galaxy-classifier-Inceptionv3

February 11, 2021

0.0.1 Classification of Galaxies Based on their Morphology using Transfer Learning

[4]:
```
#Importing libraries
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import os, random, shutil
import tensorflow as tf
import seaborn
```

[59]:
```
# paths to the archives
base_path = r'../input/galaxy-zoo-the-galaxy-challenge/'
training_solutions = os.path.join(base_path, 'training_solutions_rev1.zip')
training_images    = os.path.join(base_path, 'images_training_rev1.zip')
```

[60]:
```
df = pd.read_csv(training_solutions, compression="zip")
cols = df.columns
new = list(map(lambda s: s.replace('Class','Q'), cols))
df.columns = new
df.head()
```

[60]:

	GalaxyID	Q1.1	Q1.2	Q1.3	Q2.1	Q2.2	Q3.1	Q3.2	Q4.1	Q4.2	…	Q9.3	Q10.1	Q10.2	Q10.3	Q11.1	Q11.2	Q11.3	Q11.4	Q11.5	Q11.6
0	100008	0.383147	0.616853	0.000000	0.000000	0.616853	0.038452	0.578401	0.418398	0.198455	…	0.000000	0.279952	0.138445	0.000000	0.000000	0.092886	0.0	0.0	0.0	0.325512
1	100023	0.327001	0.663777	0.009222	0.031178	0.632599	0.467370	0.165229	0.591328	0.041271	…	0.018764	0.000000	0.131378	0.459950						
2	100053	0.765717	0.177352	0.056931	0.000000	0.177352	0.000000	0.177352	0.000000	0.177352	…	0.000000	0.000000	0.000000	0.000000						
3	100078	0.693377	0.238564	0.068059	0.000000	0.238564	0.109493	0.129071	0.189098	0.049466	…	0.000000	0.094549	0.000000	0.094549						
4	100090	0.933839	0.000000	0.066161	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	…	0.000000	0.000000	0.000000	0.000000						

```
1  0.000000  0.591328    0.0    0.0    0.0  0.000000
2  0.000000  0.000000    0.0    0.0    0.0  0.000000
3  0.189098  0.000000    0.0    0.0    0.0  0.000000
4  0.000000  0.000000    0.0    0.0    0.0  0.000000

[5 rows x 38 columns]
```

0.0.2 Class Segregation

The columns from the above dataset signifies the actual classes, considering both computations and my novice knowledge, I'm restricting the classes to three types which are root categories anyway

[91]:
```
ellipticals = df[(df['Q1.1']>0.7) & (df['Q7.1']>0.4)]['GalaxyID'].tolist()
lenticulars = df[(df['Q1.1']>0.7) & (df['Q7.2']>0.4)]['GalaxyID'].tolist()
spirals = df[(df['Q1.2']>0.7) & (df['Q2.1']>0.4)]['GalaxyID'].tolist()

print('Total number of elliptical examples: ',  len(ellipticals))
print('Total number of lenticular examples: ',  len(lenticulars))
print('Total number of spiral examples: ',  len(spirals))
```

```
Total number of elliptical examples:  7311
Total number of lenticular examples:  6625
Total number of spiral examples:  4635
```

Taking only 500 random samples from each category

[92]:
```
def return500(category):
    category = np.array(category)
    rn_500 = sorted(list(np.random.randint(1,4500,500)))
    return list(category[rn_500])

ellipticals = return500(ellipticals)
lenticulars = return500(lenticulars)
spirals = return500(spirals)
```

[93]:
```
len(spirals)
```

[93]:
```
500
```

0.0.3 Test and Validation Splits

[98]:
```
# This subroutine is lifted from a kaggle notebook
def _proc_images(src, dst, label, arr, percent):
    train_dir = os.path.join(dst, 'train')
    val_dir = os.path.join(dst, 'validation')
```

```
    train_dest = os.path.join(train_dir, label)
    val_dest   = os.path.join(val_dir, label)

    if not os.path.exists(train_dest):
        os.makedirs(train_dest)

    if not os.path.exists(val_dest):
        os.makedirs(val_dest)

    random.shuffle(arr)

    idx = int(len(arr)*percent)
    for i in arr[0:idx]:
        shutil.copyfile(os.path.join(src, str(i)+'.jpg'), os.path.
 ↪join(train_dest, str(i)+'.jpg'))
    for i in arr[idx:]:
        shutil.copyfile(os.path.join(src, str(i)+'.jpg'), os.path.
 ↪join(val_dest, str(i)+'.jpg'))

    print(label, 'done!')
```

[99]:
```
training_solutions = os.path.join(base_path, 'training_solutions_rev1')
training_images    = os.path.join(base_path, 'images_training_rev1')
```

[100]:
```
my_data = '/Users/Shared/Relocated/Security/Codes/Deep_Learning/input/
 ↪galaxy-zoo-clean/data'
```

[101]:
```
_proc_images(training_images, '../input/galaxy-zoo-clean/data/', 'elliptical',␣
 ↪ellipticals, 0.90)
_proc_images(training_images,'../input/galaxy-zoo-clean/data/', 'lenticular',␣
 ↪lenticulars, 0.90)
_proc_images(training_images, '../input/galaxy-zoo-clean/data/', 'spiral',␣
 ↪spirals, 0.90)


print('Elliptical:', len(os.listdir(os.path.join(my_data, 'train',␣
 ↪'elliptical'))))
print('Total train lenticular:', len(os.listdir(os.path.join(my_data, 'train',␣
 ↪'lenticular'))))
print('Total train spiral:', len(os.listdir(os.path.join(my_data, 'train',␣
 ↪'spiral'))))


print('Total validation elliptical:', len(os.listdir(os.path.join(my_data,␣
 ↪'validation', 'elliptical'))))
```

```
print('Total validation lenticular:', len(os.listdir(os.path.join(my_data,␣
↪'validation', 'lenticular'))))
print('Total validation spiral:', len(os.listdir(os.path.join(my_data,␣
↪'validation', 'spiral'))))
```

```
elliptical done!
lenticular done!
spiral done!
Elliptical: 425
Total train lenticular: 431
Total train spiral: 433
Total validation elliptical: 49
Total validation lenticular: 50
Total validation spiral: 50
```

[5]:
```
train_dir = '../input/galaxy-zoo-clean/data/train'
validation_dir = '../input/galaxy-zoo-clean/data/validation'
```

[30]:
```
total_train = 0
for c in ['elliptical', 'lenticular', 'spiral']:
  total_train += len(os.listdir(os.path.join(train_dir, c)))
print('Total train:', total_train)

total_validation = 0
for c in ['elliptical', 'lenticular', 'spiral']:
  total_validation += len(os.listdir(os.path.join(validation_dir, c)))
print('Total validation:', total_validation)
```

```
Total train: 1289
Total validation: 149
```

0.0.4 Data Overview

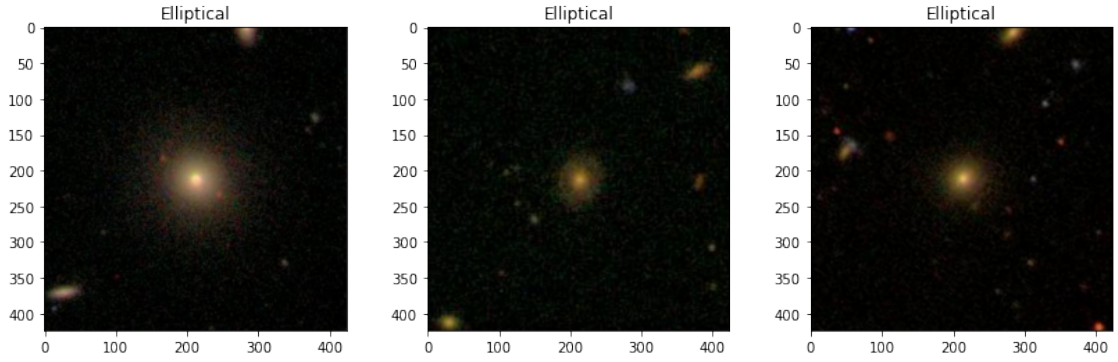
[31]:
```
from PIL import Image
import random
def return_imgarr(train_dir,label):
    img_arr = []
    paths = os.listdir(os.path.join(train_dir,label))

    for num, file in enumerate(random.choices(paths,k=3)):
        pic = Image.open(os.path.join(train_dir,label,file))
        img_arr.append(np.array(pic))

    return img_arr
```

[32]:
```
elliptical_arr = return_imgarr(train_dir,label='elliptical')
lenticular_arr = return_imgarr(train_dir, label='lenticular')
```

```
spiral_arr = return_imgarr(train_dir, label='spiral')
```

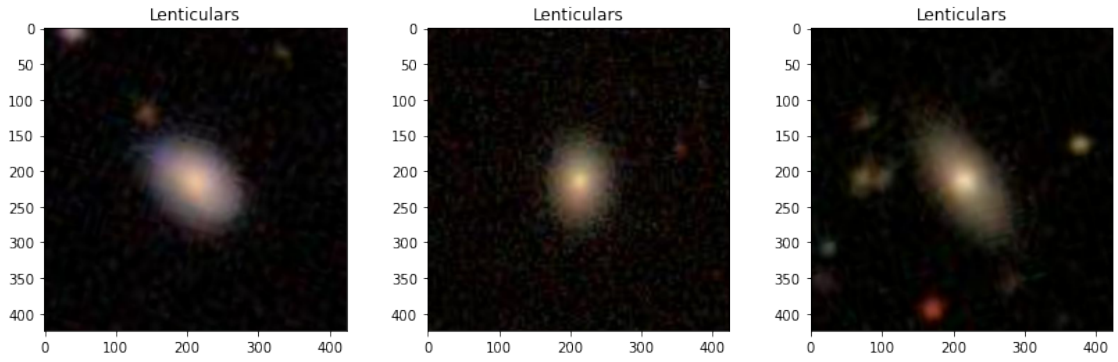
0.0.5 *Three Random Samples of Elliptical Galaxies*

[33]:
```
fig,ax = plt.subplots(1,3,figsize=(14,4))

for i, ax in enumerate(ax.ravel()):
    ax.set_title("Elliptical".format(i))
    ax.imshow(elliptical_arr[i])
```



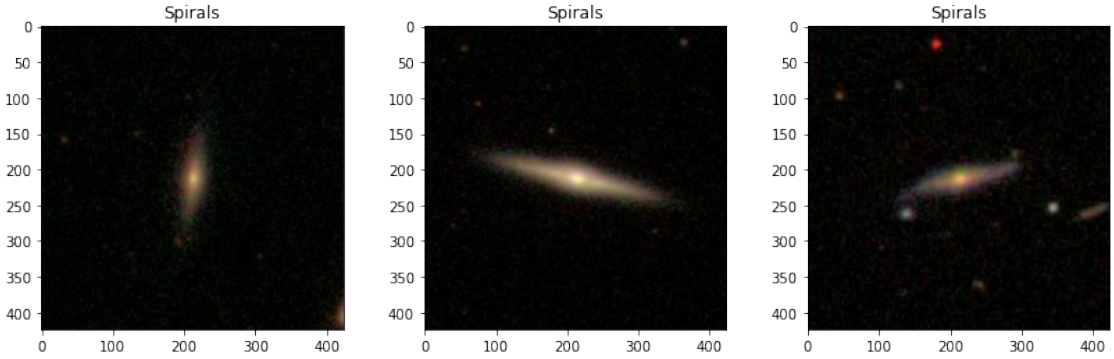
0.0.6 *Three Random Samples of Leticular Galaxies*

