   0.9438  -------
-------  Class: mostly horizontal components     AP:   0.8824  -------
-------  Class: symmetrical      AP:   0.9065  -------
-------  Class: cluttered space     AP:   0.9452  -------
-------  Class: scary            AP:   0.9261  -------
-------  Class: soothing         AP:   0.9408  -------
-------  Class: stressful        AP:   0.8900  -------
mAP: 0.9355
Avg loss: 0.036887487011223005
Evaluating classifier
Mean Precision Score for Testing on Epoch 30 is 0.9355186768650677
Starting epoch number 31
Loss for Training on Epoch 31 is 0.002681059530004859
Starting epoch number 32
Loss for Training on Epoch 32 is 0.0024660290218889713
Starting epoch number 33
Loss for Training on Epoch 33 is 0.0023123957216739655
Starting epoch number 34
Loss for Training on Epoch 34 is 0.0022481216583400965
Starting epoch number 35
Loss for Training on Epoch 35 is 0.002160392003133893
-------  Class: driving          AP:   0.9510  -------
-------  Class: biking           AP:   0.9443  -------
-------  Class: transporting things or people     AP:   0.9311  -------
-------  Class: sunbathing       AP:   0.9812  -------
-------  Class: vacationing/ touring     AP:   0.8813  -------
-------  Class: hiking           AP:   0.9633  -------
-------  Class: climbing         AP:   0.9257  -------
-------  Class: camping          AP:   0.9613  -------
-------  Class: reading          AP:   0.8997  -------
-------  Class: studying/ learning     AP:   0.9099  -------
-------  Class: teaching/ training     AP:   0.9652  -------
-------  Class: research         AP:   0.9534  -------
-------  Class: diving           AP:   0.9005  -------
-------  Class: swimming         AP:   0.9890  -------
-------  Class: bathing          AP:   0.8267  -------
-------  Class: eating           AP:   0.9662  -------
-------  Class: cleaning         AP:   1.0000  -------
-------  Class: socializing      AP:   0.9401  -------
-------  Class: congregating     AP:   0.9333  -------
-------  Class: waiting in line/ queuing     AP:   0.8713  -------
-------  Class: competing        AP:   0.9483  -------
```

```
-------  Class: sports           AP:   0.9739  -------
-------  Class: exercise         AP:   0.9115  -------
-------  Class: playing          AP:   0.9322  -------
-------  Class: gaming           AP:   0.9746  -------
-------  Class: spectating/ being in an audience     AP:   0.9495  -------
-------  Class: farming          AP:   0.9099  -------
-------  Class: constructing/ building     AP:   0.8534  -------
-------  Class: shopping         AP:   0.9633  -------
-------  Class: medical activity     AP:   0.8710  -------
-------  Class: working          AP:   0.9569  -------
-------  Class: using tools      AP:   0.9205  -------
-------  Class: digging          AP:   0.8661  -------
-------  Class: conducting business     AP:   0.9081  -------
-------  Class: praying          AP:   0.9145  -------
-------  Class: fencing          AP:   0.8049  -------
-------  Class: railing          AP:   0.8632  -------
-------  Class: wire             AP:   0.9787  -------
-------  Class: railroad         AP:   0.8970  -------
-------  Class: trees            AP:   0.9863  -------
-------  Class: grass            AP:   0.9843  -------
-------  Class: vegetation       AP:   0.9828  -------
-------  Class: shrubbery        AP:   0.9654  -------
-------  Class: foliage          AP:   0.9867  -------
-------  Class: leaves           AP:   0.9689  -------
-------  Class: flowers          AP:   1.0000  -------
-------  Class: asphalt          AP:   0.9781  -------
-------  Class: pavement         AP:   0.9282  -------
-------  Class: shingles         AP:   0.9496  -------
-------  Class: carpet           AP:   0.9298  -------
-------  Class: brick            AP:   0.9390  -------
-------  Class: tiles            AP:   0.7663  -------
-------  Class: concrete         AP:   0.8592  -------
-------  Class: metal            AP:   0.9644  -------
-------  Class: paper            AP:   0.9119  -------
-------  Class: wood (not part of a tree)     AP:   0.9345  -------
-------  Class: vinyl/ linoleum     AP:   0.9012  -------
-------  Class: rubber/ plastic     AP:   0.9431  -------
-------  Class: cloth            AP:   0.9850  -------
-------  Class: sand             AP:   0.9632  -------
-------  Class: rock/stone       AP:   0.9902  -------
-------  Class: dirt/soil        AP:   0.9467  -------
-------  Class: marble           AP:   0.7992  -------
-------  Class: glass            AP:   0.9554  -------
-------  Class: waves/ surf      AP:   0.9938  -------
-------  Class: ocean            AP:   0.9692  -------
-------  Class: running water     AP:   0.9754  -------
-------  Class: still water      AP:   0.9602  -------
-------  Class: ice              AP:   0.8184  -------
```

