finalProject

June 11, 2020

1 EDA explosive data analysis

[0]:
```
import pandas as pd
labels = pd.read_csv('labels.csv')
```

[0]:
```
n = len(labels)
breed = set(labels['breed'])
n_class = len(breed)
class_to_num = dict(zip(breed, range(n_class)))
n_class = len(breed)
```

[0]:
```
labels.head(5)
```

[0]:

	id	breed
0	000bec180eb18c7604dcecc8fe0dba07	boston_bull
1	001513dfcb2ffafc82cccf4d8bbaba97	dingo
2	001cdf01b096e06d78e9e5112d419397	pekinese
3	00214f311d5d2247d5dfe4fe24b2303d	bluetick
4	0021f9ceb3235effd7fcde7f7538ed62	golden_retriever

[0]:
```
yy = pd.value_counts(labels['breed'])
print(yy[:10])
```

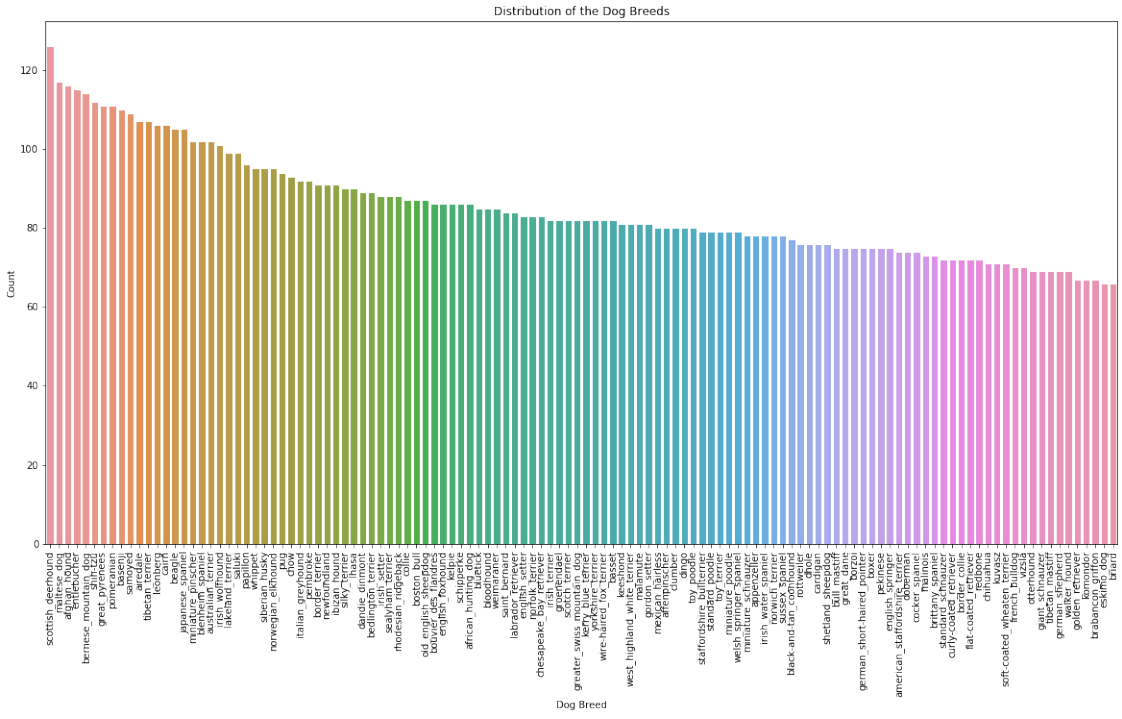
```
scottish_deerhound      126
maltese_dog             117
afghan_hound            116
entlebucher             115
bernese_mountain_dog    114
shih-tzu                112
great_pyrenees          111
pomeranian              111
basenji                 110
samoyed                 109
Name: breed, dtype: int64
```

[0]:
```
print(yy[-10:])
```

```
otterhound            69
giant_schnauzer       69
tibetan_mastiff       69
german_shepherd       69
walker_hound          69
golden_retriever      67
komondor              67
brabancon_griffon     67
eskimo_dog            66
briard                66
Name: breed, dtype: int64
```

[0]:
```
import matplotlib.pyplot as plt
import seaborn as sns
fig, ax = plt.subplots()
fig.set_size_inches(20,10)
sns.set_style("whitegrid")

ax = sns.barplot(x = yy.index, y = yy, data = labels)
ax.set_xticklabels(ax.get_xticklabels(), rotation = 90, fontsize = 10)
ax.set(xlabel='Dog Breed', ylabel='Count')
ax.set_title('Distribution of the Dog Breeds')
```

[0]:
```
Text(0.5, 1.0, 'Distribution of the Dog Breeds')
```



2 Resize the data to be three new data set as 120 * 20, 120 * 40 and 120 * 60

[0]:
```
!mkdir images120_20
!mkdir images120_40
!mkdir images120_60
```

[0]:
```
import os, random, shutil

for dir in os.listdir('Images/'):
    os.mkdir('images120_20/'+dir)
    os.mkdir('images120_40/'+dir)
    os.mkdir('images120_60/'+dir)
```

[0]:
```
# ramdomly select 20/ 40 / 60 from the original dataset of 120 do breeds

for dir in os.listdir('Images/'):
    filepath = 'Images/' + dir + '/'
    tarDir = 'images120_20/' + dir + '/'

    files = os.listdir(filepath)
    sample = random.sample(files, 20)

    for name in sample:
        shutil.copy(filepath+name, tarDir+name)
```

[0]:
```
# ramdomly select 20/ 40 / 60 from the original dataset of 120 do breeds

for dir in os.listdir('Images/'):
    filepath = 'Images/' + dir + '/'
    tarDir = 'images120_40/' + dir + '/'

    files = os.listdir(filepath)
    sample = random.sample(files, 40)

    for name in sample:
        shutil.copy(filepath+name, tarDir+name)
```

[0]:
```
# ramdomly select 20/ 40 / 60 from the original dataset of 120 do breeds

for dir in os.listdir('Images/'):
    filepath = 'Images/' + dir + '/'
    tarDir = 'images120_60/' + dir + '/'

    files = os.listdir(filepath)
    sample = random.sample(files, 60)
```

```
    for name in sample:
        shutil.copy(filepath+name, tarDir+name)
```

[0]:
```
!mkdir images120_60_train
!mkdir images120_60_val
!mkdir images120_60_test
```

[0]:
```
for dir in os.listdir('Images/'):
    os.mkdir('images120_60_train/'+dir)
    os.mkdir('images120_60_test/'+dir)
    os.mkdir('images120_60_val/'+dir)
```

[0]:
```
for dir in os.listdir('Images/'):
    filepath = 'Images/' + dir + '/'
    files = os.listdir(filepath)
    sample = random.sample(files, 60)

    tarDir = 'images120_60_train/' + dir + '/'
    for name in sample[:40]:
      shutil.copy(filepath+name, tarDir+name)

    tarDir = 'images120_60_val/' + dir + '/'
    for name in sample[40:50]:
      shutil.copy(filepath+name, tarDir+name)

    tarDir = 'images120_60_test/' + dir + '/'
    for name in sample[50:]:

      shutil.copy(filepath+name, tarDir+name)
```

3 training process starts from here

4 Pytorch

[5]:
```
from __future__ import print_function, division

import torch
from torch.utils.data import DataLoader
import torch.nn as nn
import torch.optim as optim
from torch.optim import lr_scheduler
import torchvision
from torchvision import datasets, models, transforms
```

```
import matplotlib.pyplot as plt
import numpy as np
import time
import os
import copy
```

[6]:
```
device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
device
```

[6]:
```
device(type='cuda')
```

[7]:
```
mean_nums = [0.485, 0.456, 0.406]
std_nums = [0.229, 0.224, 0.225]

chosen_transforms = {'train': transforms.Compose([
        transforms.RandomResizedCrop(size=256),
        transforms.RandomRotation(degrees=15),
        transforms.RandomResizedCrop(224),
        transforms.RandomHorizontalFlip(),
        transforms.ToTensor(),
        transforms.Normalize(mean_nums, std_nums)
]), 'val': transforms.Compose([
        transforms.Resize(256),
        transforms.CenterCrop(224),
        transforms.ToTensor(),
        transforms.Normalize(mean_nums, std_nums)
]), 'test': transforms.Compose([
        transforms.Resize(256),
        transforms.CenterCrop(224),
        transforms.ToTensor(),
        transforms.Normalize(mean_nums, std_nums)
])
}
```