[34]:
```
fig,ax = plt.subplots(1,3,figsize=(14,4))

for i, ax in enumerate(ax.ravel()):
    ax.set_title("Lenticulars".format(i))
    ax.imshow(lenticular_arr[i])
```



0.0.7 *Three Random Samples of Spiral Galaxies*

[35]:
```
fig,ax = plt.subplots(1,3,figsize=(14,4))

for i, ax in enumerate(ax.ravel()):
    ax.set_title("Spirals".format(i))
    ax.imshow(spiral_arr[i])
```



0.0.8 Image Generators

[7]:
```
BS = 64 # batch_size
train_datagen = tf.keras.preprocessing.image.ImageDataGenerator(
                    rescale=1.0/255,
                    rotation_range=25,
                    width_shift_range=.15,
                    height_shift_range=.15,
                    horizontal_flip=True,
                    zoom_range=0.2)
validation_datagen  = tf.keras.preprocessing.image.ImageDataGenerator(rescale=1.
 ↪0/255.)

train_generator = train_datagen.flow_from_directory(train_dir,
                                                    target_size=(180,180),
                                                    batch_size=BS,
                                                    shuffle=True,
                                                    class_mode='categorical')
validation_generator = train_datagen.flow_from_directory(validation_dir,
                                                         target_size=(180,180),
                                                         batch_size=BS,
                                                         shuffle=True,
                                                         ␣
 ↪class_mode='categorical')
```

```
Found 1289 images belonging to 3 classes.
```

```
Found 149 images belonging to 3 classes.
```

[8]:
```
# Required Layer artefacts
from tensorflow.keras.applications import ResNet50
from tensorflow.keras.callbacks import EarlyStopping
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import␣
↪Flatten,Dense,BatchNormalization,Activation,Dropout
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.models import Model
```

[9]:
```
train_generator.image_shape
```

[9]:
```
(180, 180, 3)
```

[83]:
```
from tensorflow.keras.applications import InceptionV3
```

[109]:
```
inception = InceptionV3(include_top=False, weights='imagenet',␣
↪input_shape=train_generator.image_shape)
```

[110]:
```
# Freezing the Weights
for layer in inception.layers:
    layer.trainable = False
```

[111]:
```
inception.summary()
```

```
Model: "inception_v3"
__________________________________________________________________________________
__________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================
==================
input_6 (InputLayer)            [(None, 180, 180, 3) 0
__________________________________________________________________________________
__________________
conv2d_282 (Conv2D)             (None, 89, 89, 32)   864         input_6[0][0]
__________________________________________________________________________________
__________________
batch_normalization_282 (BatchN (None, 89, 89, 32)   96
conv2d_282[0][0]
__________________________________________________________________________________
__________________
activation_282 (Activation)     (None, 89, 89, 32)   0
batch_normalization_282[0][0]
__________________________________________________________________________________
__________________
conv2d_283 (Conv2D)             (None, 87, 87, 32)   9216
activation_282[0][0]
```

```
____________________________________________________________________________
__________________
batch_normalization_283 (BatchN (None, 87, 87, 32)   96
conv2d_283[0][0]
____________________________________________________________________________
__________________
activation_283 (Activation)     (None, 87, 87, 32)   0
batch_normalization_283[0][0]
____________________________________________________________________________
__________________
conv2d_284 (Conv2D)             (None, 87, 87, 64)   18432
activation_283[0][0]
____________________________________________________________________________
__________________
batch_normalization_284 (BatchN (None, 87, 87, 64)   192
conv2d_284[0][0]
____________________________________________________________________________
__________________
activation_284 (Activation)     (None, 87, 87, 64)   0
batch_normalization_284[0][0]
____________________________________________________________________________
__________________
max_pooling2d_12 (MaxPooling2D) (None, 43, 43, 64)   0
activation_284[0][0]
____________________________________________________________________________
__________________
conv2d_285 (Conv2D)             (None, 43, 43, 80)   5120
max_pooling2d_12[0][0]
____________________________________________________________________________
__________________
batch_normalization_285 (BatchN (None, 43, 43, 80)   240
conv2d_285[0][0]
____________________________________________________________________________
__________________
activation_285 (Activation)     (None, 43, 43, 80)   0
batch_normalization_285[0][0]
____________________________________________________________________________
__________________
conv2d_286 (Conv2D)             (None, 41, 41, 192)  138240
activation_285[0][0]
____________________________________________________________________________
__________________
batch_normalization_286 (BatchN (None, 41, 41, 192)  576
conv2d_286[0][0]
____________________________________________________________________________
__________________
activation_286 (Activation)     (None, 41, 41, 192)  0
batch_normalization_286[0][0]
```

```
____________________________________________________________________________
__________________
max_pooling2d_13 (MaxPooling2D) (None, 20, 20, 192)  0
activation_286[0][0]
____________________________________________________________________________
__________________
conv2d_290 (Conv2D)             (None, 20, 20, 64)   12288
max_pooling2d_13[0][0]
____________________________________________________________________________
__________________
batch_normalization_290 (BatchN (None, 20, 20, 64)   192
conv2d_290[0][0]
____________________________________________________________________________
__________________
activation_290 (Activation)     (None, 20, 20, 64)   0
batch_normalization_290[0][0]
____________________________________________________________________________
__________________
conv2d_288 (Conv2D)             (None, 20, 20, 48)   9216
max_pooling2d_13[0][0]
____________________________________________________________________________
__________________
conv2d_291 (Conv2D)             (None, 20, 20, 96)   55296
activation_290[0][0]
____________________________________________________________________________
__________________
batch_normalization_288 (BatchN (None, 20, 20, 48)   144
conv2d_288[0][0]
____________________________________________________________________________
__________________
batch_normalization_291 (BatchN (None, 20, 20, 96)   288
conv2d_291[0][0]
____________________________________________________________________________
__________________
activation_288 (Activation)     (None, 20, 20, 48)   0
batch_normalization_288[0][0]
____________________________________________________________________________
__________________
activation_291 (Activation)     (None, 20, 20, 96)   0
batch_normalization_291[0][0]
____________________________________________________________________________
__________________
average_pooling2d_27 (AveragePo (None, 20, 20, 192)  0
max_pooling2d_13[0][0]
____________________________________________________________________________
__________________
conv2d_287 (Conv2D)             (None, 20, 20, 64)   12288
max_pooling2d_13[0][0]
```

```
__________________________________________________________________________________
__________________
conv2d_289 (Conv2D)             (None, 20, 20, 64)   76800
activation_288[0][0]
__________________________________________________________________________________
__________________
conv2d_292 (Conv2D)             (None, 20, 20, 96)   82944
activation_291[0][0]
__________________________________________________________________________________
__________________
conv2d_293 (Conv2D)             (None, 20, 20, 32)   6144
average_pooling2d_27[0][0]
__________________________________________________________________________________
__________________
batch_normalization_287 (BatchN (None, 20, 20, 64)   192
conv2d_287[0][0]
__________________________________________________________________________________
__________________
batch_normalization_289 (BatchN (None, 20, 20, 64)   192
conv2d_289[0][0]
__________________________________________________________________________________
__________________
batch_normalization_292 (BatchN (None, 20, 20, 96)   288
conv2d_292[0][0]
__________________________________________________________________________________
__________________
batch_normalization_293 (BatchN (None, 20, 20, 32)   96
conv2d_293[0][0]
__________________________________________________________________________________
__________________
activation_287 (Activation)     (None, 20, 20, 64)   0
batch_normalization_287[0][0]
__________________________________________________________________________________
__________________
activation_289 (Activation)     (None, 20, 20, 64)   0
batch_normalization_289[0][0]
__________________________________________________________________________________
__________________
activation_292 (Activation)     (None, 20, 20, 96)   0
batch_normalization_292[0][0]
__________________________________________________________________________________
__________________
activation_293 (Activation)     (None, 20, 20, 32)   0
batch_normalization_293[0][0]
__________________________________________________________________________________
__________________
mixed0 (Concatenate)            (None, 20, 20, 256)  0
activation_287[0][0]
```

```
activation_289[0][0]
activation_292[0][0]
activation_293[0][0]
__________________________________________________________________________________
__________________
conv2d_297 (Conv2D)             (None, 20, 20, 64)   16384       mixed0[0][0]
__________________________________________________________________________________
__________________
batch_normalization_297 (BatchN (None, 20, 20, 64)   192
conv2d_297[0][0]
__________________________________________________________________________________
__________________
activation_297 (Activation)     (None, 20, 20, 64)   0
batch_normalization_297[0][0]
__________________________________________________________________________________
__________________
conv2d_295 (Conv2D)             (None, 20, 20, 48)   12288       mixed0[0][0]
__________________________________________________________________________________
__________________
conv2d_298 (Conv2D)             (None, 20, 20, 96)   55296
activation_297[0][0]
__________________________________________________________________________________
__________________
batch_normalization_295 (BatchN (None, 20, 20, 48)   144
conv2d_295[0][0]
__________________________________________________________________________________
__________________
batch_normalization_298 (BatchN (None, 20, 20, 96)   288
conv2d_298[0][0]
__________________________________________________________________________________
__________________
activation_295 (Activation)     (None, 20, 20, 48)   0
batch_normalization_295[0][0]
__________________________________________________________________________________
__________________
activation_298 (Activation)     (None, 20, 20, 96)   0
batch_normalization_298[0][0]
__________________________________________________________________________________
__________________
average_pooling2d_28 (AveragePo (None, 20, 20, 256)  0           mixed0[0][0]
__________________________________________________________________________________
__________________
conv2d_294 (Conv2D)             (None, 20, 20, 64)   16384       mixed0[0][0]
__________________________________________________________________________________
__________________
conv2d_296 (Conv2D)             (None, 20, 20, 64)   76800
activation_295[0][0]
__________________________________________________________________________________
```

```
__________________
conv2d_299 (Conv2D)             (None, 20, 20, 96)   82944
activation_298[0][0]
__________________________________________________________________________________
__________________
conv2d_300 (Conv2D)             (None, 20, 20, 64)   16384
average_pooling2d_28[0][0]
__________________________________________________________________________________
__________________
batch_normalization_294 (BatchN (None, 20, 20, 64)   192
conv2d_294[0][0]
__________________________________________________________________________________
__________________
batch_normalization_296 (BatchN (None, 20, 20, 64)   192
conv2d_296[0][0]
__________________________________________________________________________________
__________________
batch_normalization_299 (BatchN (None, 20, 20, 96)   288
conv2d_299[0][0]
__________________________________________________________________________________
__________________
batch_normalization_300 (BatchN (None, 20, 20, 64)   192
conv2d_300[0][0]
__________________________________________________________________________________
__________________
activation_294 (Activation)     (None, 20, 20, 64)   0
batch_normalization_294[0][0]
__________________________________________________________________________________
__________________
activation_296 (Activation)     (None, 20, 20, 64)   0
batch_normalization_296[0][0]
__________________________________________________________________________________
__________________
activation_299 (Activation)     (None, 20, 20, 96)   0
batch_normalization_299[0][0]
__________________________________________________________________________________
__________________
activation_300 (Activation)     (None, 20, 20, 64)   0
batch_normalization_300[0][0]
__________________________________________________________________________________
__________________
mixed1 (Concatenate)            (None, 20, 20, 288)  0
activation_294[0][0]
activation_296[0][0]
activation_299[0][0]
activation_300[0][0]
__________________________________________________________________________________
__________________
```

```
conv2d_304 (Conv2D)             (None, 20, 20, 64)   18432       mixed1[0][0]
__________________________________________________________________________________________________
batch_normalization_304 (BatchN (None, 20, 20, 64)   192
conv2d_304[0][0]
__________________________________________________________________________________________________
activation_304 (Activation)     (None, 20, 20, 64)   0
batch_normalization_304[0][0]
__________________________________________________________________________________________________
conv2d_302 (Conv2D)             (None, 20, 20, 48)   13824       mixed1[0][0]
__________________________________________________________________________________________________
conv2d_305 (Conv2D)             (None, 20, 20, 96)   55296
activation_304[0][0]
__________________________________________________________________________________________________
batch_normalization_302 (BatchN (None, 20, 20, 48)   144
conv2d_302[0][0]
__________________________________________________________________________________________________
batch_normalization_305 (BatchN (None, 20, 20, 96)   288
conv2d_305[0][0]
__________________________________________________________________________________________________
activation_302 (Activation)     (None, 20, 20, 48)   0
batch_normalization_302[0][0]
__________________________________________________________________________________________________
activation_305 (Activation)     (None, 20, 20, 96)   0
batch_normalization_305[0][0]
__________________________________________________________________________________________________
average_pooling2d_29 (AveragePo (None, 20, 20, 288)  0           mixed1[0][0]
__________________________________________________________________________________________________
conv2d_301 (Conv2D)             (None, 20, 20, 64)   18432       mixed1[0][0]
__________________________________________________________________________________________________
conv2d_303 (Conv2D)             (None, 20, 20, 64)   76800
activation_302[0][0]
__________________________________________________________________________________________________
conv2d_306 (Conv2D)             (None, 20, 20, 96)   82944
activation_305[0][0]
__________________________________________________________________________________________________
```

```
conv2d_307 (Conv2D)             (None, 20, 20, 64)   18432
average_pooling2d_29[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_301 (BatchN (None, 20, 20, 64)   192
conv2d_301[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_303 (BatchN (None, 20, 20, 64)   192
conv2d_303[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_306 (BatchN (None, 20, 20, 96)   288
conv2d_306[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_307 (BatchN (None, 20, 20, 64)   192
conv2d_307[0][0]
--------------------------------------------------------------------------------
------------------
activation_301 (Activation)     (None, 20, 20, 64)   0
batch_normalization_301[0][0]
--------------------------------------------------------------------------------
------------------
activation_303 (Activation)     (None, 20, 20, 64)   0
batch_normalization_303[0][0]
--------------------------------------------------------------------------------
------------------
activation_306 (Activation)     (None, 20, 20, 96)   0
batch_normalization_306[0][0]
--------------------------------------------------------------------------------
------------------
activation_307 (Activation)     (None, 20, 20, 64)   0
batch_normalization_307[0][0]
--------------------------------------------------------------------------------
------------------
mixed2 (Concatenate)            (None, 20, 20, 288)  0
activation_301[0][0]
activation_303[0][0]
activation_306[0][0]
activation_307[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_309 (Conv2D)             (None, 20, 20, 64)   18432       mixed2[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_309 (BatchN (None, 20, 20, 64)   192
conv2d_309[0][0]
```

```
__________________________________________________________________________________
__________________
activation_309 (Activation)     (None, 20, 20, 64)   0
batch_normalization_309[0][0]
__________________________________________________________________________________
__________________
conv2d_310 (Conv2D)             (None, 20, 20, 96)   55296
activation_309[0][0]
__________________________________________________________________________________
__________________
batch_normalization_310 (BatchN (None, 20, 20, 96)   288
conv2d_310[0][0]
__________________________________________________________________________________
__________________
activation_310 (Activation)     (None, 20, 20, 96)   0
batch_normalization_310[0][0]
__________________________________________________________________________________
__________________
conv2d_308 (Conv2D)             (None, 9, 9, 384)    995328      mixed2[0][0]
__________________________________________________________________________________
__________________
conv2d_311 (Conv2D)             (None, 9, 9, 96)     82944
activation_310[0][0]
__________________________________________________________________________________
__________________
batch_normalization_308 (BatchN (None, 9, 9, 384)    1152
conv2d_308[0][0]
__________________________________________________________________________________
__________________
batch_normalization_311 (BatchN (None, 9, 9, 96)     288
conv2d_311[0][0]
__________________________________________________________________________________
__________________
activation_308 (Activation)     (None, 9, 9, 384)    0
batch_normalization_308[0][0]
__________________________________________________________________________________
__________________
activation_311 (Activation)     (None, 9, 9, 96)     0
batch_normalization_311[0][0]
__________________________________________________________________________________
__________________
max_pooling2d_14 (MaxPooling2D) (None, 9, 9, 288)    0           mixed2[0][0]
__________________________________________________________________________________
__________________
mixed3 (Concatenate)            (None, 9, 9, 768)    0
activation_308[0][0]
activation_311[0][0]
max_pooling2d_14[0][0]
```