```
-------  Class: snow             AP:   0.9985  -------
-------  Class: clouds           AP:   0.9953  -------
-------  Class: smoke            AP:   1.0000  -------
-------  Class: fire             AP:   0.9667  -------
-------  Class: natural light     AP:   0.9832  -------
-------  Class: direct sun/sunny     AP:   0.9574  -------
-------  Class: electric/indoor lighting     AP:   0.9855  -------
-------  Class: aged/ worn       AP:   0.8883  -------
-------  Class: glossy           AP:   0.9105  -------
-------  Class: matte            AP:   0.8481  -------
-------  Class: sterile          AP:   0.8771  -------
-------  Class: moist/ damp      AP:   0.9488  -------
-------  Class: dry              AP:   0.9452  -------
-------  Class: dirty            AP:   0.9276  -------
-------  Class: rusty            AP:   0.8285  -------
-------  Class: warm             AP:   0.9547  -------
-------  Class: cold             AP:   0.9928  -------
-------  Class: natural          AP:   0.9849  -------
-------  Class: man-made         AP:   0.9876  -------
-------  Class: open area        AP:   0.9872  -------
-------  Class: semi-enclosed area     AP:   0.9441  -------
-------  Class: enclosed area     AP:   0.9879  -------
-------  Class: far-away horizon     AP:   0.9702  -------
-------  Class: no horizon       AP:   0.9716  -------
-------  Class: rugged scene     AP:   0.9607  -------
-------  Class: mostly vertical components     AP:   0.9493  -------
-------  Class: mostly horizontal components     AP:   0.8810  -------
-------  Class: symmetrical      AP:   0.9118  -------
-------  Class: cluttered space     AP:   0.9466  -------
-------  Class: scary            AP:   0.9284  -------
-------  Class: soothing         AP:   0.9405  -------
-------  Class: stressful        AP:   0.8906  -------
mAP: 0.9364
Avg loss: 0.03818422883492092
Evaluating classifier
Mean Precision Score for Testing on Epoch 35 is 0.9364261012813871
Starting epoch number 36
Loss for Training on Epoch 36 is 0.002036087913438678
Starting epoch number 37
Loss for Training on Epoch 37 is 0.001957477070391178
Starting epoch number 38
Loss for Training on Epoch 38 is 0.0018339568050578237
Starting epoch number 39
Loss for Training on Epoch 39 is 0.0017476597568020225
Starting epoch number 40
Loss for Training on Epoch 40 is 0.0016411376418545842
-------  Class: driving          AP:   0.9598  -------
-------  Class: biking           AP:   0.9380  -------
```

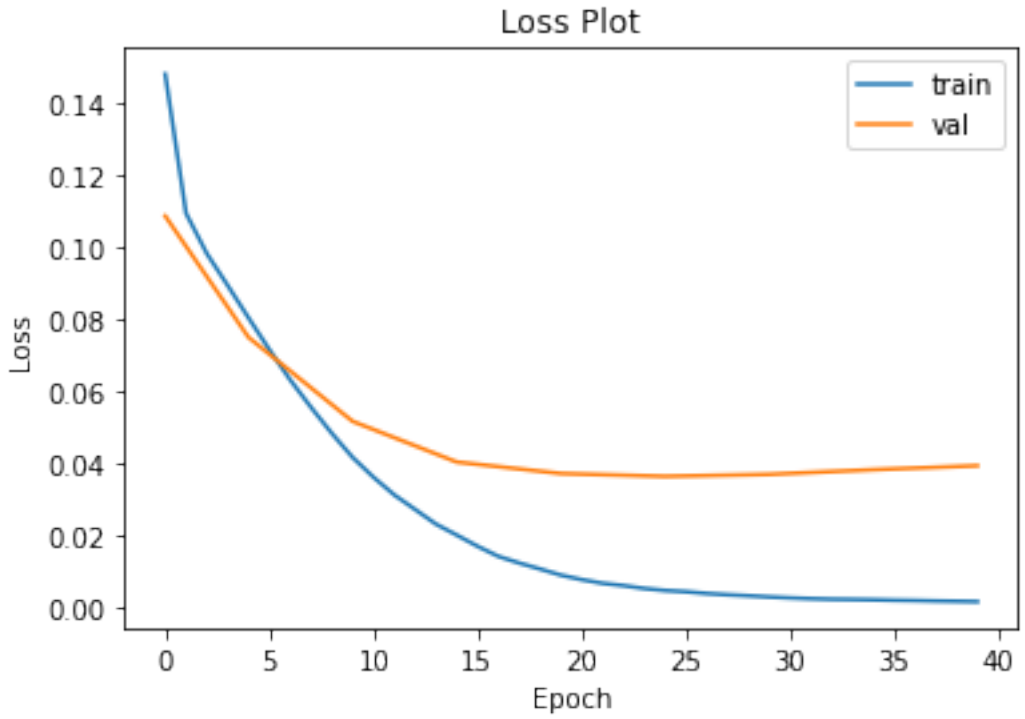
```
-------  Class: transporting things or people     AP:   0.9311  -------
-------  Class: sunbathing       AP:   0.9806  -------
-------  Class: vacationing/ touring     AP:   0.8810  -------