[8]:
```
# Set the directory for the data
data_dir = 'images120_60_'

# Use the image folder function to create datasets
dog_datasets = {x: datasets.ImageFolder(data_dir+x+'/',
  chosen_transforms[x]) for x in ['train', 'val', 'test']}
```

[9]:
```
dataloaders = {x: DataLoader(dataset=dog_datasets[x], batch_size=8,␣
 ↪shuffle=True, num_workers=4)
  for x in ['train','val','test']}
```

[10]:
```
dataset_sizes = {x: len(dog_datasets[x]) for x in ['train','val','test']}
class_names = dog_datasets['train'].classes
```

```
print(dataset_sizes)
print(len(class_names))
```

```
{'train': 4800, 'val': 1200, 'test': 1200}
120
```

[11]:
```
# Visualize some images
def imshow(inp, title=None):
    inp = inp.numpy().transpose((1, 2, 0))
    mean = np.array([mean_nums])
    std = np.array([std_nums])
    inp = std * inp + mean
    inp = np.clip(inp, 0, 1)
    plt.imshow(inp)
    if title is not None:
        plt.title(title)
    plt.pause(0.001)  # Pause a bit so that plots are updated

# Grab some of the training data to visualize
inputs, classes = next(iter(dataloaders['train']))

# Now we construct a grid from batch
out = torchvision.utils.make_grid(inputs)

imshow(out, title=[class_names[x] for x in classes])
```

[12]:
```
LOG_DIR = 'log/'
def train_model(model, criterion, optimizer, num_epochs=10,␣
 ↪log_file_name='log'):
    log_file = open(LOG_DIR + log_file_name, 'w')
    since = time.time()

    best_model_wts = copy.deepcopy(model.state_dict())
    best_acc = 0.0

    for epoch in range(num_epochs):
        print('Epoch {}/{}'.format(epoch, num_epochs - 1))
        print('-' * 10)

        # Each epoch has a training and validation phase
        for phase in ['train','val']:
            if phase == 'train':
```

```
            # scheduler.step()
            model.train()  # Set model to training mode
        else:
            model.eval()   # Set model to evaluate mode

        current_loss = 0.0
        current_corrects = 0

        # Here's where the training happens
        # print('Iterating through data...')

        for inputs, labels in dataloaders[phase]:
            inputs = inputs.to(device)
            labels = labels.to(device)

            # We need to zero the gradients, don't forget it
            optimizer.zero_grad()

            outputs = model(inputs)
            _, preds = torch.max(outputs, 1)
            loss = criterion(outputs, labels)

            # backward + optimize only if in training phase
            if phase == 'train':
              loss.backward()
              optimizer.step()

            # We want variables to hold the loss statistics
            current_loss += loss.item()# * inputs.size(0)
            current_corrects += torch.sum(preds == labels.data)

        epoch_loss = current_loss / dataset_sizes[phase]
        epoch_acc = current_corrects.double() / dataset_sizes[phase]

        outline = f'{epoch} {epoch_loss:.4f} {epoch_acc:.4f} {phase}\n'
        log_file.write(outline)

        print('{} Loss: {:.4f} Acc: {:.4f}'.format(
            phase, epoch_loss, epoch_acc))

        # Make a copy of the model if the accuracy on the validation set␣
↪has improved
        if phase == 'val' and epoch_acc > best_acc:
            best_acc = epoch_acc
            best_model_wts = copy.deepcopy(model.state_dict())

    print()
```

```
    log_file.close()
    time_since = time.time() - since
    print('Training complete in {:.0f}m {:.0f}s'.format(
        time_since // 60, time_since % 60))
    print('Best val Acc: {:4f}'.format(best_acc))

    # Now we'll load in the best model weights and return it
    model.load_state_dict(best_model_wts)
    return model
```

[13]:
```
def evaluate_model(model, log_file_name='log'):

  phase = 'test'
  log_file = open(LOG_DIR + log_file_name, 'a')
  model.eval()   # Set model to evaluate mode

  current_loss = 0.0
  current_corrects = 0

  for inputs, labels in dataloaders[phase]:
      inputs = inputs.to(device)
      labels = labels.to(device)

      outputs = model(inputs)
      _, preds = torch.max(outputs, 1)
      loss = criterion(outputs, labels)


      # We want variables to hold the loss statistics
      current_loss += loss.item()# * inputs.size(0)
      current_corrects += torch.sum(preds == labels.data)

  epoch_loss = current_loss / dataset_sizes[phase]
  epoch_acc = current_corrects.double() / dataset_sizes[phase]

  outline = f'{phase} {epoch_loss:.4f} {epoch_acc:.4f} {phase}\n'
  log_file.write(outline)
  log_file.close()

  print('{} Loss: {:.4f} Acc: {:.4f}'.format(
      phase, epoch_loss, epoch_acc))
```

5 Model 1– CNN

[14]:
```
import torch.nn.functional as F

n_classes = 120

# define the CNN architecture
class Net(nn.Module):
    ### TODO: choose an architecture, and complete the class
    def __init__(self):
        super(Net, self).__init__()

        ## Define layers of a CNN
        # convolutional layer (sees 224x224x3 image tensor)
        self.conv1 = nn.Conv2d(3, 16, 3, padding = 1 )
        # convolutional layer (sees 112x112x16 image tensor)
        self.conv2 = nn.Conv2d(16, 32, 3, padding = 1)
        # convolutional layer (sees 56x56x32 image tensor)
        self.conv3 = nn.Conv2d(32, 64, 3, padding = 1)
        # convolutional layer (sees 28x28x64 image tensor)
        self.conv4 = nn.Conv2d(64, 128, 3, padding = 1)
        # convolutional layer (sees 14x14x128 image tensor)
        self.conv5 = nn.Conv2d(128, 256, 3, padding = 1 )

        # max pooling layer
        self.pool = nn.MaxPool2d(2, 2)
        # dropout layer (p=0.2)
        self.dropout = nn.Dropout(0.2)

        self.conv_bn1 = nn.BatchNorm2d(224,3)
        self.conv_bn2 = nn.BatchNorm2d(16)
        self.conv_bn3 = nn.BatchNorm2d(32)
        self.conv_bn4 = nn.BatchNorm2d(64)
        self.conv_bn5 = nn.BatchNorm2d(128)
        self.conv_bn6 = nn.BatchNorm2d(256)

        # linear layer (256 * 7 * 7 -> 512)
        self.fc1 = nn.Linear(256 * 7 * 7, 512)
        # linear layer (256 * 7 * 7 -> n_classes (133))
        self.fc2 = nn.Linear(512, n_classes)

    def forward(self, x):
        ## Define forward behavior
        # add sequence of convolutional and max pooling layers
        x = self.pool(F.relu(self.conv1(x)))
        x = self.conv_bn2(x)
        x = self.pool(F.relu(self.conv2(x)))
```

```
        x = self.conv_bn3(x)
        x = self.pool(F.relu(self.conv3(x)))
        x = self.conv_bn4(x)
        x = self.pool(F.relu(self.conv4(x)))
        x = self.conv_bn5(x)
        x = self.pool(F.relu(self.conv5(x)))
        x = self.conv_bn6(x)

        # flatten image input
        x = x.view(-1, 256 * 7 * 7)
        # add dropout layer
        x = self.dropout(x)
        # add second hidden layer
        x = F.relu(self.fc1(x))
        x = self.dropout(x)
        x = self.fc2(x)
        return x
```