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__________________________________________________________________________________
__________________
conv2d_316 (Conv2D)             (None, 9, 9, 128)    98304       mixed3[0][0]
__________________________________________________________________________________
__________________
batch_normalization_316 (BatchN (None, 9, 9, 128)    384
conv2d_316[0][0]
__________________________________________________________________________________
__________________
activation_316 (Activation)     (None, 9, 9, 128)    0
batch_normalization_316[0][0]
__________________________________________________________________________________
__________________
conv2d_317 (Conv2D)             (None, 9, 9, 128)    114688
activation_316[0][0]
__________________________________________________________________________________
__________________
batch_normalization_317 (BatchN (None, 9, 9, 128)    384
conv2d_317[0][0]
__________________________________________________________________________________
__________________
activation_317 (Activation)     (None, 9, 9, 128)    0
batch_normalization_317[0][0]
__________________________________________________________________________________
__________________
conv2d_313 (Conv2D)             (None, 9, 9, 128)    98304       mixed3[0][0]
__________________________________________________________________________________
__________________
conv2d_318 (Conv2D)             (None, 9, 9, 128)    114688
activation_317[0][0]
__________________________________________________________________________________
__________________
batch_normalization_313 (BatchN (None, 9, 9, 128)    384
conv2d_313[0][0]
__________________________________________________________________________________
__________________
batch_normalization_318 (BatchN (None, 9, 9, 128)    384
conv2d_318[0][0]
__________________________________________________________________________________
__________________
activation_313 (Activation)     (None, 9, 9, 128)    0
batch_normalization_313[0][0]
__________________________________________________________________________________
__________________
activation_318 (Activation)     (None, 9, 9, 128)    0
batch_normalization_318[0][0]
__________________________________________________________________________________
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conv2d_314 (Conv2D)             (None, 9, 9, 128)    114688
activation_313[0][0]
__________________________________________________________________________________
__________________
conv2d_319 (Conv2D)             (None, 9, 9, 128)    114688
activation_318[0][0]
__________________________________________________________________________________
__________________
batch_normalization_314 (BatchN (None, 9, 9, 128)    384
conv2d_314[0][0]
__________________________________________________________________________________
__________________
batch_normalization_319 (BatchN (None, 9, 9, 128)    384
conv2d_319[0][0]
__________________________________________________________________________________
__________________
activation_314 (Activation)     (None, 9, 9, 128)    0
batch_normalization_314[0][0]
__________________________________________________________________________________
__________________
activation_319 (Activation)     (None, 9, 9, 128)    0
batch_normalization_319[0][0]
__________________________________________________________________________________
__________________
average_pooling2d_30 (AveragePo (None, 9, 9, 768)    0           mixed3[0][0]
__________________________________________________________________________________
__________________
conv2d_312 (Conv2D)             (None, 9, 9, 192)    147456      mixed3[0][0]
__________________________________________________________________________________
__________________
conv2d_315 (Conv2D)             (None, 9, 9, 192)    172032
activation_314[0][0]
__________________________________________________________________________________
__________________
conv2d_320 (Conv2D)             (None, 9, 9, 192)    172032
activation_319[0][0]
__________________________________________________________________________________
__________________
conv2d_321 (Conv2D)             (None, 9, 9, 192)    147456
average_pooling2d_30[0][0]
__________________________________________________________________________________
__________________
batch_normalization_312 (BatchN (None, 9, 9, 192)    576
conv2d_312[0][0]
__________________________________________________________________________________
__________________
batch_normalization_315 (BatchN (None, 9, 9, 192)    576
conv2d_315[0][0]
```

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__________________________________________________________________________________
__________________
batch_normalization_320 (BatchN (None, 9, 9, 192)    576
conv2d_320[0][0]
__________________________________________________________________________________
__________________
batch_normalization_321 (BatchN (None, 9, 9, 192)    576
conv2d_321[0][0]
__________________________________________________________________________________
__________________
activation_312 (Activation)     (None, 9, 9, 192)    0
batch_normalization_312[0][0]
__________________________________________________________________________________
__________________
activation_315 (Activation)     (None, 9, 9, 192)    0
batch_normalization_315[0][0]
__________________________________________________________________________________
__________________
activation_320 (Activation)     (None, 9, 9, 192)    0
batch_normalization_320[0][0]
__________________________________________________________________________________
__________________
activation_321 (Activation)     (None, 9, 9, 192)    0
batch_normalization_321[0][0]
__________________________________________________________________________________
__________________
mixed4 (Concatenate)            (None, 9, 9, 768)    0
activation_312[0][0]
activation_315[0][0]
activation_320[0][0]
activation_321[0][0]
__________________________________________________________________________________
__________________
conv2d_326 (Conv2D)             (None, 9, 9, 160)    122880      mixed4[0][0]
__________________________________________________________________________________
__________________
batch_normalization_326 (BatchN (None, 9, 9, 160)    480
conv2d_326[0][0]
__________________________________________________________________________________
__________________
activation_326 (Activation)     (None, 9, 9, 160)    0
batch_normalization_326[0][0]
__________________________________________________________________________________
__________________
conv2d_327 (Conv2D)             (None, 9, 9, 160)    179200
activation_326[0][0]
__________________________________________________________________________________
__________________
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batch_normalization_327 (BatchN (None, 9, 9, 160)    480
conv2d_327[0][0]
__________________________________________________________________________________
__________________
activation_327 (Activation)     (None, 9, 9, 160)    0
batch_normalization_327[0][0]
__________________________________________________________________________________
__________________
conv2d_323 (Conv2D)             (None, 9, 9, 160)    122880      mixed4[0][0]
__________________________________________________________________________________
__________________
conv2d_328 (Conv2D)             (None, 9, 9, 160)    179200
activation_327[0][0]
__________________________________________________________________________________
__________________
batch_normalization_323 (BatchN (None, 9, 9, 160)    480
conv2d_323[0][0]
__________________________________________________________________________________
__________________
batch_normalization_328 (BatchN (None, 9, 9, 160)    480
conv2d_328[0][0]
__________________________________________________________________________________
__________________
activation_323 (Activation)     (None, 9, 9, 160)    0
batch_normalization_323[0][0]
__________________________________________________________________________________
__________________
activation_328 (Activation)     (None, 9, 9, 160)    0
batch_normalization_328[0][0]
__________________________________________________________________________________
__________________
conv2d_324 (Conv2D)             (None, 9, 9, 160)    179200
activation_323[0][0]
__________________________________________________________________________________
__________________
conv2d_329 (Conv2D)             (None, 9, 9, 160)    179200
activation_328[0][0]
__________________________________________________________________________________
__________________
batch_normalization_324 (BatchN (None, 9, 9, 160)    480
conv2d_324[0][0]
__________________________________________________________________________________
__________________
batch_normalization_329 (BatchN (None, 9, 9, 160)    480
conv2d_329[0][0]
__________________________________________________________________________________
__________________
activation_324 (Activation)     (None, 9, 9, 160)    0
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batch_normalization_324[0][0]
__________________________________________________________________________________________________
activation_329 (Activation)     (None, 9, 9, 160)    0
batch_normalization_329[0][0]
__________________________________________________________________________________________________
average_pooling2d_31 (AveragePo (None, 9, 9, 768)    0           mixed4[0][0]
__________________________________________________________________________________________________
conv2d_322 (Conv2D)             (None, 9, 9, 192)    147456      mixed4[0][0]
__________________________________________________________________________________________________
conv2d_325 (Conv2D)             (None, 9, 9, 192)    215040
activation_324[0][0]
__________________________________________________________________________________________________
conv2d_330 (Conv2D)             (None, 9, 9, 192)    215040
activation_329[0][0]
__________________________________________________________________________________________________
conv2d_331 (Conv2D)             (None, 9, 9, 192)    147456
average_pooling2d_31[0][0]
__________________________________________________________________________________________________
batch_normalization_322 (BatchN (None, 9, 9, 192)    576
conv2d_322[0][0]
__________________________________________________________________________________________________
batch_normalization_325 (BatchN (None, 9, 9, 192)    576
conv2d_325[0][0]
__________________________________________________________________________________________________
batch_normalization_330 (BatchN (None, 9, 9, 192)    576
conv2d_330[0][0]
__________________________________________________________________________________________________
batch_normalization_331 (BatchN (None, 9, 9, 192)    576
conv2d_331[0][0]
__________________________________________________________________________________________________
activation_322 (Activation)     (None, 9, 9, 192)    0
batch_normalization_322[0][0]
__________________________________________________________________________________________________
activation_325 (Activation)     (None, 9, 9, 192)    0
batch_normalization_325[0][0]
__________________________________________________________________________________________________
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__________________
activation_330 (Activation)     (None, 9, 9, 192)    0
batch_normalization_330[0][0]

__________________________________________________________________________________
__________________
activation_331 (Activation)     (None, 9, 9, 192)    0
batch_normalization_331[0][0]

__________________________________________________________________________________
__________________
mixed5 (Concatenate)            (None, 9, 9, 768)    0
activation_322[0][0]
activation_325[0][0]
activation_330[0][0]
activation_331[0][0]

__________________________________________________________________________________
__________________
conv2d_336 (Conv2D)             (None, 9, 9, 160)    122880      mixed5[0][0]

__________________________________________________________________________________
__________________
batch_normalization_336 (BatchN (None, 9, 9, 160)    480
conv2d_336[0][0]

__________________________________________________________________________________
__________________
activation_336 (Activation)     (None, 9, 9, 160)    0
batch_normalization_336[0][0]

__________________________________________________________________________________
__________________
conv2d_337 (Conv2D)             (None, 9, 9, 160)    179200
activation_336[0][0]

__________________________________________________________________________________
__________________
batch_normalization_337 (BatchN (None, 9, 9, 160)    480
conv2d_337[0][0]

__________________________________________________________________________________
__________________
activation_337 (Activation)     (None, 9, 9, 160)    0
batch_normalization_337[0][0]