-------  Class: hiking           AP:   0.9657  -------
-------  Class: climbing         AP:   0.9368  -------
-------  Class: camping          AP:   0.9613  -------
-------  Class: reading          AP:   0.8980  -------
-------  Class: studying/ learning     AP:   0.9305  -------
-------  Class: teaching/ training     AP:   0.9687  -------
-------  Class: research         AP:   0.9535  -------
-------  Class: diving           AP:   0.9389  -------
-------  Class: swimming         AP:   0.9844  -------
-------  Class: bathing          AP:   0.8262  -------
-------  Class: eating           AP:   0.9579  -------
-------  Class: cleaning         AP:   1.0000  -------
-------  Class: socializing      AP:   0.9434  -------
-------  Class: congregating     AP:   0.9334  -------
-------  Class: waiting in line/ queuing     AP:   0.8655  -------
-------  Class: competing        AP:   0.9498  -------
-------  Class: sports           AP:   0.9721  -------
-------  Class: exercise         AP:   0.8887  -------
-------  Class: playing          AP:   0.9208  -------
-------  Class: gaming           AP:   0.9690  -------
-------  Class: spectating/ being in an audience     AP:   0.9506  -------
-------  Class: farming          AP:   0.9123  -------
-------  Class: constructing/ building     AP:   0.8288  -------
-------  Class: shopping         AP:   0.9752  -------
-------  Class: medical activity     AP:   0.8785  -------
-------  Class: working          AP:   0.9552  -------
-------  Class: using tools      AP:   0.9223  -------
-------  Class: digging          AP:   0.8469  -------
-------  Class: conducting business     AP:   0.9146  -------
-------  Class: praying          AP:   0.8994  -------
-------  Class: fencing          AP:   0.8104  -------
-------  Class: railing          AP:   0.8722  -------
-------  Class: wire             AP:   0.9775  -------
-------  Class: railroad         AP:   0.8957  -------
-------  Class: trees            AP:   0.9875  -------
-------  Class: grass            AP:   0.9790  -------
-------  Class: vegetation       AP:   0.9863  -------
-------  Class: shrubbery        AP:   0.9686  -------
-------  Class: foliage          AP:   0.9878  -------
-------  Class: leaves           AP:   0.9620  -------
-------  Class: flowers          AP:   1.0000  -------
-------  Class: asphalt          AP:   0.9785  -------
-------  Class: pavement         AP:   0.9175  -------
-------  Class: shingles         AP:   0.9396  -------
-------  Class: carpet           AP:   0.9259  -------
```

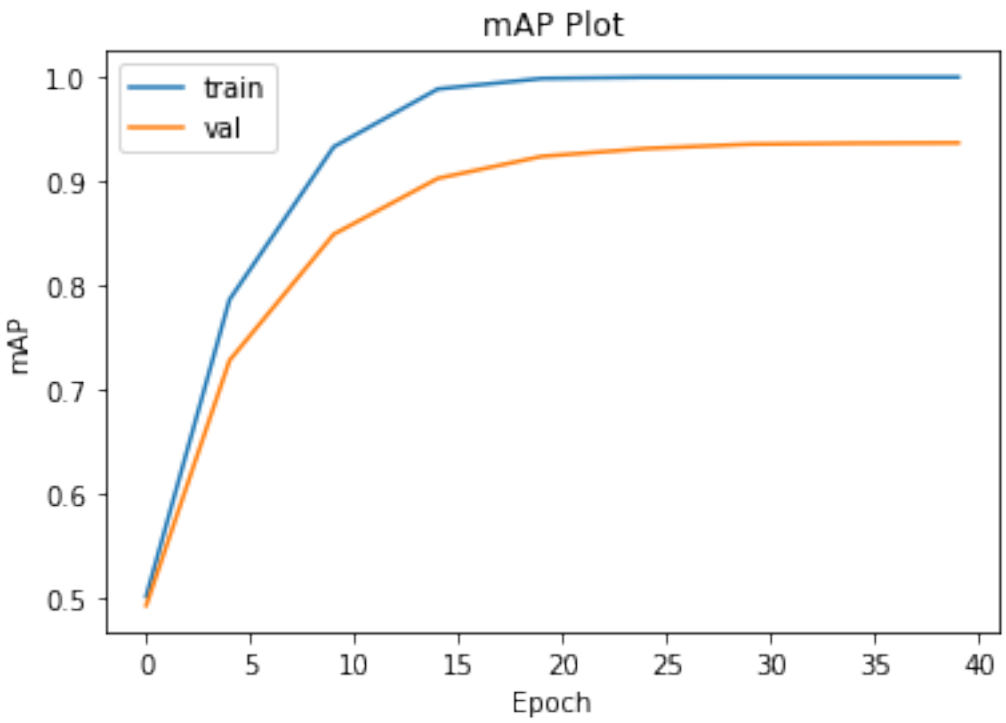
```
-------  Class: brick            AP:   0.9626  -------