[ ]:
```
cnn = Net()
cnn = cnn.to(device)
criterion = nn.CrossEntropyLoss().to(device)
optimizer_ft = optim.SGD(cnn.parameters(), lr=0.00001, momentum=0.9)

cnn_best = train_model(cnn, criterion, optimizer_ft,num_epochs=10,
                       log_file_name='cnn_60_0dot00001')

print('-' * 10)
evaluate_model(cnn_best, log_file_name='cnn_60_0dot00001')
```

```
Epoch 0/9
----------
train Loss: 0.6043 Acc: 0.0075
val Loss: 0.6044 Acc: 0.0067

Epoch 1/9
----------
train Loss: 0.6025 Acc: 0.0121
val Loss: 0.6017 Acc: 0.0067

Epoch 2/9
----------
train Loss: 0.6007 Acc: 0.0085
val Loss: 0.5995 Acc: 0.0075

Epoch 3/9
----------
train Loss: 0.5989 Acc: 0.0138
```

```
val Loss: 0.5979 Acc: 0.0117

Epoch 4/9
----------
train Loss: 0.5985 Acc: 0.0158
val Loss: 0.5959 Acc: 0.0100

Epoch 5/9
----------
train Loss: 0.5965 Acc: 0.0158
```

6 Model2: Resnet34

[0]:
```
resnet = models.resnet34(pretrained=True)
# for param in resnet.parameters():
#   param.requires_grad = False

num_ftrs = resnet.fc.in_features
resnet.fc = nn.Linear(num_ftrs, 120)

# lr = [0.001, 0.0001, 0.00001]
# log_file_name = ['resnet_40_0dot001', 'resnet_40_0dot0001',␣
 ↪'resnet_40_0dot00001']

resnet = resnet.to(device)
criterion = nn.CrossEntropyLoss().to(device)
optimizer_ft = optim.SGD(resnet.parameters(), lr=0.0001, momentum=0.9)

resnet_best = train_model(resnet, criterion, optimizer_ft,
              num_epochs=20, log_file_name='resnet_60_0dot0001')

print('-' * 10)
evaluate_model(resnet_best, log_file_name='resnet_60_0dot0001')
```

```
Downloading: "https://download.pytorch.org/models/resnet34-333f7ec4.pth" to
/root/.cache/torch/checkpoints/resnet34-333f7ec4.pth

HBox(children=(FloatProgress(value=0.0, max=87306240.0), HTML(value='')))


Epoch 0/19
----------
train Loss: 0.6009 Acc: 0.0204
val Loss: 0.5626 Acc: 0.0483

Epoch 1/19
```

```
----------
train Loss: 0.5658 Acc: 0.0577
val Loss: 0.4914 Acc: 0.1733

Epoch 2/19
----------
train Loss: 0.5294 Acc: 0.1250
val Loss: 0.4136 Acc: 0.3217

Epoch 3/19
----------
train Loss: 0.4920 Acc: 0.1854
val Loss: 0.3448 Acc: 0.4467

Epoch 4/19
----------
train Loss: 0.4589 Acc: 0.2331
val Loss: 0.2832 Acc: 0.5400

Epoch 5/19
----------
train Loss: 0.4325 Acc: 0.2827
val Loss: 0.2421 Acc: 0.5883

Epoch 6/19
----------
train Loss: 0.4102 Acc: 0.2981
val Loss: 0.2087 Acc: 0.6267

Epoch 7/19
----------
train Loss: 0.3923 Acc: 0.3346
val Loss: 0.1833 Acc: 0.6592

Epoch 8/19
----------
train Loss: 0.3733 Acc: 0.3533
val Loss: 0.1707 Acc: 0.6775

Epoch 9/19
----------
train Loss: 0.3593 Acc: 0.3744
val Loss: 0.1581 Acc: 0.6917

Epoch 10/19
----------
train Loss: 0.3501 Acc: 0.3858
val Loss: 0.1418 Acc: 0.7150
```

```
Epoch 11/19
----------
train Loss: 0.3396 Acc: 0.3996
val Loss: 0.1371 Acc: 0.7258

Epoch 12/19
----------
train Loss: 0.3318 Acc: 0.4123
val Loss: 0.1309 Acc: 0.7292

Epoch 13/19
----------
train Loss: 0.3233 Acc: 0.4173
val Loss: 0.1215 Acc: 0.7250

Epoch 14/19
----------
train Loss: 0.3138 Acc: 0.4383
val Loss: 0.1197 Acc: 0.7333

Epoch 15/19
----------
train Loss: 0.3106 Acc: 0.4294
val Loss: 0.1189 Acc: 0.7333

Epoch 16/19
----------
train Loss: 0.3037 Acc: 0.4438
val Loss: 0.1097 Acc: 0.7583

Epoch 17/19
----------
train Loss: 0.2946 Acc: 0.4590
val Loss: 0.1098 Acc: 0.7475

Epoch 18/19
----------
train Loss: 0.2959 Acc: 0.4471
val Loss: 0.1050 Acc: 0.7642

Epoch 19/19
----------
train Loss: 0.2889 Acc: 0.4646
val Loss: 0.1016 Acc: 0.7592

Training complete in 15m 31s
Best val Acc: 0.764167
```

```
----------
test Loss: 0.1053 Acc: 0.7333
```

[0]:
```
def cm(model):
  nb_classes = 120

  confusion_matrix = torch.zeros(nb_classes, nb_classes)
  with torch.no_grad():
    for i, (inputs, classes) in enumerate(dataloaders['test']):
      inputs = inputs.to(device)
      classes = classes.to(device)
      outputs = model(inputs)
      _, preds = torch.max(outputs, 1)
      for t, p in zip(classes.view(-1), preds.view(-1)):
        confusion_matrix[t.long(), p.long()] += 1

  return confusion_matrix

cm_resnet = cm(resnet_best)
cm_resnet
```

[0]:
```
tensor([[ 9.,  0.,  0.,  …,  0.,  0.,  0.],
        [ 0.,  7.,  0.,  …,  0.,  0.,  0.],
        [ 0.,  0., 10.,  …,  0.,  0.,  0.],
        …,
        [ 0.,  0.,  0.,  …, 10.,  0.,  0.],
        [ 0.,  0.,  0.,  …,  0., 10.,  0.],
        [ 0.,  0.,  0.,  …,  0.,  0., 10.]])
```

[0]:
```
cm_resnet.shape
```

[0]:
```
torch.Size([120, 120])
```

[0]:
```
my_class_names = [x.split('-')[1] for x in class_names]
my_class_names
```