__________________________________________________________________________________
__________________
conv2d_333 (Conv2D)             (None, 9, 9, 160)    122880      mixed5[0][0]

__________________________________________________________________________________
__________________
conv2d_338 (Conv2D)             (None, 9, 9, 160)    179200
activation_337[0][0]

__________________________________________________________________________________
__________________
batch_normalization_333 (BatchN (None, 9, 9, 160)    480
conv2d_333[0][0]
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__________________________________________________________________________________
__________________
batch_normalization_338 (BatchN (None, 9, 9, 160)    480
conv2d_338[0][0]
__________________________________________________________________________________
__________________
activation_333 (Activation)     (None, 9, 9, 160)    0
batch_normalization_333[0][0]
__________________________________________________________________________________
__________________
activation_338 (Activation)     (None, 9, 9, 160)    0
batch_normalization_338[0][0]
__________________________________________________________________________________
__________________
conv2d_334 (Conv2D)             (None, 9, 9, 160)    179200
activation_333[0][0]
__________________________________________________________________________________
__________________
conv2d_339 (Conv2D)             (None, 9, 9, 160)    179200
activation_338[0][0]
__________________________________________________________________________________
__________________
batch_normalization_334 (BatchN (None, 9, 9, 160)    480
conv2d_334[0][0]
__________________________________________________________________________________
__________________
batch_normalization_339 (BatchN (None, 9, 9, 160)    480
conv2d_339[0][0]
__________________________________________________________________________________
__________________
activation_334 (Activation)     (None, 9, 9, 160)    0
batch_normalization_334[0][0]
__________________________________________________________________________________
__________________
activation_339 (Activation)     (None, 9, 9, 160)    0
batch_normalization_339[0][0]
__________________________________________________________________________________
__________________
average_pooling2d_32 (AveragePo (None, 9, 9, 768)    0           mixed5[0][0]
__________________________________________________________________________________
__________________
conv2d_332 (Conv2D)             (None, 9, 9, 192)    147456      mixed5[0][0]
__________________________________________________________________________________
__________________
conv2d_335 (Conv2D)             (None, 9, 9, 192)    215040
activation_334[0][0]
__________________________________________________________________________________
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conv2d_340 (Conv2D)             (None, 9, 9, 192)    215040
activation_339[0][0]
-------------------------------------------------------------------------------
------------------
conv2d_341 (Conv2D)             (None, 9, 9, 192)    147456
average_pooling2d_32[0][0]
-------------------------------------------------------------------------------
------------------
batch_normalization_332 (BatchN (None, 9, 9, 192)    576
conv2d_332[0][0]
-------------------------------------------------------------------------------
------------------
batch_normalization_335 (BatchN (None, 9, 9, 192)    576
conv2d_335[0][0]
-------------------------------------------------------------------------------
------------------
batch_normalization_340 (BatchN (None, 9, 9, 192)    576
conv2d_340[0][0]
-------------------------------------------------------------------------------
------------------
batch_normalization_341 (BatchN (None, 9, 9, 192)    576
conv2d_341[0][0]
-------------------------------------------------------------------------------
------------------
activation_332 (Activation)     (None, 9, 9, 192)    0
batch_normalization_332[0][0]
-------------------------------------------------------------------------------
------------------
activation_335 (Activation)     (None, 9, 9, 192)    0
batch_normalization_335[0][0]
-------------------------------------------------------------------------------
------------------
activation_340 (Activation)     (None, 9, 9, 192)    0
batch_normalization_340[0][0]
-------------------------------------------------------------------------------
------------------
activation_341 (Activation)     (None, 9, 9, 192)    0
batch_normalization_341[0][0]
-------------------------------------------------------------------------------
------------------
mixed6 (Concatenate)            (None, 9, 9, 768)    0
activation_332[0][0]
activation_335[0][0]
activation_340[0][0]
activation_341[0][0]
-------------------------------------------------------------------------------
------------------
conv2d_346 (Conv2D)             (None, 9, 9, 192)    147456      mixed6[0][0]
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__________________________________________________________________________________
__________________
batch_normalization_346 (BatchN (None, 9, 9, 192)    576
conv2d_346[0][0]
__________________________________________________________________________________
__________________
activation_346 (Activation)     (None, 9, 9, 192)    0
batch_normalization_346[0][0]
__________________________________________________________________________________
__________________
conv2d_347 (Conv2D)             (None, 9, 9, 192)    258048
activation_346[0][0]
__________________________________________________________________________________
__________________
batch_normalization_347 (BatchN (None, 9, 9, 192)    576
conv2d_347[0][0]
__________________________________________________________________________________
__________________
activation_347 (Activation)     (None, 9, 9, 192)    0
batch_normalization_347[0][0]
__________________________________________________________________________________
__________________
conv2d_343 (Conv2D)             (None, 9, 9, 192)    147456      mixed6[0][0]
__________________________________________________________________________________
__________________
conv2d_348 (Conv2D)             (None, 9, 9, 192)    258048
activation_347[0][0]
__________________________________________________________________________________
__________________
batch_normalization_343 (BatchN (None, 9, 9, 192)    576
conv2d_343[0][0]
__________________________________________________________________________________
__________________
batch_normalization_348 (BatchN (None, 9, 9, 192)    576
conv2d_348[0][0]
__________________________________________________________________________________
__________________
activation_343 (Activation)     (None, 9, 9, 192)    0
batch_normalization_343[0][0]
__________________________________________________________________________________
__________________
activation_348 (Activation)     (None, 9, 9, 192)    0
batch_normalization_348[0][0]
__________________________________________________________________________________
__________________
conv2d_344 (Conv2D)             (None, 9, 9, 192)    258048
activation_343[0][0]
__________________________________________________________________________________
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__________________
conv2d_349 (Conv2D)             (None, 9, 9, 192)    258048
activation_348[0][0]
__________________________________________________________________________________
__________________
batch_normalization_344 (BatchN (None, 9, 9, 192)    576
conv2d_344[0][0]
__________________________________________________________________________________
__________________
batch_normalization_349 (BatchN (None, 9, 9, 192)    576
conv2d_349[0][0]
__________________________________________________________________________________
__________________
activation_344 (Activation)     (None, 9, 9, 192)    0
batch_normalization_344[0][0]
__________________________________________________________________________________
__________________
activation_349 (Activation)     (None, 9, 9, 192)    0
batch_normalization_349[0][0]
__________________________________________________________________________________
__________________
average_pooling2d_33 (AveragePo (None, 9, 9, 768)    0           mixed6[0][0]
__________________________________________________________________________________
__________________
conv2d_342 (Conv2D)             (None, 9, 9, 192)    147456      mixed6[0][0]
__________________________________________________________________________________
__________________
conv2d_345 (Conv2D)             (None, 9, 9, 192)    258048
activation_344[0][0]
__________________________________________________________________________________
__________________
conv2d_350 (Conv2D)             (None, 9, 9, 192)    258048
activation_349[0][0]
__________________________________________________________________________________
__________________
conv2d_351 (Conv2D)             (None, 9, 9, 192)    147456
average_pooling2d_33[0][0]
__________________________________________________________________________________
__________________
batch_normalization_342 (BatchN (None, 9, 9, 192)    576
conv2d_342[0][0]
__________________________________________________________________________________
__________________
batch_normalization_345 (BatchN (None, 9, 9, 192)    576
conv2d_345[0][0]
__________________________________________________________________________________
__________________
batch_normalization_350 (BatchN (None, 9, 9, 192)    576
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conv2d_350[0][0]
__________________________________________________________________________________________________
batch_normalization_351 (BatchN (None, 9, 9, 192)    576
conv2d_351[0][0]
__________________________________________________________________________________________________
activation_342 (Activation)     (None, 9, 9, 192)    0
batch_normalization_342[0][0]
__________________________________________________________________________________________________
activation_345 (Activation)     (None, 9, 9, 192)    0
batch_normalization_345[0][0]
__________________________________________________________________________________________________
activation_350 (Activation)     (None, 9, 9, 192)    0
batch_normalization_350[0][0]
__________________________________________________________________________________________________
activation_351 (Activation)     (None, 9, 9, 192)    0
batch_normalization_351[0][0]
__________________________________________________________________________________________________
mixed7 (Concatenate)            (None, 9, 9, 768)    0
activation_342[0][0]
activation_345[0][0]
activation_350[0][0]
activation_351[0][0]
__________________________________________________________________________________________________
conv2d_354 (Conv2D)             (None, 9, 9, 192)    147456      mixed7[0][0]
__________________________________________________________________________________________________
batch_normalization_354 (BatchN (None, 9, 9, 192)    576
conv2d_354[0][0]
__________________________________________________________________________________________________
activation_354 (Activation)     (None, 9, 9, 192)    0
batch_normalization_354[0][0]
__________________________________________________________________________________________________
conv2d_355 (Conv2D)             (None, 9, 9, 192)    258048
activation_354[0][0]
__________________________________________________________________________________________________
batch_normalization_355 (BatchN (None, 9, 9, 192)    576
conv2d_355[0][0]
__________________________________________________________________________________________________
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__________________
activation_355 (Activation)     (None, 9, 9, 192)    0
batch_normalization_355[0][0]

__________________________________________________________________________________
__________________
conv2d_352 (Conv2D)             (None, 9, 9, 192)    147456      mixed7[0][0]

__________________________________________________________________________________
__________________
conv2d_356 (Conv2D)             (None, 9, 9, 192)    258048
activation_355[0][0]

__________________________________________________________________________________
__________________
batch_normalization_352 (BatchN (None, 9, 9, 192)    576
conv2d_352[0][0]

__________________________________________________________________________________
__________________
batch_normalization_356 (BatchN (None, 9, 9, 192)    576
conv2d_356[0][0]

__________________________________________________________________________________
__________________
activation_352 (Activation)     (None, 9, 9, 192)    0
batch_normalization_352[0][0]

__________________________________________________________________________________
__________________
activation_356 (Activation)     (None, 9, 9, 192)    0
batch_normalization_356[0][0]

__________________________________________________________________________________
__________________
conv2d_353 (Conv2D)             (None, 4, 4, 320)    552960