-------  Class: tiles            AP:   0.7603  -------
-------  Class: concrete         AP:   0.8528  -------
-------  Class: metal            AP:   0.9643  -------
-------  Class: paper            AP:   0.9108  -------
-------  Class: wood (not part of a tree)     AP:   0.9348  -------
-------  Class: vinyl/ linoleum     AP:   0.9002  -------
-------  Class: rubber/ plastic     AP:   0.9356  -------
-------  Class: cloth            AP:   0.9836  -------
-------  Class: sand             AP:   0.9642  -------
-------  Class: rock/stone       AP:   0.9929  -------
-------  Class: dirt/soil        AP:   0.9478  -------
-------  Class: marble           AP:   0.8100  -------
-------  Class: glass            AP:   0.9539  -------
-------  Class: waves/ surf      AP:   0.9903  -------
-------  Class: ocean            AP:   0.9633  -------
-------  Class: running water     AP:   0.9813  -------
-------  Class: still water      AP:   0.9605  -------
-------  Class: ice              AP:   0.8119  -------
-------  Class: snow             AP:   0.9933  -------
-------  Class: clouds           AP:   0.9955  -------
-------  Class: smoke            AP:   1.0000  -------
-------  Class: fire             AP:   1.0000  -------
-------  Class: natural light     AP:   0.9809  -------
-------  Class: direct sun/sunny     AP:   0.9645  -------
-------  Class: electric/indoor lighting     AP:   0.9843  -------
-------  Class: aged/ worn       AP:   0.8969  -------
-------  Class: glossy           AP:   0.9117  -------
-------  Class: matte            AP:   0.8486  -------
-------  Class: sterile          AP:   0.8678  -------
-------  Class: moist/ damp      AP:   0.9540  -------
-------  Class: dry              AP:   0.9446  -------
-------  Class: dirty            AP:   0.9378  -------
-------  Class: rusty            AP:   0.8207  -------
-------  Class: warm             AP:   0.9593  -------
-------  Class: cold             AP:   0.9938  -------
-------  Class: natural          AP:   0.9869  -------
-------  Class: man-made         AP:   0.9870  -------
-------  Class: open area        AP:   0.9890  -------
-------  Class: semi-enclosed area     AP:   0.9405  -------
-------  Class: enclosed area     AP:   0.9883  -------
-------  Class: far-away horizon     AP:   0.9704  -------
-------  Class: no horizon       AP:   0.9718  -------
-------  Class: rugged scene     AP:   0.9562  -------
-------  Class: mostly vertical components     AP:   0.9503  -------
-------  Class: mostly horizontal components     AP:   0.8840  -------
-------  Class: symmetrical      AP:   0.9139  -------
-------  Class: cluttered space     AP:   0.9509  -------
```