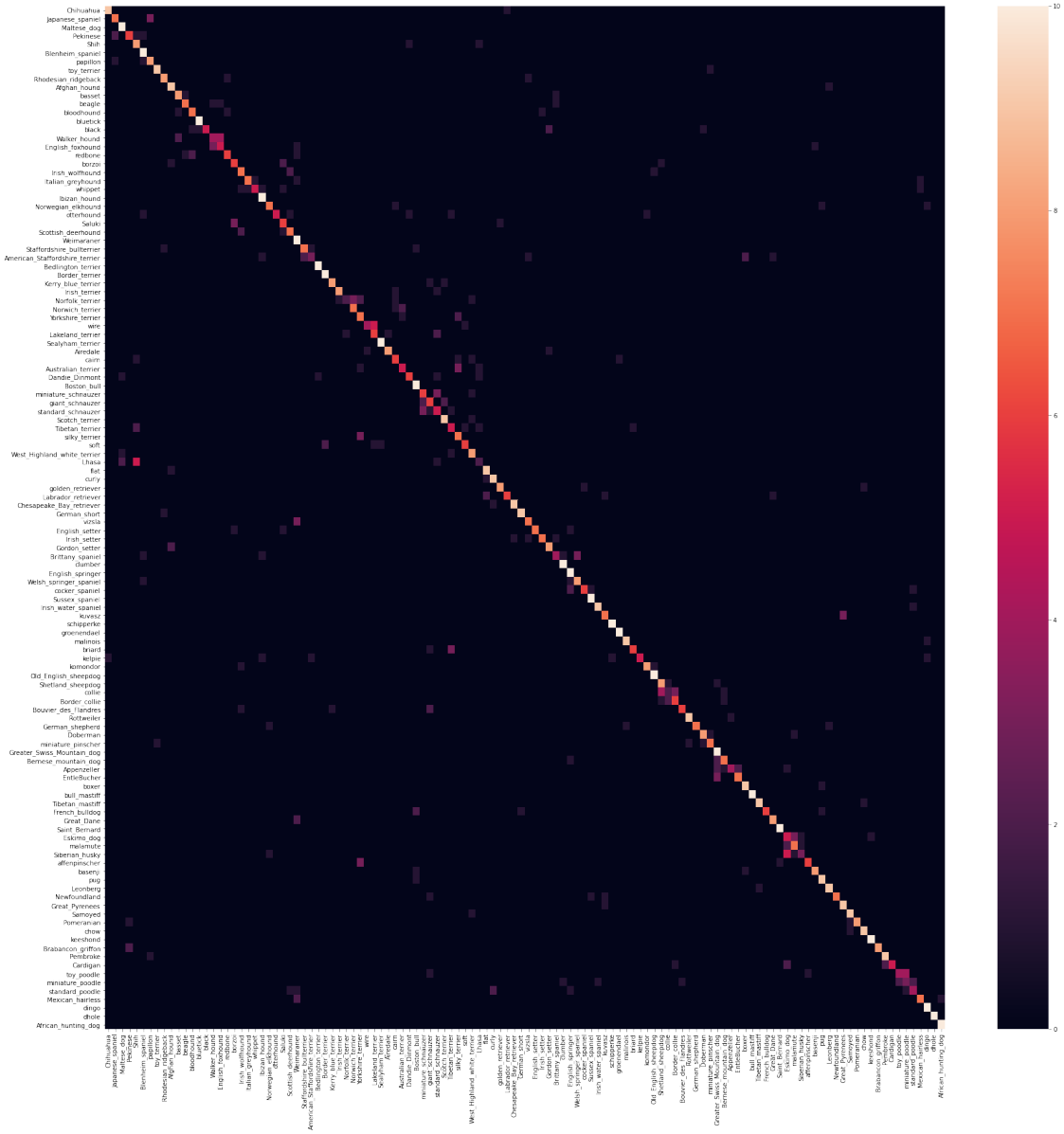
[0]:
```
['Chihuahua',
 'Japanese_spaniel',
 'Maltese_dog',
 'Pekinese',
 'Shih',
 'Blenheim_spaniel',
 'papillon',
 'toy_terrier',
 'Rhodesian_ridgeback',
 'Afghan_hound',
 'basset',
```

```
'beagle',
'bloodhound',
'bluetick',
'black',
'Walker_hound',
'English_foxhound',
'redbone',
'borzoi',
'Irish_wolfhound',
'Italian_greyhound',
'whippet',
'Ibizan_hound',
'Norwegian_elkhound',
'otterhound',
'Saluki',
'Scottish_deerhound',
'Weimaraner',
'Staffordshire_bullterrier',
'American_Staffordshire_terrier',
'Bedlington_terrier',
'Border_terrier',
'Kerry_blue_terrier',
'Irish_terrier',
'Norfolk_terrier',
'Norwich_terrier',
'Yorkshire_terrier',
'wire',
'Lakeland_terrier',
'Sealyham_terrier',
'Airedale',
'cairn',
'Australian_terrier',
'Dandie_Dinmont',
'Boston_bull',
'miniature_schnauzer',
'giant_schnauzer',
'standard_schnauzer',
'Scotch_terrier',
'Tibetan_terrier',
'silky_terrier',
'soft',
'West_Highland_white_terrier',
'Lhasa',
'flat',
'curly',
'golden_retriever',
'Labrador_retriever',
```

```
'Chesapeake_Bay_retriever',
'German_short',
'vizsla',
'English_setter',
'Irish_setter',
'Gordon_setter',
'Brittany_spaniel',
'clumber',
'English_springer',
'Welsh_springer_spaniel',
'cocker_spaniel',
'Sussex_spaniel',
'Irish_water_spaniel',
'kuvasz',
'schipperke',
'groenendael',
'malinois',
'briard',
'kelpie',
'komondor',
'Old_English_sheepdog',
'Shetland_sheepdog',
'collie',
'Border_collie',
'Bouvier_des_Flandres',
'Rottweiler',
'German_shepherd',
'Doberman',
'miniature_pinscher',
'Greater_Swiss_Mountain_dog',
'Bernese_mountain_dog',
'Appenzeller',
'EntleBucher',
'boxer',
'bull_mastiff',
'Tibetan_mastiff',
'French_bulldog',
'Great_Dane',
'Saint_Bernard',
'Eskimo_dog',
'malamute',
'Siberian_husky',
'affenpinscher',
'basenji',
'pug',
'Leonberg',
'Newfoundland',
```

```
'Great_Pyrenees',
'Samoyed',
'Pomeranian',
'chow',
'keeshond',
'Brabancon_griffon',
'Pembroke',
'Cardigan',
'toy_poodle',
'miniature_poodle',
'standard_poodle',
'Mexican_hairless',
'dingo',
'dhole',
'African_hunting_dog']
```

[0]:
```
import seaborn as sn
import pandas as pd
# cm_resnet = cm(resnet_best)
df_cm = pd.DataFrame(cm_resnet.numpy(), index = [i for i in my_class_names],
                     columns = [i for i in my_class_names])
plt.figure(figsize = (30,30))
sn.heatmap(df_cm)
plt.savefig('confusion_matrix')
```



7 Model3: VGG19

[0]:
```
vgg = models.vgg19(pretrained=True)

vgg.classifier[6] = nn.Linear(4096, 120)

# lr = [0.001, 0.0001, 0.00001]
# log_file_name = ['vgg_60_0dot001', 'vgg_60_0dot0001', 'vgg_60_0dot00001']
```

```
vgg = vgg.to(device)
criterion = nn.CrossEntropyLoss().to(device)
optimizer_ft = optim.SGD(vgg.parameters(), lr=0.0001, momentum=0.9)

vgg_best = train_model(vgg, criterion, optimizer_ft,
              num_epochs=20, log_file_name='vgg_20_0dot0001')

print('-' * 10)
evaluate_model(vgg_best, log_file_name='vgg_20_0dot0001')
```

```
Epoch 0/19
----------
train Loss: 0.5927 Acc: 0.0167
val Loss: 0.5408 Acc: 0.1333

Epoch 1/19
----------
train Loss: 0.5320 Acc: 0.0988
val Loss: 0.2870 Acc: 0.4417

Epoch 2/19
----------
train Loss: 0.4148 Acc: 0.2393
val Loss: 0.1736 Acc: 0.5778

Epoch 3/19
----------
train Loss: 0.3568 Acc: 0.3054
val Loss: 0.1428 Acc: 0.6500

Epoch 4/19
----------
train Loss: 0.3209 Acc: 0.3744
val Loss: 0.1286 Acc: 0.6833

Epoch 5/19
----------
train Loss: 0.3009 Acc: 0.3917
val Loss: 0.1225 Acc: 0.6917

Epoch 6/19
----------
train Loss: 0.2930 Acc: 0.4089
val Loss: 0.1141 Acc: 0.7056

Epoch 7/19
----------
```

```
train Loss: 0.2829 Acc: 0.4411
val Loss: 0.1129 Acc: 0.7111

Epoch 8/19
----------
train Loss: 0.2734 Acc: 0.4351
val Loss: 0.1039 Acc: 0.7389

Epoch 9/19
----------
train Loss: 0.2694 Acc: 0.4411
val Loss: 0.1073 Acc: 0.7222

Epoch 10/19
----------
train Loss: 0.2533 Acc: 0.4750
val Loss: 0.1084 Acc: 0.7278

Epoch 11/19
----------
train Loss: 0.2462 Acc: 0.4899
val Loss: 0.1098 Acc: 0.7306

Epoch 12/19
----------
train Loss: 0.2393 Acc: 0.5024
val Loss: 0.0995 Acc: 0.7472

Epoch 13/19
----------
train Loss: 0.2378 Acc: 0.5131
val Loss: 0.1129 Acc: 0.7139

Epoch 14/19
----------
train Loss: 0.2447 Acc: 0.4893
val Loss: 0.1138 Acc: 0.7222

Epoch 15/19
----------
train Loss: 0.2320 Acc: 0.5196
val Loss: 0.1019 Acc: 0.7417

Epoch 16/19
----------
train Loss: 0.2264 Acc: 0.5280
val Loss: 0.1097 Acc: 0.7333
```

```
Epoch 17/19
----------
train Loss: 0.2270 Acc: 0.5304
val Loss: 0.1069 Acc: 0.7389

Epoch 18/19
----------
train Loss: 0.2234 Acc: 0.5167
val Loss: 0.1131 Acc: 0.7139

Epoch 19/19
----------
train Loss: 0.2265 Acc: 0.5238
val Loss: 0.1054 Acc: 0.7500

Training complete in 16m 6s
Best val Acc: 0.750000
----------
test Loss: 0.1005 Acc: 0.7861
```