activation_352[0][0]

__________________________________________________________________________________
__________________
conv2d_357 (Conv2D)             (None, 4, 4, 192)    331776
activation_356[0][0]

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__________________
batch_normalization_353 (BatchN (None, 4, 4, 320)    960
conv2d_353[0][0]

__________________________________________________________________________________
__________________
batch_normalization_357 (BatchN (None, 4, 4, 192)    576
conv2d_357[0][0]

__________________________________________________________________________________
__________________
activation_353 (Activation)     (None, 4, 4, 320)    0
batch_normalization_353[0][0]

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activation_357 (Activation)     (None, 4, 4, 192)    0
batch_normalization_357[0][0]
__________________________________________________________________________________
__________________
max_pooling2d_15 (MaxPooling2D) (None, 4, 4, 768)    0           mixed7[0][0]
__________________________________________________________________________________
__________________
mixed8 (Concatenate)            (None, 4, 4, 1280)   0
activation_353[0][0]
activation_357[0][0]
max_pooling2d_15[0][0]
__________________________________________________________________________________
__________________
conv2d_362 (Conv2D)             (None, 4, 4, 448)    573440      mixed8[0][0]
__________________________________________________________________________________
__________________
batch_normalization_362 (BatchN (None, 4, 4, 448)    1344
conv2d_362[0][0]
__________________________________________________________________________________
__________________
activation_362 (Activation)     (None, 4, 4, 448)    0
batch_normalization_362[0][0]
__________________________________________________________________________________
__________________
conv2d_359 (Conv2D)             (None, 4, 4, 384)    491520      mixed8[0][0]
__________________________________________________________________________________
__________________
conv2d_363 (Conv2D)             (None, 4, 4, 384)    1548288
activation_362[0][0]
__________________________________________________________________________________
__________________
batch_normalization_359 (BatchN (None, 4, 4, 384)    1152
conv2d_359[0][0]
__________________________________________________________________________________
__________________
batch_normalization_363 (BatchN (None, 4, 4, 384)    1152
conv2d_363[0][0]
__________________________________________________________________________________
__________________
activation_359 (Activation)     (None, 4, 4, 384)    0
batch_normalization_359[0][0]
__________________________________________________________________________________
__________________
activation_363 (Activation)     (None, 4, 4, 384)    0
batch_normalization_363[0][0]
__________________________________________________________________________________
__________________
conv2d_360 (Conv2D)             (None, 4, 4, 384)    442368
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activation_359[0][0]
__________________________________________________________________________________________________
conv2d_361 (Conv2D)             (None, 4, 4, 384)    442368
activation_359[0][0]
__________________________________________________________________________________________________
conv2d_364 (Conv2D)             (None, 4, 4, 384)    442368
activation_363[0][0]
__________________________________________________________________________________________________
conv2d_365 (Conv2D)             (None, 4, 4, 384)    442368
activation_363[0][0]
__________________________________________________________________________________________________
average_pooling2d_34 (AveragePo (None, 4, 4, 1280)   0           mixed8[0][0]
__________________________________________________________________________________________________
conv2d_358 (Conv2D)             (None, 4, 4, 320)    409600      mixed8[0][0]
__________________________________________________________________________________________________
batch_normalization_360 (BatchN (None, 4, 4, 384)    1152
conv2d_360[0][0]
__________________________________________________________________________________________________
batch_normalization_361 (BatchN (None, 4, 4, 384)    1152
conv2d_361[0][0]
__________________________________________________________________________________________________
batch_normalization_364 (BatchN (None, 4, 4, 384)    1152
conv2d_364[0][0]
__________________________________________________________________________________________________
batch_normalization_365 (BatchN (None, 4, 4, 384)    1152
conv2d_365[0][0]
__________________________________________________________________________________________________
conv2d_366 (Conv2D)             (None, 4, 4, 192)    245760
average_pooling2d_34[0][0]
__________________________________________________________________________________________________
batch_normalization_358 (BatchN (None, 4, 4, 320)    960
conv2d_358[0][0]
__________________________________________________________________________________________________
activation_360 (Activation)     (None, 4, 4, 384)    0
batch_normalization_360[0][0]
__________________________________________________________________________________________________
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__________________
activation_361 (Activation)     (None, 4, 4, 384)    0
batch_normalization_361[0][0]

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__________________
activation_364 (Activation)     (None, 4, 4, 384)    0
batch_normalization_364[0][0]

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__________________
activation_365 (Activation)     (None, 4, 4, 384)    0
batch_normalization_365[0][0]

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__________________
batch_normalization_366 (BatchN (None, 4, 4, 192)    576
conv2d_366[0][0]

__________________________________________________________________________________
__________________
activation_358 (Activation)     (None, 4, 4, 320)    0
batch_normalization_358[0][0]

__________________________________________________________________________________
__________________
mixed9_0 (Concatenate)          (None, 4, 4, 768)    0
activation_360[0][0]
activation_361[0][0]

__________________________________________________________________________________
__________________
concatenate_6 (Concatenate)     (None, 4, 4, 768)    0
activation_364[0][0]
activation_365[0][0]

__________________________________________________________________________________
__________________
activation_366 (Activation)     (None, 4, 4, 192)    0
batch_normalization_366[0][0]

__________________________________________________________________________________
__________________
mixed9 (Concatenate)            (None, 4, 4, 2048)   0
activation_358[0][0]
                                                                 mixed9_0[0][0]
concatenate_6[0][0]
activation_366[0][0]

__________________________________________________________________________________
__________________
conv2d_371 (Conv2D)             (None, 4, 4, 448)    917504      mixed9[0][0]

__________________________________________________________________________________
__________________
batch_normalization_371 (BatchN (None, 4, 4, 448)    1344
conv2d_371[0][0]

__________________________________________________________________________________
```

```
__________________
activation_371 (Activation)     (None, 4, 4, 448)    0
batch_normalization_371[0][0]

__________________________________________________________________________________
__________________
conv2d_368 (Conv2D)             (None, 4, 4, 384)    786432      mixed9[0][0]

__________________________________________________________________________________
__________________
conv2d_372 (Conv2D)             (None, 4, 4, 384)    1548288
activation_371[0][0]

__________________________________________________________________________________
__________________
batch_normalization_368 (BatchN (None, 4, 4, 384)    1152
conv2d_368[0][0]

__________________________________________________________________________________
__________________
batch_normalization_372 (BatchN (None, 4, 4, 384)    1152
conv2d_372[0][0]

__________________________________________________________________________________
__________________
activation_368 (Activation)     (None, 4, 4, 384)    0
batch_normalization_368[0][0]

__________________________________________________________________________________
__________________
activation_372 (Activation)     (None, 4, 4, 384)    0
batch_normalization_372[0][0]

__________________________________________________________________________________
__________________
conv2d_369 (Conv2D)             (None, 4, 4, 384)    442368
activation_368[0][0]

__________________________________________________________________________________
__________________
conv2d_370 (Conv2D)             (None, 4, 4, 384)    442368
activation_368[0][0]

__________________________________________________________________________________
__________________
conv2d_373 (Conv2D)             (None, 4, 4, 384)    442368
activation_372[0][0]

__________________________________________________________________________________
__________________
conv2d_374 (Conv2D)             (None, 4, 4, 384)    442368
activation_372[0][0]

__________________________________________________________________________________
__________________
average_pooling2d_35 (AveragePo (None, 4, 4, 2048)   0           mixed9[0][0]

__________________________________________________________________________________
__________________
conv2d_367 (Conv2D)             (None, 4, 4, 320)    655360      mixed9[0][0]
```

```
____________________________________________________________________________
__________________
batch_normalization_369 (BatchN (None, 4, 4, 384)    1152
conv2d_369[0][0]
____________________________________________________________________________
__________________
batch_normalization_370 (BatchN (None, 4, 4, 384)    1152
conv2d_370[0][0]
____________________________________________________________________________
__________________
batch_normalization_373 (BatchN (None, 4, 4, 384)    1152
conv2d_373[0][0]
____________________________________________________________________________
__________________
batch_normalization_374 (BatchN (None, 4, 4, 384)    1152
conv2d_374[0][0]
____________________________________________________________________________
__________________
conv2d_375 (Conv2D)             (None, 4, 4, 192)    393216
average_pooling2d_35[0][0]
____________________________________________________________________________
__________________
batch_normalization_367 (BatchN (None, 4, 4, 320)    960
conv2d_367[0][0]
____________________________________________________________________________
__________________
activation_369 (Activation)     (None, 4, 4, 384)    0
batch_normalization_369[0][0]
____________________________________________________________________________
__________________
activation_370 (Activation)     (None, 4, 4, 384)    0
batch_normalization_370[0][0]
____________________________________________________________________________
__________________
activation_373 (Activation)     (None, 4, 4, 384)    0
batch_normalization_373[0][0]
____________________________________________________________________________
__________________
activation_374 (Activation)     (None, 4, 4, 384)    0
batch_normalization_374[0][0]
____________________________________________________________________________
__________________
batch_normalization_375 (BatchN (None, 4, 4, 192)    576
conv2d_375[0][0]
____________________________________________________________________________
__________________
activation_367 (Activation)     (None, 4, 4, 320)    0
batch_normalization_367[0][0]
```

```
__________________________________________________________________________________
__________________
mixed9_1 (Concatenate)          (None, 4, 4, 768)    0
activation_369[0][0]
activation_370[0][0]

__________________________________________________________________________________
__________________
concatenate_7 (Concatenate)     (None, 4, 4, 768)    0
activation_373[0][0]
activation_374[0][0]

__________________________________________________________________________________
__________________
activation_375 (Activation)     (None, 4, 4, 192)    0
batch_normalization_375[0][0]

__________________________________________________________________________________
__________________
mixed10 (Concatenate)           (None, 4, 4, 2048)   0
activation_367[0][0]
                                                                 mixed9_1[0][0]
concatenate_7[0][0]
activation_375[0][0]
==================================================================================
==================
Total params: 21,802,784
Trainable params: 0
Non-trainable params: 21,802,784
__________________________________________________________________________________
__________________
```