```
-------  Class: scary            AP:   0.9346  -------
-------  Class: soothing         AP:   0.9432  -------
-------  Class: stressful        AP:   0.8880  -------
mAP: 0.9368
Avg loss: 0.0392803238897488
Evaluating classifier
Mean Precision Score for Testing on Epoch 40 is 0.9368053344609433
```

[ ]:
```
torch.save(classifier.state_dict(), './sun_attribute_classifier.pth')
```

[ ]:
```
plot_losses(train_losses, val_losses, test_frequency, num_epochs)
plot_mAP(train_mAPs, val_mAPs, test_frequency, num_epochs)
```






### 2.3 Testing

[ ]:
```
ds_test = SunDataset('images/','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)
print("Test mAP: ", mAP_test)
```

```
-------  Class: driving          AP:   0.9876  -------
-------  Class: biking           AP:   0.9742  -------
-------  Class: transporting things or people     AP:   0.9460  -------
-------  Class: sunbathing       AP:   0.9251  -------
-------  Class: vacationing/ touring     AP:   0.9345  -------
-------  Class: hiking           AP:   0.9697  -------
-------  Class: climbing         AP:   0.9732  -------
-------  Class: camping          AP:   0.9915  -------
-------  Class: reading          AP:   0.8877  -------
-------  Class: studying/ learning     AP:   0.9697  -------
-------  Class: teaching/ training     AP:   0.8502  -------
-------  Class: research         AP:   0.9530  -------
```