8 Model4: Inception V3

[0]:
```
mean_nums = [0.485, 0.456, 0.406]
std_nums = [0.229, 0.224, 0.225]

chosen_transforms = {'train': transforms.Compose([
        transforms.RandomResizedCrop(size=324),
        transforms.RandomRotation(degrees=15),
        transforms.RandomResizedCrop(299),
        transforms.RandomHorizontalFlip(),
        transforms.ToTensor(),
        transforms.Normalize(mean_nums, std_nums)
]), 'val': transforms.Compose([
        transforms.Resize(324),
        transforms.CenterCrop(299),
        transforms.ToTensor(),
        transforms.Normalize(mean_nums, std_nums)
]), 'test': transforms.Compose([
        transforms.Resize(324),
        transforms.CenterCrop(299),
        transforms.ToTensor(),
        transforms.Normalize(mean_nums, std_nums)
])
}

# Set the directory for the data
```

```
data_dir = 'images120_60_'

# Use the image folder function to create datasets
dog_datasets = {x: datasets.ImageFolder(data_dir+x+'/',
  chosen_transforms[x]) for x in ['train', 'val', 'test']}

dataloaders = {x: DataLoader(dataset=dog_datasets[x], batch_size=8,␣
 ↪shuffle=True, num_workers=4)
  for x in ['train','val','test']}

dataset_sizes = {x: len(dog_datasets[x]) for x in ['train','val','test']}
class_names = dog_datasets['train'].classes
print(dataset_sizes)
print(len(class_names))
```

```
{'train': 4800, 'val': 1200, 'test': 1200}
120
```

[0]:
```
LOG_DIR = 'log/'
def train_model_inception(model, criterion, optimizer, num_epochs=10,␣
 ↪log_file_name='log'):
    log_file = open(LOG_DIR + log_file_name, 'w')
    since = time.time()

    best_model_wts = copy.deepcopy(model.state_dict())
    best_acc = 0.0

    for epoch in range(num_epochs):
        print('Epoch {}/{}'.format(epoch, num_epochs - 1))
        print('-' * 10)

        # Each epoch has a training and validation phase
        for phase in ['train','val']:
            if phase == 'train':
                # scheduler.step()
                model.train()  # Set model to training mode
            else:
                model.eval()  # Set model to evaluate mode

            current_loss = 0.0
            current_corrects = 0

            # Here's where the training happens
            # print('Iterating through data...')

            for inputs, labels in dataloaders[phase]:
                inputs = inputs.to(device)
```

```
                labels = labels.to(device)

                # We need to zero the gradients, don't forget it
                optimizer.zero_grad()


                if phase == 'train':
                  outputs, aux_outputs = model(inputs)
                  loss1 = criterion(outputs, labels)
                  loss2 = criterion(aux_outputs, labels)
                  loss = loss1 + 0.4 * loss2
                else:
                  outputs = model(inputs)
                  loss = criterion(outputs, labels)

                _, preds = torch.max(outputs, 1)

                # backward + optimize only if in training phase
                if phase == 'train':
                  loss.backward()
                  optimizer.step()

                # We want variables to hold the loss statistics
                current_loss += loss.item()# * inputs.size(0)
                current_corrects += torch.sum(preds == labels.data)

            epoch_loss = current_loss / dataset_sizes[phase]
            epoch_acc = current_corrects.double() / dataset_sizes[phase]

            outline = f'{epoch} {epoch_loss:.4f} {epoch_acc:.4f} {phase}\n'
            log_file.write(outline)

            print('{} Loss: {:.4f} Acc: {:.4f}'.format(
                phase, epoch_loss, epoch_acc))

            # Make a copy of the model if the accuracy on the validation set␣
↪has improved
            if phase == 'val' and epoch_acc > best_acc:
                best_acc = epoch_acc
                best_model_wts = copy.deepcopy(model.state_dict())

        print()

    log_file.close()
    time_since = time.time() - since
    print('Training complete in {:.0f}m {:.0f}s'.format(
        time_since // 60, time_since % 60))
```

```
    print('Best val Acc: {:4f}'.format(best_acc))

    # Now we'll load in the best model weights and return it
    model.load_state_dict(best_model_wts)
    return model
```

[0]:
```
inception = models.inception_v3(pretrained=True)

inception.AuxLogits.fc = nn.Linear(768, 120)
inception.fc = nn.Linear(2048, 120)

# lr = [0.001, 0.0001, 0.00001]
# log_file_name = ['inception_60_0dot001', 'inception_60_0dot0001',␣
 ↪'inception_60_0dot00001']

inception = inception.to(device)
criterion = nn.CrossEntropyLoss().to(device)
optimizer_ft = optim.SGD(inception.parameters(), lr=0.0001, momentum=0.9)

inception_best = train_model_inception(inception, criterion, optimizer_ft,
              num_epochs=20, log_file_name='inception_60_0dot0001')

print('-' * 10)
evaluate_model(inception_best, log_file_name='inception_60_0dot0001')
```

```
Downloading:
"https://download.pytorch.org/models/inception_v3_google-1a9a5a14.pth" to
/root/.cache/torch/checkpoints/inception_v3_google-1a9a5a14.pth
```

```
HBox(children=(FloatProgress(value=0.0, max=108857766.0), HTML(value='')))
```