[112]:
```
model = Sequential()
model.add(inception)
model.add(Flatten())

model.add(Dense(512,activation='relu'))
model.add(Dropout(0.4))
model.add(Dense(256,activation='relu'))
model.add(Dense(64,activation='relu'))
model.add(Dropout(0.4))
model.add(Dense(3,activation='softmax'))
```

[113]:
```
model.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
inception_v3 (Functional)    (None, 4, 4, 2048)        21802784
_________________________________________________________________
```

```
flatten_3 (Flatten)          (None, 32768)             0
_________________________________________________________________
dense_12 (Dense)             (None, 512)               16777728
_________________________________________________________________
dropout_6 (Dropout)          (None, 512)               0
_________________________________________________________________
dense_13 (Dense)             (None, 256)               131328
_________________________________________________________________
dense_14 (Dense)             (None, 64)                16448
_________________________________________________________________
dropout_7 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_15 (Dense)             (None, 3)                 195
=================================================================
Total params: 38,728,483
Trainable params: 16,925,699
Non-trainable params: 21,802,784
_________________________________________________________________
```

[114]:
```
model.
 ↪compile(loss='categorical_crossentropy',optimizer='adam',metrics=['accuracy'])
#callbacks
early_stop = EarlyStopping(monitor = 'val_accuracy', patience=3)
```

[115]:
```
import time

start = time.perf_counter()

model.fit(train_generator, epochs=30,␣
 ↪validation_data=validation_generator,callbacks=[early_stop])

elapsed = time.perf_counter() - start
```

```
Epoch 1/30
21/21 [==============================] - 39s 2s/step - loss: 3.0289 - accuracy:
0.3841 - val_loss: 0.9531 - val_accuracy: 0.4362
Epoch 2/30
21/21 [==============================] - 42s 2s/step - loss: 1.0111 - accuracy:
0.4777 - val_loss: 0.7067 - val_accuracy: 0.5705
Epoch 3/30
21/21 [==============================] - 35s 2s/step - loss: 0.8604 - accuracy:
0.5536 - val_loss: 0.6962 - val_accuracy: 0.5705
Epoch 4/30
21/21 [==============================] - 40s 2s/step - loss: 0.7697 - accuracy:
0.5776 - val_loss: 0.6254 - val_accuracy: 0.6309
Epoch 5/30
```

```
21/21 [==============================] - 36s 2s/step - loss: 0.7364 - accuracy:
0.6293 - val_loss: 0.5875 - val_accuracy: 0.6443
Epoch 6/30
21/21 [==============================] - 35s 2s/step - loss: 0.7181 - accuracy:
0.6244 - val_loss: 0.6263 - val_accuracy: 0.6443
Epoch 7/30
21/21 [==============================] - 42s 2s/step - loss: 0.7045 - accuracy:
0.6436 - val_loss: 0.5552 - val_accuracy: 0.6510
Epoch 8/30
21/21 [==============================] - 41s 2s/step - loss: 0.6553 - accuracy:
0.6186 - val_loss: 0.5519 - val_accuracy: 0.6779
Epoch 9/30
21/21 [==============================] - 29s 1s/step - loss: 0.6612 - accuracy:
0.6665 - val_loss: 0.6127 - val_accuracy: 0.6443
Epoch 10/30
21/21 [==============================] - 27s 1s/step - loss: 0.8600 - accuracy:
0.5894 - val_loss: 0.5974 - val_accuracy: 0.6711
Epoch 11/30
21/21 [==============================] - 29s 1s/step - loss: 0.6950 - accuracy:
0.6459 - val_loss: 0.5552 - val_accuracy: 0.6443
```

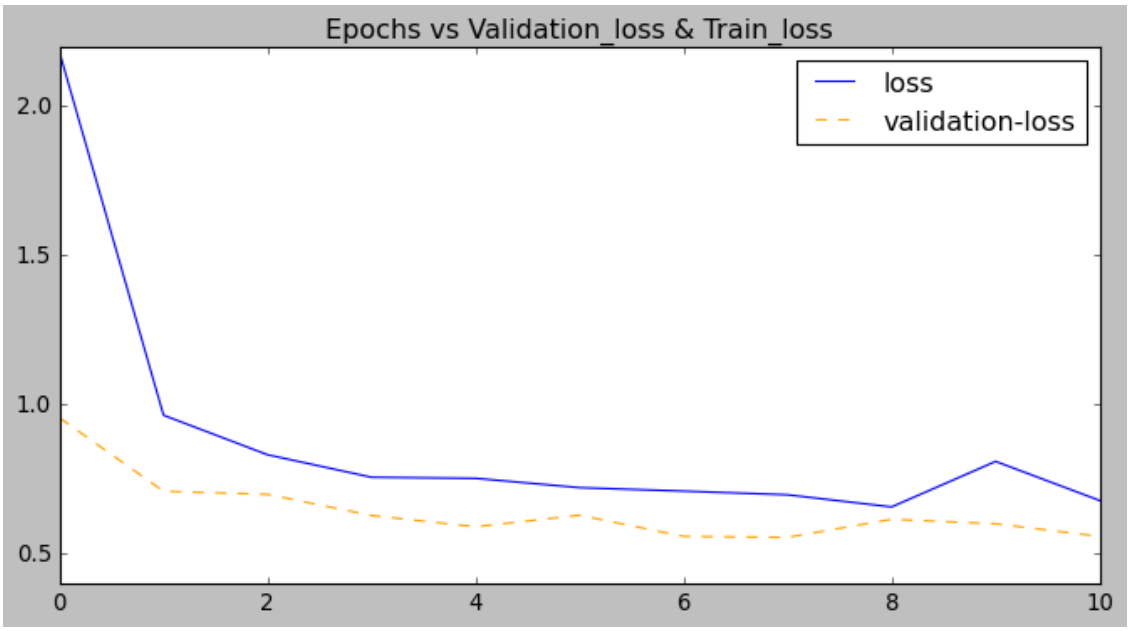
[121]:
```
import pandas as pd
history = pd.DataFrame(model.history.history)
history
```

[121]:

	loss	accuracy	val_loss	val_accuracy
0	2.179312	0.418154	0.953067	0.436242
1	0.961773	0.522110	0.706701	0.570470
2	0.829118	0.577192	0.696200	0.570470
3	0.753635	0.591932	0.625395	0.630872
4	0.750024	0.617533	0.587511	0.644295
5	0.718781	0.623739	0.626285	0.644295
6	0.707123	0.631497	0.555202	0.651007
7	0.694791	0.630722	0.551940	0.677852
8	0.654065	0.645462	0.612667	0.644295
9	0.806783	0.613654	0.597448	0.671141
10	0.675678	0.644686	0.555222	0.644295

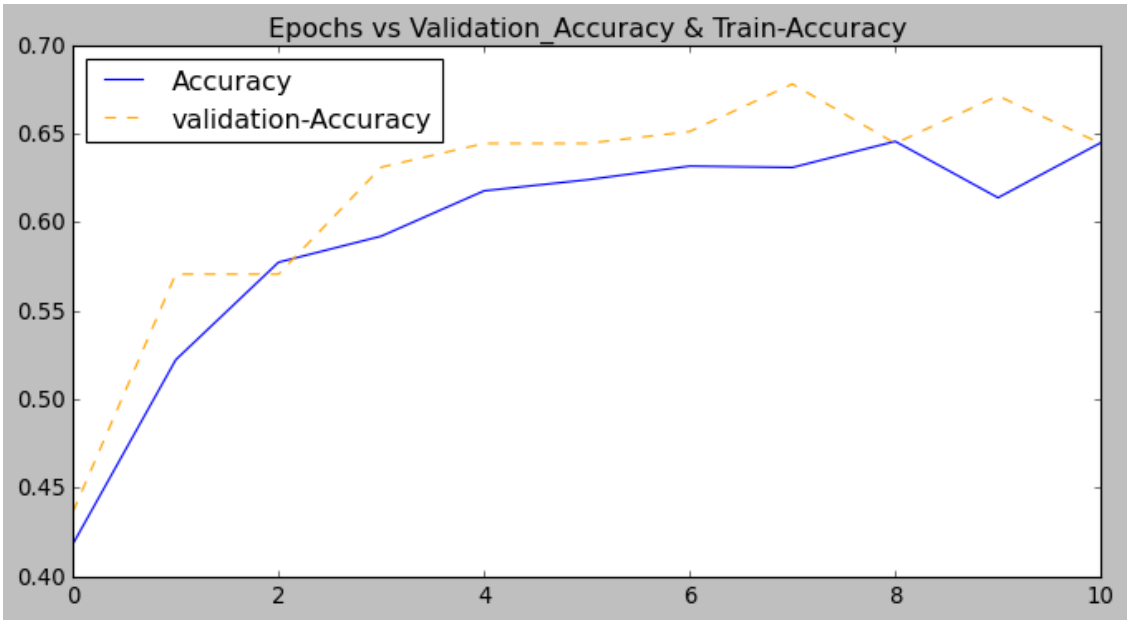
[129]:
```
plt.style.use('classic')
plt.figure(figsize=(10,5))
plt.plot(history['loss'],label='loss')
plt.plot(history['val_loss'],ls='--',color='orange',label='validation-loss')
plt.title('Epochs vs Validation_loss & Train_loss')
plt.legend()
```