```
-------  Class: diving           AP:   0.9667  -------
-------  Class: swimming         AP:   0.9456  -------
-------  Class: bathing          AP:   0.9911  -------
-------  Class: eating           AP:   0.9539  -------
-------  Class: cleaning         AP:   1.0000  -------
-------  Class: socializing      AP:   0.9098  -------
-------  Class: congregating     AP:   0.9641  -------
-------  Class: waiting in line/ queuing     AP:   0.7965  -------
-------  Class: competing        AP:   0.9637  -------
-------  Class: sports           AP:   0.9834  -------
-------  Class: exercise         AP:   0.9395  -------
-------  Class: playing          AP:   0.9603  -------
-------  Class: gaming           AP:   0.9809  -------
-------  Class: spectating/ being in an audience     AP:   0.9873  -------
-------  Class: farming          AP:   0.9587  -------
-------  Class: constructing/ building     AP:   1.0000  -------
-------  Class: shopping         AP:   0.9687  -------
-------  Class: medical activity     AP:   0.9272  -------
-------  Class: working          AP:   0.9612  -------
-------  Class: using tools      AP:   0.9831  -------
-------  Class: digging          AP:   0.9298  -------
-------  Class: conducting business     AP:   0.8189  -------
-------  Class: praying          AP:   1.0000  -------
-------  Class: fencing          AP:   0.7758  -------
-------  Class: railing          AP:   0.9561  -------
-------  Class: wire             AP:   0.8876  -------
-------  Class: railroad         AP:   1.0000  -------
-------  Class: trees            AP:   0.9906  -------
-------  Class: grass            AP:   0.9735  -------
-------  Class: vegetation       AP:   0.9871  -------
-------  Class: shrubbery        AP:   0.9333  -------
-------  Class: foliage          AP:   0.9812  -------
-------  Class: leaves           AP:   0.9871  -------
-------  Class: flowers          AP:   0.9971  -------
-------  Class: asphalt          AP:   0.9807  -------
-------  Class: pavement         AP:   0.9439  -------
-------  Class: shingles         AP:   0.9635  -------
-------  Class: carpet           AP:   0.9973  -------
-------  Class: brick            AP:   0.9334  -------
-------  Class: tiles            AP:   0.8407  -------
-------  Class: concrete         AP:   0.7910  -------
-------  Class: metal            AP:   0.9383  -------
-------  Class: paper            AP:   0.9611  -------
-------  Class: wood (not part of a tree)     AP:   0.9833  -------
-------  Class: vinyl/ linoleum     AP:   0.8094  -------
-------  Class: rubber/ plastic     AP:   0.9404  -------
-------  Class: cloth            AP:   0.9232  -------
-------  Class: sand             AP:   0.9589  -------
```