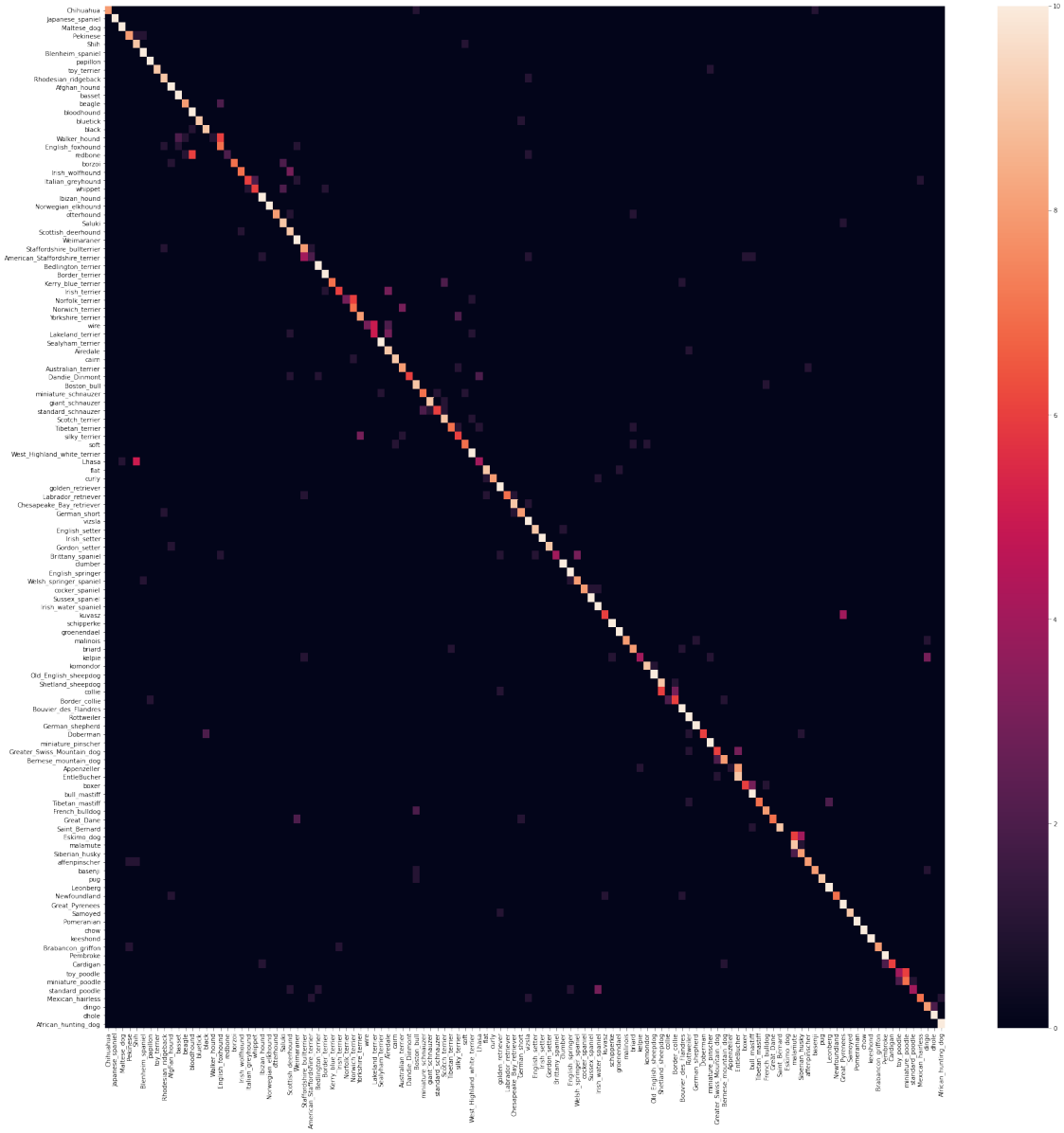
```
Epoch 0/19
----------
train Loss: 0.8416 Acc: 0.0123
val Loss: 0.5818 Acc: 0.0758

Epoch 1/19
----------
train Loss: 0.8212 Acc: 0.0283
val Loss: 0.5584 Acc: 0.2350

Epoch 2/19
----------
train Loss: 0.8009 Acc: 0.0683
val Loss: 0.5254 Acc: 0.4383
```

```
Epoch 3/19
----------
train Loss: 0.7730 Acc: 0.1233
val Loss: 0.4849 Acc: 0.5383

Epoch 4/19
----------
train Loss: 0.7474 Acc: 0.1715
val Loss: 0.4345 Acc: 0.6142

Epoch 5/19
----------
train Loss: 0.7174 Acc: 0.2110
val Loss: 0.3832 Acc: 0.6600

Epoch 6/19
----------
train Loss: 0.6923 Acc: 0.2290
val Loss: 0.3409 Acc: 0.6617

Epoch 7/19
----------
train Loss: 0.6648 Acc: 0.2667
val Loss: 0.2844 Acc: 0.7042

Epoch 8/19
----------
train Loss: 0.6409 Acc: 0.2742
val Loss: 0.2521 Acc: 0.7108

Epoch 9/19
----------
train Loss: 0.6159 Acc: 0.3050
val Loss: 0.2178 Acc: 0.7300

Epoch 10/19
----------
train Loss: 0.5935 Acc: 0.3238
val Loss: 0.1984 Acc: 0.7358

Epoch 11/19
----------
train Loss: 0.5728 Acc: 0.3465
val Loss: 0.1715 Acc: 0.7517

Epoch 12/19
----------
train Loss: 0.5541 Acc: 0.3575
```

```
val Loss: 0.1517 Acc: 0.7575

Epoch 13/19
----------
train Loss: 0.5366 Acc: 0.3665
val Loss: 0.1401 Acc: 0.7700

Epoch 14/19
----------
train Loss: 0.5252 Acc: 0.3744
val Loss: 0.1285 Acc: 0.7817

Epoch 15/19
----------
train Loss: 0.5170 Acc: 0.3804
val Loss: 0.1170 Acc: 0.7917

Epoch 16/19
----------
train Loss: 0.5012 Acc: 0.4052
val Loss: 0.1141 Acc: 0.7775

Epoch 17/19
----------
train Loss: 0.4929 Acc: 0.4021
val Loss: 0.0989 Acc: 0.8017

Epoch 18/19
----------
train Loss: 0.4802 Acc: 0.4142
val Loss: 0.0980 Acc: 0.7900

Epoch 19/19
----------
train Loss: 0.4763 Acc: 0.4102
val Loss: 0.0964 Acc: 0.7933

Training complete in 31m 30s
Best val Acc: 0.801667
----------
test Loss: 0.0990 Acc: 0.7867
```

[0]:
```
cm_inception = cm(inception_best)
df_cm = pd.DataFrame(cm_inception.numpy(), index = [i for i in my_class_names],
                     columns = [i for i in my_class_names])
plt.figure(figsize = (30,30))
sn.heatmap(df_cm)
```

```
plt.savefig('confusion_matrix_inception')
```