[129]:
```
<matplotlib.legend.Legend at 0x7fd0b6975dc0>
```



[132]:
```
plt.style.use('classic')
plt.figure(figsize=(10,5))
plt.plot(history['accuracy'],label='Accuracy')
plt.
 ↪plot(history['val_accuracy'],ls='--',color='orange',label='validation-Accuracy')
plt.title('Epochs vs Validation_Accuracy & Train-Accuracy')
plt.legend(loc='upper left')
```

[132]: <matplotlib.legend.Legend at 0x7fd0b0bc60a0>



[133]:
```
predictions = model.predict_classes(validation_generator)
```

```
/Users/rohan/opt/anaconda3/lib/python3.8/site-
packages/tensorflow/python/keras/engine/sequential.py:450: UserWarning:
`model.predict_classes()` is deprecated and will be removed after 2021-01-01.
Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if your model
does multi-class classification   (e.g. if it uses a `softmax` last-layer
activation).* `(model.predict(x) > 0.5).astype("int32")`,   if your model does
binary classification   (e.g. if it uses a `sigmoid` last-layer activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```

[134]:
```
predictions
```

[134]:
```
array([0, 0, 0, 0, 0, 2, 0, 0, 2, 0, 0, 2, 0, 2, 0, 2, 0, 0, 0, 0, 2, 0,
       0, 2, 0, 2, 2, 0, 0, 2, 0, 0, 0, 2, 0, 0, 0, 2, 0, 0, 0, 2, 2, 0,
       0, 2, 2, 0, 0, 2, 0, 0, 2, 0, 0, 2, 2, 0, 0, 2, 2, 2, 2, 2, 0, 0,
       0, 2, 0, 2, 0, 0, 0, 0, 0, 2, 0, 0, 0, 2, 2, 0, 0, 2, 0, 2, 0, 2,
       2, 0, 0, 0, 0, 0, 0, 0, 0, 2, 0, 2, 0, 2, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 2, 0, 0, 0, 0, 2, 0, 0, 2, 0, 2, 0, 0, 2, 2, 0, 0, 0,
       0, 0, 0, 2, 0, 2, 0, 2, 0, 0, 2, 0, 2, 0, 0, 0, 0])
```

[139]:
```
# saving model
model.save('inception-model.h5')
```

[137]:
```
# Deconstructing Validation Set as x_test, and y_test for classification report
```

[236]:
```
x_train, y_train = next(train_generator)
x_test, y_test = next(validation_generator)
class_names = validation_generator.class_indices
```

[237]:
```
y_test[index].argmax()
```

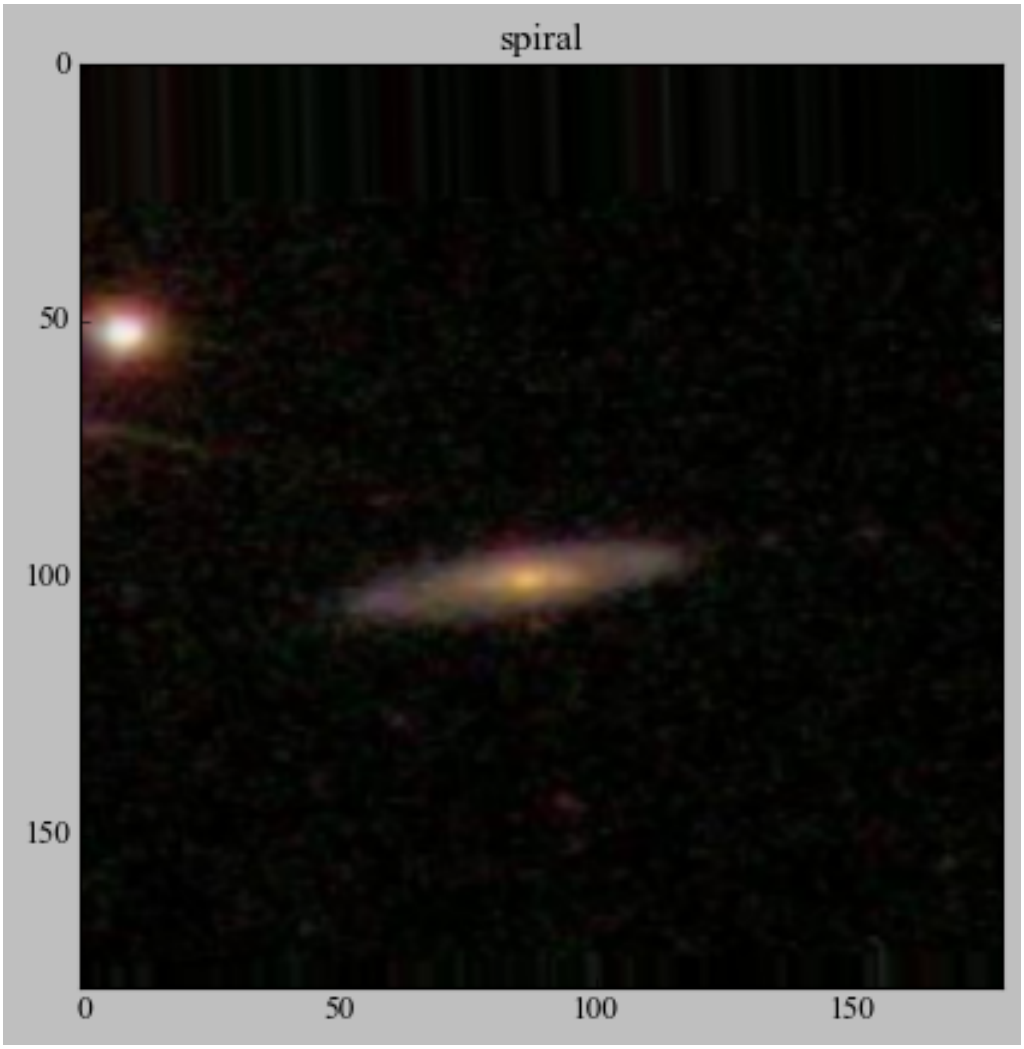
[237]:
```
2
```

[238]:
```
x_test.shape
```

[238]:
```
(64, 180, 180, 3)
```

[227]:
```
index = 63
plt.imshow(x_test[index])
plt.title(list(class_names.keys())[y_test[index].argmax()])
```

[227]:
```
Text(0.5, 1.0, 'spiral')
```



[228]:
```
predictions
```

[228]:
```
array([0, 0, 0, 0, 0, 2, 0, 0, 2, 0, 0, 2, 0, 2, 0, 2, 0, 0, 0, 0, 2, 0,
       0, 2, 0, 2, 2, 0, 0, 2, 0, 0, 0, 2, 0, 0, 0, 2, 0, 0, 0, 2, 2, 0,
       0, 2, 2, 0, 0, 2, 0, 0, 2, 0, 0, 2, 2, 0, 0, 2, 2, 2, 2, 2, 0, 0,
       0, 2, 0, 2, 0, 0, 0, 0, 0, 2, 0, 0, 0, 2, 2, 0, 0, 2, 0, 2, 0, 2,
       2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2, 0, 2, 0, 2, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 2, 0, 0, 0, 0, 2, 0, 0, 2, 0, 2, 0, 0, 2, 2, 0, 0, 0,
       0, 0, 0, 2, 0, 2, 0, 2, 0, 0, 2, 0, 2, 0, 0, 0, 0])
```

[248]:
```
predictions = model.predict_classes(x_train)
```

```
/Users/rohan/opt/anaconda3/lib/python3.8/site-
packages/tensorflow/python/keras/engine/sequential.py:450: UserWarning:
`model.predict_classes()` is deprecated and will be removed after 2021-01-01.
Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if your model
```

```
does multi-class classification   (e.g. if it uses a `softmax` last-layer
activation).* `(model.predict(x) > 0.5).astype("int32")`,   if your model does
binary classification   (e.g. if it uses a `sigmoid` last-layer activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```

[242]:
```
y_test = np.array([np.where(r==1)[0][0] for r in y_test])
```

[243]:
```
y_test
```

[243]:
```
array([1, 1, 0, 1, 2, 2, 0, 1, 1, 1, 0, 0, 0, 0, 2, 0, 2, 2, 1, 1, 2, 0,
       0, 2, 2, 1, 0, 1, 1, 2, 0, 0, 1, 1, 2, 0, 2, 0, 0, 1, 2, 0, 2, 1,
       1, 0, 2, 0, 0, 2, 2, 1, 0, 0, 0, 2, 2, 2, 2, 1, 1, 2, 0, 2])
```

[245]:
```
len(y_train)
```

[245]:
```
64
```

[250]:
```
from sklearn.metrics import classification_report,confusion_matrix
```

[256]:
```
history
```

[256]:

	loss	accuracy	val_loss	val_accuracy
0	2.179312	0.418154	0.953067	0.436242
1	0.961773	0.522110	0.706701	0.570470
2	0.829118	0.577192	0.696200	0.570470
3	0.753635	0.591932	0.625395	0.630872
4	0.750024	0.617533	0.587511	0.644295
5	0.718781	0.623739	0.626285	0.644295
6	0.707123	0.631497	0.555202	0.651007
7	0.694791	0.630722	0.551940	0.677852
8	0.654065	0.645462	0.612667	0.644295
9	0.806783	0.613654	0.597448	0.671141
10	0.675678	0.644686	0.555222	0.644295