```
-------  Class: rock/stone       AP:   0.9552  -------
-------  Class: dirt/soil        AP:   0.9727  -------
-------  Class: marble           AP:   0.9087  -------
-------  Class: glass            AP:   0.9491  -------
-------  Class: waves/ surf      AP:   0.9704  -------
-------  Class: ocean            AP:   0.9586  -------
-------  Class: running water     AP:   0.9334  -------
-------  Class: still water      AP:   0.9519  -------
-------  Class: ice              AP:   0.9862  -------
-------  Class: snow             AP:   0.9902  -------
-------  Class: clouds           AP:   0.9932  -------
-------  Class: smoke            AP:   1.0000  -------
-------  Class: fire             AP:   0.9405  -------
-------  Class: natural light     AP:   0.9803  -------
-------  Class: direct sun/sunny     AP:   0.9885  -------
-------  Class: electric/indoor lighting     AP:   0.9675  -------
-------  Class: aged/ worn       AP:   0.9137  -------
-------  Class: glossy           AP:   0.9318  -------
-------  Class: matte            AP:   0.8767  -------
-------  Class: sterile          AP:   0.9633  -------
-------  Class: moist/ damp      AP:   0.9316  -------
-------  Class: dry              AP:   0.9593  -------
-------  Class: dirty            AP:   0.9202  -------
-------  Class: rusty            AP:   0.8597  -------
-------  Class: warm             AP:   0.9403  -------
-------  Class: cold             AP:   0.9589  -------
-------  Class: natural          AP:   0.9683  -------
-------  Class: man-made         AP:   0.9794  -------
-------  Class: open area        AP:   0.9927  -------
-------  Class: semi-enclosed area     AP:   0.9623  -------
-------  Class: enclosed area     AP:   0.9850  -------
-------  Class: far-away horizon     AP:   0.9877  -------
-------  Class: no horizon       AP:   0.9763  -------
-------  Class: rugged scene     AP:   0.9867  -------
-------  Class: mostly vertical components     AP:   0.9428  -------
-------  Class: mostly horizontal components     AP:   0.9073  -------
-------  Class: symmetrical      AP:   0.9367  -------
-------  Class: cluttered space     AP:   0.9627  -------
-------  Class: scary            AP:   0.9591  -------
-------  Class: soothing         AP:   0.9050  -------
-------  Class: stressful        AP:   0.8950  -------
mAP: 0.9479
Avg loss: 0.0339951959663424
Test mAP:  0.9478817674151206
```

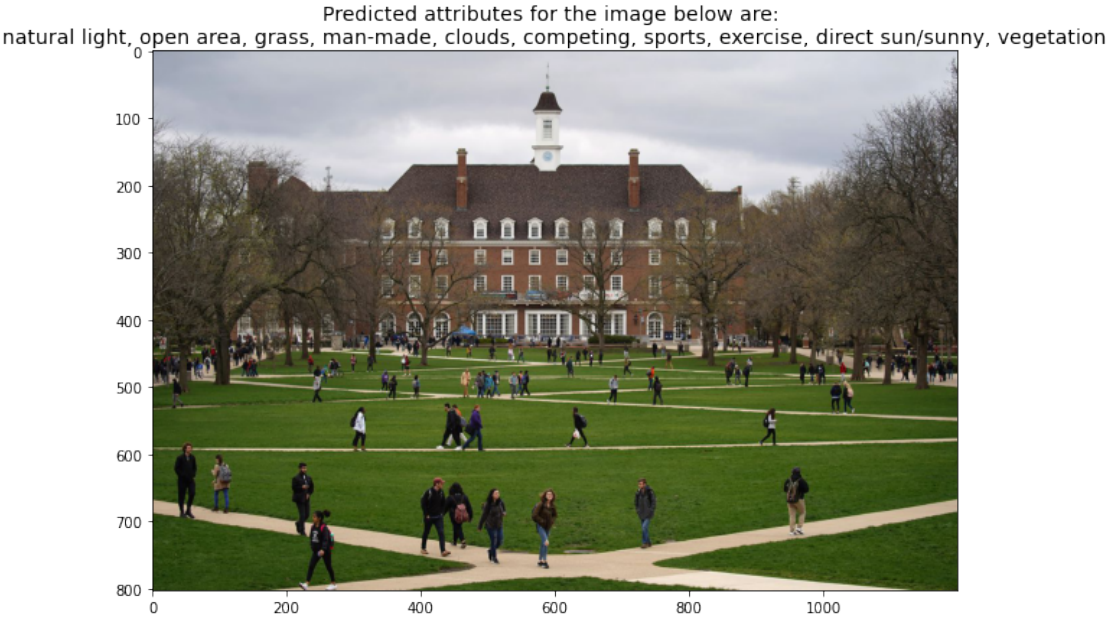
### 2.4 Attribute classifier on a sample image

[ ]:
```
def format_image(x):
    scale = np.random.rand() * 2 + 0.25
    w = int(x.size[0] * scale)
    h = int(x.size[1] * scale)
    if min(w, h) < 227:
        scale = 227 / min(w, h)
        w = int(x.size[0] * scale)
        h = int(x.size[1] * scale)
    x = test_transform(x)
    x = x.view(1, 3, 227, 227)
    return x

def get_top_10_attributes(x, classifier):
    classifier.eval()
    classifier = classifier.cpu()
    logits = classifier(x)
    sorted_indices = torch.argsort(logits, descending=True)
    top_10_indices = sorted_indices.numpy()[0][:10]
    return [SUN_CLASSES[i] for i in top_10_indices]
```

[ ]:
```
load_network_path = './sun_attribute_classifier.pth'

# use to load a previously trained network
if load_network_path is not None:
    print('Loading saved network from {}'.format(load_network_path))
    classifier = torchvision.models.densenet201()
    classifier.classifier = nn.Linear(1920, 102)
    classifier.load_state_dict(torch.load(load_network_path, map_location=torch.
 ↪device('cpu') ))
```

```
Loading saved network from ./sun_attribute_classifier.pth
```

[ ]:
```
img = Image.open('./university.jfif').convert('RGB')
img_formatted = format_image(img)
top_10_attributes = get_top_10_attributes(img_formatted, classifier)

draw = ImageDraw.Draw(img)
plt.figure(figsize = (10,10))
plt.imshow(img)
plt.title("Predicted attributes for the image below are: \n" + ", ".
 ↪join(top_10_attributes), pad = 5, fontdict={'fontsize': 14});
```




### 2.5 Predicting the scene of an input image using the pre-trained scene classifier and outputting a heat map for an input image

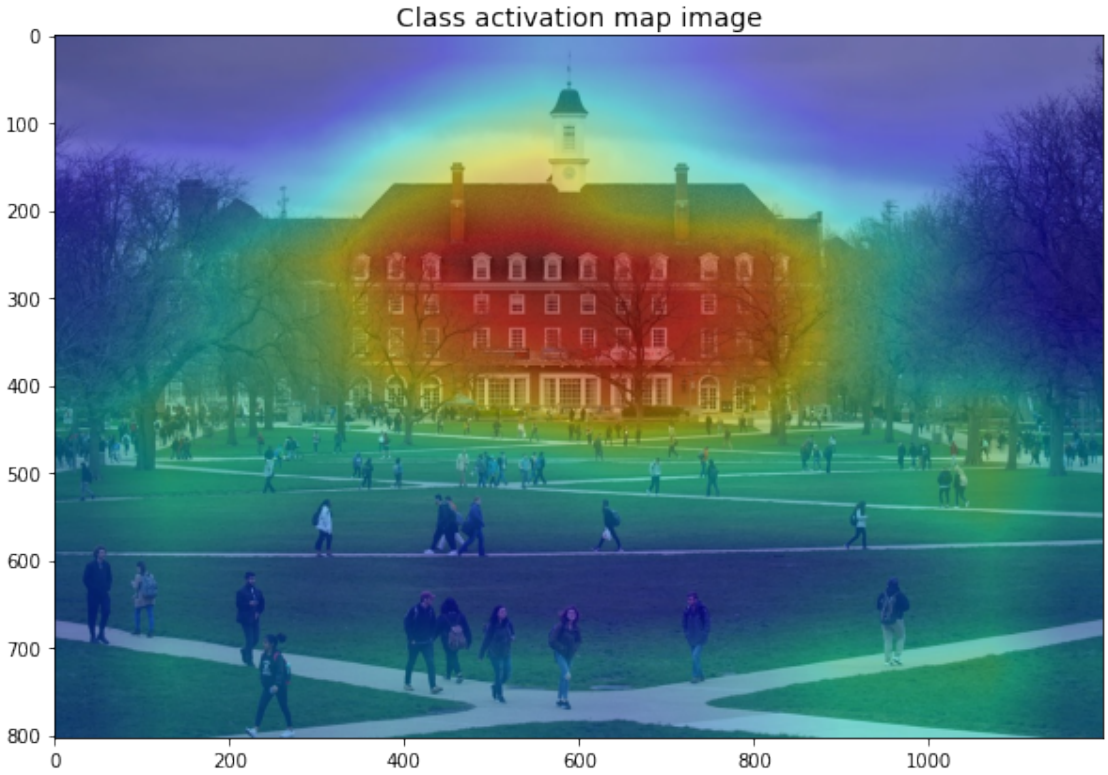
[ ]:
```
from torch.autograd import Variable as V
import torchvision.models as models
from torchvision import transforms as trn
from torch.nn import functional as F
import cv2
from run_all_classifiers import load_labels, load_model, returnTF,␣
↪load_attributes_classifier, returnCAM, features_blobs
```

[ ]:
```
# load the test image
img_name = 'university.jfif'
img = Image.open(img_name)
draw = ImageDraw.Draw(img)
plt.figure(figsize = (10,10))
plt.imshow(img)
plt.title("Input image", pad = 5, fontdict={'fontsize': 14});
input_img = V(tf(img).unsqueeze(0))

# load the labels
classes, labels_IO, labels_attribute = load_labels()
# load the model
model = load_model()
# load the transformer
tf = returnTF() # image transformer
```

```
# get the softmax weight
params = list(model.parameters())
weight_softmax = params[-2].data.numpy()
weight_softmax[weight_softmax<0] = 0

# forward pass
logit = model.forward(input_img)
h_x = F.softmax(logit, 1).data.squeeze()
probs, idx = h_x.sort(0, True)
probs = probs.numpy()
idx = idx.numpy()

# output the IO prediction
io_image = np.mean(labels_IO[idx[:10]]) # vote for the indoor or outdoor
if io_image < 0.5:
    print('--TYPE OF ENVIRONMENT: indoor')
else:
    print('--TYPE OF ENVIRONMENT: outdoor')

# output the prediction of scene category
print('--SCENE CATEGORIES:')
for i in range(0, 5):
    print('{:.3f} -> {}'.format(probs[i], classes[idx[i]]))

# generate class activation mapping
CAMs = returnCAM(features_blobs[0], weight_softmax, [idx[0]])
# render the CAM and output
img = cv2.imread(img_name)
height, width, _ = img.shape
heatmap = cv2.applyColorMap(cv2.resize(CAMs[0],(width, height)), cv2.
 ↪COLORMAP_JET)
result = heatmap * 0.4 + img * 0.5
cv2.imwrite('cam.jpg', result)

cam_name = 'cam.jpg'
cam_img = Image.open(cam_name)
draw = ImageDraw.Draw(cam_img)
plt.figure(figsize = (10,10))
plt.imshow(cam_img)
plt.title("Class activation map image", pad = 5, fontdict={'fontsize': 14});
```

```
--TYPE OF ENVIRONMENT: outdoor
--SCENE CATEGORIES:
0.700 -> campus
0.062 -> courthouse
0.052 -> embassy
0.030 -> golf_course
0.022 -> lawn
```


Input image
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000


Class activation map image
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000