[0]:
```
torch.save(inception_best.state_dict(), 'inception_60')
```

[0]:
```
inception = models.inception_v3()

inception.AuxLogits.fc = nn.Linear(768, 120)
inception.fc = nn.Linear(2048, 120)

inception.load_state_dict(torch.load('inception_60'))
inception.eval()
```

```
[0]: Inception3(
       (Conv2d_1a_3x3): BasicConv2d(
         (conv): Conv2d(3, 32, kernel_size=(3, 3), stride=(2, 2), bias=False)
         (bn): BatchNorm2d(32, eps=0.001, momentum=0.1, affine=True,
     track_running_stats=True)
       )
       (Conv2d_2a_3x3): BasicConv2d(
         (conv): Conv2d(32, 32, kernel_size=(3, 3), stride=(1, 1), bias=False)
         (bn): BatchNorm2d(32, eps=0.001, momentum=0.1, affine=True,
     track_running_stats=True)
       )
       (Conv2d_2b_3x3): BasicConv2d(
         (conv): Conv2d(32, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
     bias=False)
         (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
     track_running_stats=True)
       )
       (Conv2d_3b_1x1): BasicConv2d(
         (conv): Conv2d(64, 80, kernel_size=(1, 1), stride=(1, 1), bias=False)
         (bn): BatchNorm2d(80, eps=0.001, momentum=0.1, affine=True,
     track_running_stats=True)
       )
       (Conv2d_4a_3x3): BasicConv2d(
         (conv): Conv2d(80, 192, kernel_size=(3, 3), stride=(1, 1), bias=False)
         (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
     track_running_stats=True)
       )
       (Mixed_5b): InceptionA(
         (branch1x1): BasicConv2d(
           (conv): Conv2d(192, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
           (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
     track_running_stats=True)
         )
         (branch5x5_1): BasicConv2d(
           (conv): Conv2d(192, 48, kernel_size=(1, 1), stride=(1, 1), bias=False)
           (bn): BatchNorm2d(48, eps=0.001, momentum=0.1, affine=True,
     track_running_stats=True)
         )
         (branch5x5_2): BasicConv2d(
           (conv): Conv2d(48, 64, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
     bias=False)
           (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
     track_running_stats=True)
         )
         (branch3x3dbl_1): BasicConv2d(
           (conv): Conv2d(192, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
           (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
```

```
track_running_stats=True)
    )
    (branch3x3dbl_2): BasicConv2d(
      (conv): Conv2d(64, 96, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
bias=False)
      (bn): BatchNorm2d(96, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_3): BasicConv2d(
      (conv): Conv2d(96, 96, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
bias=False)
      (bn): BatchNorm2d(96, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch_pool): BasicConv2d(
      (conv): Conv2d(192, 32, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(32, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_5c): InceptionA(
    (branch1x1): BasicConv2d(
      (conv): Conv2d(256, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch5x5_1): BasicConv2d(
      (conv): Conv2d(256, 48, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(48, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch5x5_2): BasicConv2d(
      (conv): Conv2d(48, 64, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_1): BasicConv2d(
      (conv): Conv2d(256, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_2): BasicConv2d(
      (conv): Conv2d(64, 96, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
bias=False)
      (bn): BatchNorm2d(96, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
```

```
    )
    (branch3x3dbl_3): BasicConv2d(
      (conv): Conv2d(96, 96, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
bias=False)
      (bn): BatchNorm2d(96, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch_pool): BasicConv2d(
      (conv): Conv2d(256, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_5d): InceptionA(
    (branch1x1): BasicConv2d(
      (conv): Conv2d(288, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch5x5_1): BasicConv2d(
      (conv): Conv2d(288, 48, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(48, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch5x5_2): BasicConv2d(
      (conv): Conv2d(48, 64, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2),
bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_1): BasicConv2d(
      (conv): Conv2d(288, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_2): BasicConv2d(
      (conv): Conv2d(64, 96, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
bias=False)
      (bn): BatchNorm2d(96, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_3): BasicConv2d(
      (conv): Conv2d(96, 96, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
bias=False)
      (bn): BatchNorm2d(96, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
```

```
    (branch_pool): BasicConv2d(
      (conv): Conv2d(288, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_6a): InceptionB(
    (branch3x3): BasicConv2d(
      (conv): Conv2d(288, 384, kernel_size=(3, 3), stride=(2, 2), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_1): BasicConv2d(
      (conv): Conv2d(288, 64, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(64, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_2): BasicConv2d(
      (conv): Conv2d(64, 96, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1),
bias=False)
      (bn): BatchNorm2d(96, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_3): BasicConv2d(
      (conv): Conv2d(96, 96, kernel_size=(3, 3), stride=(2, 2), bias=False)
      (bn): BatchNorm2d(96, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_6b): InceptionC(
    (branch1x1): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_1): BasicConv2d(
      (conv): Conv2d(768, 128, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(128, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_2): BasicConv2d(
      (conv): Conv2d(128, 128, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(128, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_3): BasicConv2d(
```

```
      (conv): Conv2d(128, 192, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_1): BasicConv2d(
      (conv): Conv2d(768, 128, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(128, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_2): BasicConv2d(
      (conv): Conv2d(128, 128, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(128, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_3): BasicConv2d(
      (conv): Conv2d(128, 128, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(128, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_4): BasicConv2d(
      (conv): Conv2d(128, 128, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(128, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_5): BasicConv2d(
      (conv): Conv2d(128, 192, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch_pool): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_6c): InceptionC(
    (branch1x1): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_1): BasicConv2d(
```

```
      (conv): Conv2d(768, 160, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_2): BasicConv2d(
      (conv): Conv2d(160, 160, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_3): BasicConv2d(
      (conv): Conv2d(160, 192, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_1): BasicConv2d(
      (conv): Conv2d(768, 160, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_2): BasicConv2d(
      (conv): Conv2d(160, 160, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_3): BasicConv2d(
      (conv): Conv2d(160, 160, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_4): BasicConv2d(
      (conv): Conv2d(160, 160, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_5): BasicConv2d(
      (conv): Conv2d(160, 192, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch_pool): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
```

```
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_6d): InceptionC(
    (branch1x1): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_1): BasicConv2d(
      (conv): Conv2d(768, 160, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_2): BasicConv2d(
      (conv): Conv2d(160, 160, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_3): BasicConv2d(
      (conv): Conv2d(160, 192, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_1): BasicConv2d(
      (conv): Conv2d(768, 160, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_2): BasicConv2d(
      (conv): Conv2d(160, 160, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_3): BasicConv2d(
      (conv): Conv2d(160, 160, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_4): BasicConv2d(
      (conv): Conv2d(160, 160, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
```

```
      (bn): BatchNorm2d(160, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_5): BasicConv2d(
      (conv): Conv2d(160, 192, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch_pool): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_6e): InceptionC(
    (branch1x1): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_1): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_2): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7_3): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_1): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_2): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
```

```
track_running_stats=True)
    )
    (branch7x7dbl_3): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_4): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7dbl_5): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch_pool): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (AuxLogits): InceptionAux(
    (conv0): BasicConv2d(
      (conv): Conv2d(768, 128, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(128, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (conv1): BasicConv2d(
      (conv): Conv2d(128, 768, kernel_size=(5, 5), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(768, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (fc): Linear(in_features=768, out_features=120, bias=True)
  )
  (Mixed_7a): InceptionD(
    (branch3x3_1): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3_2): BasicConv2d(
      (conv): Conv2d(192, 320, kernel_size=(3, 3), stride=(2, 2), bias=False)
```

```
      (bn): BatchNorm2d(320, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7x3_1): BasicConv2d(
      (conv): Conv2d(768, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7x3_2): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(1, 7), stride=(1, 1), padding=(0,
3), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7x3_3): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(7, 1), stride=(1, 1), padding=(3,
0), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch7x7x3_4): BasicConv2d(
      (conv): Conv2d(192, 192, kernel_size=(3, 3), stride=(2, 2), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_7b): InceptionE(
    (branch1x1): BasicConv2d(
      (conv): Conv2d(1280, 320, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(320, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3_1): BasicConv2d(
      (conv): Conv2d(1280, 384, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3_2a): BasicConv2d(
      (conv): Conv2d(384, 384, kernel_size=(1, 3), stride=(1, 1), padding=(0,
1), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3_2b): BasicConv2d(
      (conv): Conv2d(384, 384, kernel_size=(3, 1), stride=(1, 1), padding=(1,
0), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
```

```
track_running_stats=True)
    )
    (branch3x3dbl_1): BasicConv2d(
      (conv): Conv2d(1280, 448, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(448, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_2): BasicConv2d(
      (conv): Conv2d(448, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_3a): BasicConv2d(
      (conv): Conv2d(384, 384, kernel_size=(1, 3), stride=(1, 1), padding=(0,
1), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_3b): BasicConv2d(
      (conv): Conv2d(384, 384, kernel_size=(3, 1), stride=(1, 1), padding=(1,
0), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch_pool): BasicConv2d(
      (conv): Conv2d(1280, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (Mixed_7c): InceptionE(
    (branch1x1): BasicConv2d(
      (conv): Conv2d(2048, 320, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(320, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3_1): BasicConv2d(
      (conv): Conv2d(2048, 384, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3_2a): BasicConv2d(
      (conv): Conv2d(384, 384, kernel_size=(1, 3), stride=(1, 1), padding=(0,
1), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
```

```
    )
    (branch3x3_2b): BasicConv2d(
      (conv): Conv2d(384, 384, kernel_size=(3, 1), stride=(1, 1), padding=(1,
0), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_1): BasicConv2d(
      (conv): Conv2d(2048, 448, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(448, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_2): BasicConv2d(
      (conv): Conv2d(448, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_3a): BasicConv2d(
      (conv): Conv2d(384, 384, kernel_size=(1, 3), stride=(1, 1), padding=(0,
1), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch3x3dbl_3b): BasicConv2d(
      (conv): Conv2d(384, 384, kernel_size=(3, 1), stride=(1, 1), padding=(1,
0), bias=False)
      (bn): BatchNorm2d(384, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
    (branch_pool): BasicConv2d(
      (conv): Conv2d(2048, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
      (bn): BatchNorm2d(192, eps=0.001, momentum=0.1, affine=True,
track_running_stats=True)
    )
  )
  (fc): Linear(in_features=2048, out_features=120, bias=True)
)
```

9 Finally showing some test image results

[0]:
```
from PIL import Image
from torch.autograd import Variable
imsize = 299
loader = transforms.Compose([transforms.Resize(imsize), transforms.ToTensor()])
```

```
def image_loader(image_name):
    """load image, returns cuda tensor"""
    image = Image.open(image_name)
    image = loader(image).float()
    image = Variable(image, requires_grad=True)
    image = image.unsqueeze(0)  #this is for VGG, may not be needed for ResNet
    return image.cuda()  #assumes that you're using GPU

# image = image_loader('/content/images120_60_test/n02086240-Shih-Tzu/
 ↪n02086240_1725.jpg')
# image = image_loader('/content/german_shepherd.jpg')

# outputs = inception_best(image)
# _, pred = torch.max(outputs, 1)
# print(my_class_names[pred])
```

[0]:
```
# show image
image_name = '/content/beagle.jpg'
plt.figure(figsize=(5,10))
plt.imshow(Image.open(image_name))
plt.axis('off')
plt.show()

# prediction
image = image_loader(image_name)
outputs = inception_best(image)
_, pred = torch.max(outputs, 1)
print('Predict as --- ', my_class_names[pred])
```


```
Predict as ---  beagle
```

[0]:
```
# show image
image_name = '/content/german_shepherd.jpg'
plt.figure(figsize=(5,10))
plt.imshow(Image.open(image_name))
plt.axis('off')
plt.show()

# prediction
image = image_loader(image_name)
outputs = inception_best(image)
_, pred = torch.max(outputs, 1)
print('Predict as --- ', my_class_names[pred])
```


```
Predict as ---  German_shepherd
```

[0]:
```
# show image
image_name = '/content/gsmd.jpg'
plt.figure(figsize=(5,10))
plt.imshow(Image.open(image_name))
plt.axis('off')
plt.show()

# prediction
```

```
image = image_loader(image_name)
outputs = inception_best(image)
_, pred = torch.max(outputs, 1)
print('Predict as --- ', my_class_names[pred])
```

```
Predict as ---  Greater_Swiss_Mountain_dog
```

[0]:
```
class_names
```

[0]:
```
['n02085620-Chihuahua',
 'n02085782-Japanese_spaniel',
 'n02085936-Maltese_dog',
 'n02086079-Pekinese',
 'n02086240-Shih-Tzu',
 'n02086646-Blenheim_spaniel',
 'n02086910-papillon',
 'n02087046-toy_terrier',
 'n02087394-Rhodesian_ridgeback',
 'n02088094-Afghan_hound',
 'n02088238-basset',
 'n02088364-beagle',
 'n02088466-bloodhound',
 'n02088632-bluetick',
 'n02089078-black-and-tan_coonhound',
 'n02089867-Walker_hound',
 'n02089973-English_foxhound',
 'n02090379-redbone',
 'n02090622-borzoi',
 'n02090721-Irish_wolfhound',
```

```
'n02091032-Italian_greyhound',
'n02091134-whippet',
'n02091244-Ibizan_hound',
'n02091467-Norwegian_elkhound',
'n02091635-otterhound',
'n02091831-Saluki',
'n02092002-Scottish_deerhound',
'n02092339-Weimaraner',
'n02093256-Staffordshire_bullterrier',
'n02093428-American_Staffordshire_terrier',
'n02093647-Bedlington_terrier',
'n02093754-Border_terrier',
'n02093859-Kerry_blue_terrier',
'n02093991-Irish_terrier',
'n02094114-Norfolk_terrier',
'n02094258-Norwich_terrier',
'n02094433-Yorkshire_terrier',
'n02095314-wire-haired_fox_terrier',
'n02095570-Lakeland_terrier',
'n02095889-Sealyham_terrier',
'n02096051-Airedale',
'n02096177-cairn',
'n02096294-Australian_terrier',
'n02096437-Dandie_Dinmont',
'n02096585-Boston_bull',
'n02097047-miniature_schnauzer',
'n02097130-giant_schnauzer',
'n02097209-standard_schnauzer',
'n02097298-Scotch_terrier',
'n02097474-Tibetan_terrier',
'n02097658-silky_terrier',
'n02098105-soft-coated_wheaten_terrier',
'n02098286-West_Highland_white_terrier',
'n02098413-Lhasa',
'n02099267-flat-coated_retriever',
'n02099429-curly-coated_retriever',
'n02099601-golden_retriever',
'n02099712-Labrador_retriever',
'n02099849-Chesapeake_Bay_retriever',
'n02100236-German_short-haired_pointer',
'n02100583-vizsla',
'n02100735-English_setter',
'n02100877-Irish_setter',
'n02101006-Gordon_setter',
'n02101388-Brittany_spaniel',
'n02101556-clumber',
'n02102040-English_springer',
```

```
'n02102177-Welsh_springer_spaniel',
'n02102318-cocker_spaniel',
'n02102480-Sussex_spaniel',
'n02102973-Irish_water_spaniel',
'n02104029-kuvasz',
'n02104365-schipperke',
'n02105056-groenendael',
'n02105162-malinois',
'n02105251-briard',
'n02105412-kelpie',
'n02105505-komondor',
'n02105641-Old_English_sheepdog',
'n02105855-Shetland_sheepdog',
'n02106030-collie',
'n02106166-Border_collie',
'n02106382-Bouvier_des_Flandres',
'n02106550-Rottweiler',
'n02106662-German_shepherd',
'n02107142-Doberman',
'n02107312-miniature_pinscher',
'n02107574-Greater_Swiss_Mountain_dog',
'n02107683-Bernese_mountain_dog',
'n02107908-Appenzeller',
'n02108000-EntleBucher',
'n02108089-boxer',
'n02108422-bull_mastiff',
'n02108551-Tibetan_mastiff',
'n02108915-French_bulldog',
'n02109047-Great_Dane',
'n02109525-Saint_Bernard',
'n02109961-Eskimo_dog',
'n02110063-malamute',
'n02110185-Siberian_husky',
'n02110627-affenpinscher',
'n02110806-basenji',
'n02110958-pug',
'n02111129-Leonberg',
'n02111277-Newfoundland',
'n02111500-Great_Pyrenees',
'n02111889-Samoyed',
'n02112018-Pomeranian',
'n02112137-chow',
'n02112350-keeshond',
'n02112706-Brabancon_griffon',
'n02113023-Pembroke',
'n02113186-Cardigan',
'n02113624-toy_poodle',
```

```
 'n02113712-miniature_poodle',
 'n02113799-standard_poodle',
 'n02113978-Mexican_hairless',
 'n02115641-dingo',
 'n02115913-dhole',
 'n02116738-African_hunting_dog']
```

[0]:
```
with open('log/inception_60_0dot0001', 'r') as inFile:
  for line in inFile.readlines():
    print(line.split(' '))
```

```
['0', '0.8416', '0.0123', 'train\n']
['0', '0.5818', '0.0758', 'val\n']
['1', '0.8212', '0.0283', 'train\n']
['1', '0.5584', '0.2350', 'val\n']
['2', '0.8009', '0.0683', 'train\n']
['2', '0.5254', '0.4383', 'val\n']
['3', '0.7730', '0.1233', 'train\n']
['3', '0.4849', '0.5383', 'val\n']
['4', '0.7474', '0.1715', 'train\n']
['4', '0.4345', '0.6142', 'val\n']
['5', '0.7174', '0.2110', 'train\n']
['5', '0.3832', '0.6600', 'val\n']
['6', '0.6923', '0.2290', 'train\n']
['6', '0.3409', '0.6617', 'val\n']
['7', '0.6648', '0.2667', 'train\n']
['7', '0.2844', '0.7042', 'val\n']
['8', '0.6409', '0.2742', 'train\n']
['8', '0.2521', '0.7108', 'val\n']
['9', '0.6159', '0.3050', 'train\n']
['9', '0.2178', '0.7300', 'val\n']
['10', '0.5935', '0.3238', 'train\n']
['10', '0.1984', '0.7358', 'val\n']
['11', '0.5728', '0.3465', 'train\n']
['11', '0.1715', '0.7517', 'val\n']
['12', '0.5541', '0.3575', 'train\n']
['12', '0.1517', '0.7575', 'val\n']
['13', '0.5366', '0.3665', 'train\n']
['13', '0.1401', '0.7700', 'val\n']
['14', '0.5252', '0.3744', 'train\n']
['14', '0.1285', '0.7817', 'val\n']
['15', '0.5170', '0.3804', 'train\n']
['15', '0.1170', '0.7917', 'val\n']
['16', '0.5012', '0.4052', 'train\n']
['16', '0.1141', '0.7775', 'val\n']
['17', '0.4929', '0.4021', 'train\n']
['17', '0.0989', '0.8017', 'val\n']
```

```
['18', '0.4802', '0.4142', 'train\n']
['18', '0.0980', '0.7900', 'val\n']
['19', '0.4763', '0.4102', 'train\n']
['19', '0.0964', '0.7933', 'val\n']
['test', '0.0990', '0.7867', 'test\n']
```

[0]:
```
!zip -r log2.zip log
```

```
  adding: log/ (stored 0%)
  adding: log/resnet_40_0dot0001 (deflated 61%)
  adding: log/resnet_20_0dot001 (deflated 61%)
  adding: log/resnet_20_0dot0001 (deflated 61%)
  adding: log/.ipynb_checkpoints/ (stored 0%)
  adding: log/resnet_40_0dot001 (deflated 61%)
  adding: log/vgg_40_0dot0001 (deflated 62%)
  adding: log/inception_40_0dot0001 (deflated 60%)
  adding: log/vgg_20_0dot0001 (deflated 61%)
  adding: log/inception_20_0dot0001 (deflated 60%)
```

[0]:
```

```