0.0.9 Load Model

[10]:
```
from tensorflow.keras.models import load_model
```

[11]:
```
inceptionNet = load_model('inception-model.h5')
```

[15]:
```
inceptionNet.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
inception_v3 (Functional)    (None, 4, 4, 2048)        21802784
_________________________________________________________________
```

```
flatten_3 (Flatten)          (None, 32768)             0
_________________________________________________________________
dense_12 (Dense)             (None, 512)               16777728
_________________________________________________________________
dropout_6 (Dropout)          (None, 512)               0
_________________________________________________________________
dense_13 (Dense)             (None, 256)               131328
_________________________________________________________________
dense_14 (Dense)             (None, 64)                16448
_________________________________________________________________
dropout_7 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_15 (Dense)             (None, 3)                 195
=================================================================
Total params: 38,728,483
Trainable params: 16,925,699
Non-trainable params: 21,802,784
_________________________________________________________________
```

0.0.10 Miscellaneous

[17]:
```
import os
path = '../samples/'
overview_path = '../samples/overview.txt'
eval_path  = '../samples/evaluate.txt'

if os.path.exists(path):

    print('samples dir, exists..checking for dictionaries existence..')

    if os.path.exists(overview_path) and os.path.exists(eval_path):
        print('Data exists. no need of overwritting.')
    else:
        print("overview and eval doesn't exist, proceed to step-2")

else:
    print("samples/ dir is non-existent, Establishing one..")
    os.mkdir(path) # samples directory
```

```
samples dir, exists..checking for dictionaries existence..
overview and eval doesn't exist, proceed to step-2
```

[21]:
```
shape = (train_generator.samples,*train_generator.image_shape)
shape
```

[21]:
```
(1289, 180, 180, 3)
```

[23]:
```
train_generator.class_indices.values()
```

[23]:
```
dict_values([0, 1, 2])
```

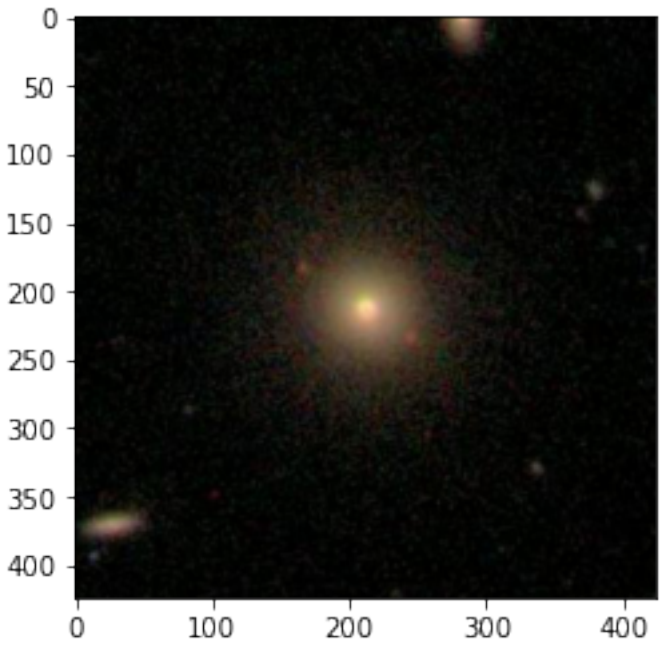
[37]:
```
sample = list()
sample.append(elliptical_arr[0])
sample.append(lenticular_arr[0])
sample.append(spiral_arr[1])
```

[39]:
```
sample = np.array(sample)
```

[43]:
```

```

[43]:
```
<matplotlib.image.AxesImage at 0x7fbbc18aa400>
```



[44]:
```
x_test, y_test = next(validation_generator)
```

[73]:
```
# dictionary init
overview_dict = {}
eval_dict = {}

# fill the following -
# for overview
#string
kind = 'Image Data'
#tuple
dimensions = shape
```

```
#labels : str(list of unique target values)
targets = list(train_generator.class_indices.values())
#nd.array
data = sample
#nd.array or class_names
labels = ['elliptical','lenticular','spiral']

vars0 = ['kind','dimensions', 'targets', 'data', 'labels']

# filling overview_dict
for x in vars0:
    try:
        overview_dict[x] = eval(x)
    except:
        overview_dict[x] = x

# evaluate_dict

eval_dict = {'test_cases' : x_test, 'true': y_test, 'class_names':␣
 ↪list(validation_generator.class_indices.keys())  ,'model':'/
 ↪inceptionv3-model.h5'}
```

[77]:
```
import pickle
# dump 1
with open(overview_path,'wb') as f:
    pickle.dump(overview_dict,f)

# dump 2
with open(eval_path,'wb') as f:
    pickle.dump(eval_dict,f)
```

[ ]:
```
# desc-----string
# project_name-----string
# framework-----string
# prediction_type-----string
# network_type-----string
# architecture-----model()
# layers-----int
# hidden_units-----int
# activations-----string(list)
# epochs-----int
# metrics-----string(list)
# loss-----string
# optimiser-----string
# learning_rate-----float
# batch_size-----int/string
# train_performance-----float
```

```
# test_performance-----float
# classification_report-----string
# elapsed-----float
# summary-----string
# ipynb-----path
# plots-----path
```

[81]:
```
inceptionNet.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
inception_v3 (Functional)    (None, 4, 4, 2048)        21802784
_________________________________________________________________
flatten_3 (Flatten)          (None, 32768)             0
_________________________________________________________________
dense_12 (Dense)             (None, 512)               16777728
_________________________________________________________________
dropout_6 (Dropout)          (None, 512)               0
_________________________________________________________________
dense_13 (Dense)             (None, 256)               131328
_________________________________________________________________
dense_14 (Dense)             (None, 64)                16448
_________________________________________________________________
dropout_7 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_15 (Dense)             (None, 3)                 195
=================================================================
Total params: 38,728,483
Trainable params: 16,925,699
Non-trainable params: 21,802,784
_________________________________________________________________
```

[82]:
```
synopsis = '''Considering my computation limitations as well as being a␣
↪neophyte to use pre-trained networks, working on this project was quite␣
↪challenging for me. This dataset was sliced down to a considerable amount to␣
↪train an InceptionV3 with Imagenet weights. This implementation shows the␣
↪quick efficiency that Transfer Learning delivers. My analogy for only␣
↪getting a 60% accuracy is ideally because of using only 500 samples of each␣
↪class instead of the original amount which is over 5000 samples for each␣
↪class.'''
```

[94]:
```

```

```
desc = '''The Galaxy Zoo Project is an ensembled collection of Images of␣
 ↪different classes of Galaxies cateogorised based on their Morphology. Data␣
 ↪collection is a part of Sloan Digital Sky Survey. six categories include -␣
 ↪elliptical, clockwise spiral, anticlockwise spiral, edge-on , lenticular, or␣
 ↪merger.'''
project_name = 'Galaxy Classification'
framework = 'Keras'
prediction_type = 'Classification of 3 Classes'
network_type = 'INCEPTION-V3'
architecture = str(inceptionNet.summary())
layers = 'InceptionV3 (48) + 7 Layers'
hidden_units = 'None'
activations = "['relu','softmax']"
epochs = '30, with earlystopping(patience=3) - trained for 8 epochs'
metrics = 'Accuracy'
loss = 'Categorical Cross-Entropy'
optimiser = 'Adam'
learning_rate = 0.001
batch_size = 64
train_performance = '64.32%'
test_performance = '64.46%'
classification_report = 'None'
elapsed = '23.4 Mins'
summary = synopsis
ipynb = './Projects/galaxy-classifier/galaxy-classifier-Inceptionv3.ipynb'
plots = './Projects/galaxy-classifier/Plots'
```

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
inception_v3 (Functional)    (None, 4, 4, 2048)        21802784
_________________________________________________________________
flatten_3 (Flatten)          (None, 32768)             0
_________________________________________________________________
dense_12 (Dense)             (None, 512)               16777728
_________________________________________________________________
dropout_6 (Dropout)          (None, 512)               0
_________________________________________________________________
dense_13 (Dense)             (None, 256)               131328
_________________________________________________________________
dense_14 (Dense)             (None, 64)                16448
_________________________________________________________________
dropout_7 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_15 (Dense)             (None, 3)                 195
=================================================================
```

```
Total params: 38,728,483
Trainable params: 16,925,699
Non-trainable params: 21,802,784
_________________________________________________________________
```

[95]:
```
var = ['desc','project_name', 'framework','prediction_type','network_type',
'architecture','layers','hidden_units','activations','epochs',
'metrics','loss','optimiser','learning_rate','batch_size','train_performance','test_performanc
,'ipynb','plots']
param = {}
for val in var:

    try:
        param[val] = eval(val)

    except:
        param[val] = val
```

[103]:
```
param
```

[103]:
```
{'desc': 'The Galaxy Zoo Project is an ensembled collection of Images of
different classes of Galaxies cateogorised based on their Morphology. Data
collection is a part of Sloan Digital Sky Survey. six categories include -
elliptical, clockwise spiral, anticlockwise spiral, edge-on , lenticular, or
merger.',
 'project_name': 'Galaxy Classification',
 'framework': 'Keras',
 'prediction_type': 'Classification of 3 Classes',
 'network_type': 'INCEPTION-V3',
 'architecture': '\nModel: "sequential_3"\n_____________________________________
_____________________________\nLayer (type)                 Output Shape
Param #   \n=================================================================\ni
nception_v3 (Functional)    (None, 4, 4, 2048)        21802784
\n_____________________________________________________________________\nflatten_3
(Flatten)          (None, 32768)             0
\n_____________________________________________________________________\ndense_12
(Dense)             (None, 512)               16777728
\n_____________________________________________________________________\ndropout_6
(Dropout)          (None, 512)               0
\n_____________________________________________________________________\ndense_13
(Dense)             (None, 256)               131328
\n_____________________________________________________________________\ndense_14
(Dense)             (None, 64)                16448
\n_____________________________________________________________________\ndropout_7
(Dropout)          (None, 64)                0
\n_____________________________________________________________________\ndense_15
(Dense)             (None, 3)                 195
```

\n===\nTotal params: 38,728,483\nTrainable params: 16,925,699\nNon-trainable params: 21,802,784\n____\n\n',
 'layers': 'InceptionV3 (48) + 7 Layers',
 'hidden_units': 'None',
 'activations': "['relu','softmax']",
 'epochs': '30, with earlystopping(patience=3) - trained for 8 epochs',
 'metrics': 'Accuracy',
 'loss': 'Categorical Cross-Entropy',
 'optimiser': 'Adam',
 'learning_rate': 0.001,
 'batch_size': 64,
 'train_performance': '64.32%',
 'test_performance': '64.46%',
 'classification_report': 'None',
 'elapsed': '23.4 Mins',
 'summary': 'Considering my computation limitations as well as being a neophyte to use pre-trained networks, working on this project was quite challenging for me. This dataset was sliced down to a considerable amount to train an InceptionV3 with Imagenet weights. This implementation shows the quick efficiency that Transfer Learning delivers. My analogy for only getting a 60% accuracy is ideally because of using only 500 samples of each class instead of the original amount which is over 5000 samples for each class.',
 'ipynb': './Projects/galaxy-classifier/galaxy-classifier-Inceptionv3.ipynb',
 'plots': './Projects/galaxy-classifier/Plots'}

[ ]: