In [6]:

```
# This Python 3 environment comes with many helpful analytics libraries installed
# It is defined by the kaggle/python Docker image: https://github.com/kaggle/docker-pytho
n
# For example, here's several helpful packages to load

import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)

# Input data files are available in the read-only "../input/" directory
# For example, running this (by clicking run or pressing Shift+Enter) will list all files
under the input directory

dr_name=[]
fl_names=[]
fl_name=[]
path=[]
import os
for dirname, _, filenames in os.walk('/kaggle/input'):
    dr_name.append(dirname)
    fl_names.append(filenames)

    for filename in filenames:
        fl_name.append(filename)
        a=os.path.join(dirname, filename)
        path.append(a)

# You can write up to 20GB to the current directory (/kaggle/working/) that gets preserve
d as output when you create a version using "Save & Run All"
# You can also write temporary files to /kaggle/temp/, but they won't be saved outside of
the current session
```

In [3]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
import os
import itertools

from glob import glob
from PIL import Image
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix, plot_confusion_matrix
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout, Flatten, Conv2D, MaxPool2D
from tensorflow.keras import backend as K
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.callbacks import EarlyStopping, ReduceLROnPlateau
from keras.utils.vis_utils import plot_model
```

In [5]:

```
df = pd.read_csv('../input/skin-cancer-mnist-ham10000/HAM10000_metadata.csv')
df.head()
```

Out[5]:

	lesion_id	image_id	dx	dx_type	age	sex	localization
0	HAM_0000118	ISIC_0027419	bkl	histo	80.0	male	scalp
1	HAM_0000118	ISIC_0025030	bkl	histo	80.0	male	scalp

	lesion_id	image_id	dx	dx_type	age	sex	localization
2	HAM_0002730	ISIC_0026769	bkl	histo	80.0	male	scalp
3	HAM_0002730	ISIC_0025661	bkl	histo	80.0	male	scalp
4	HAM_0001466	ISIC_0031633	bkl	histo	75.0	male	ear

In [6]:

```
df[df['image_id']=='ISIC_0031633']
```

Out[6]:

	lesion_id	image_id	dx	dx_type	age	sex	localization
4	HAM_0001466	ISIC_0031633	bkl	histo	75.0	male	ear

In [7]:

```
df.head(10)
```

Out[7]:

	lesion_id	image_id	dx	dx_type	age	sex	localization
0	HAM_0000118	ISIC_0027419	bkl	histo	80.0	male	scalp
1	HAM_0000118	ISIC_0025030	bkl	histo	80.0	male	scalp
2	HAM_0002730	ISIC_0026769	bkl	histo	80.0	male	scalp
3	HAM_0002730	ISIC_0025661	bkl	histo	80.0	male	scalp
4	HAM_0001466	ISIC_0031633	bkl	histo	75.0	male	ear
5	HAM_0001466	ISIC_0027850	bkl	histo	75.0	male	ear
6	HAM_0002761	ISIC_0029176	bkl	histo	60.0	male	face
7	HAM_0002761	ISIC_0029068	bkl	histo	60.0	male	face
8	HAM_0005132	ISIC_0025837	bkl	histo	70.0	female	back
9	HAM_0005132	ISIC_0025209	bkl	histo	70.0	female	back

In [8]:

```
df['dx'].value_counts()
```

Out[8]:

```
nv        6705
mel       1113
bkl       1099
bcc        514
akiec      327
vasc       142
df         115
Name: dx, dtype: int64
```

In [9]:

```
df['dx']
```

Out[9]:

```
0          bkl
1          bkl
2          bkl
3          bkl
4          bkl
         ...
10010    akiec
10011    akiec
10012    akiec
10013    akiec
10014      mel
Name: dx, Length: 10015, dtype: object
```

```
Name: dx, Length: 10015, dtype: object
```

In [10]:

```
labels_dictionary_dx_num = {'nv':0, 'mel':1, 'bkl':2, 'bcc':3, 'akiec':4, 'vasc':5, 'df'
:6}
```

In [11]:

```
lesion_type_dict = {
    'nv': 'Melanocytic nevi',
    'mel': 'Melanoma',
    'bkl': 'Benign keratosis-like lesions ',
    'bcc': 'Basal cell carcinoma',
    'akiec': 'Actinic keratoses',
    'vasc': 'Vascular lesions',
    'df': 'Dermatofibroma'
}
```

In [12]:

```
base_skin_dir = '../input/skin-cancer-mnist-ham10000'
imageid_path_dict = {os.path.splitext(os.path.basename(x))[0]: x
                     for x in glob(os.path.join(base_skin_dir, '*', '*.jpg'))}
print(type(imageid_path_dict))
```

```
<class 'dict'>
```

In [13]:

```
df['path'] = df['image_id'].map(imageid_path_dict.get)
df['cell_type'] = df['dx'].map(lesion_type_dict.get)
df['cell_type_idx'] = pd.Categorical(df['cell_type']).codes

print(df['path'][10],"   ",df['image_id'][10])
print(len(df['path']))
```

```
../input/skin-cancer-mnist-ham10000/ham10000_images_part_1/ISIC_0025276.jpg     ISIC_0025
276
10015
```

In [14]:

```
from PIL import Image as pl
im = pl.open("../input/skin-cancer-mnist-ham10000/ham10000_images_part_1/ISIC_0025276.jpg
")
im=np.array(im)
print(im.shape)
```

```
(450, 600, 3)
```

In [15]:

```
labels = [labels_dictionary_dx_num[i] for i in df['dx']]
print(len(labels))
```

```
10015
```

In [16]:

```
df.isna().sum()
df['age'].fillna((df['age'].mean()), inplace=True)
df.isna().sum().sum()
```

Out[16]:

```
0
```

In [17]:

```
from PIL import Image
print(len(df['path']))
```

```
data = []

for image_path in df['path']:
    image = Image.open(image_path)
    image_resised_71_71=image.resize((71,71))
    image_resised_71_71 = np.array(image_resised_71_71)
#     image_resised_224_224=image.resize((224,224))
#     image_resised_256_256=image.resize((256,256))
#     image_resised_100_100 = np.array(image_resised_100_100)
#     image_resised_224_224 = np.array(image_resised_224_224)
#     image_resised_256_256 = np.array(image_resised_256_256)
    data.append(image_resised_71_71)
```

```
10015
```

In [18]:

```
print(df['path'])
```

```
0        ../input/skin-cancer-mnist-ham10000/ham10000_i...
1        ../input/skin-cancer-mnist-ham10000/ham10000_i...
2        ../input/skin-cancer-mnist-ham10000/ham10000_i...
3        ../input/skin-cancer-mnist-ham10000/ham10000_i...
4        ../input/skin-cancer-mnist-ham10000/ham10000_i...
                                ...
10010    ../input/skin-cancer-mnist-ham10000/ham10000_i...
10011    ../input/skin-cancer-mnist-ham10000/ham10000_i...
10012    ../input/skin-cancer-mnist-ham10000/ham10000_i...
10013    ../input/skin-cancer-mnist-ham10000/ham10000_i...
10014    ../input/skin-cancer-mnist-ham10000/ham10000_i...
Name: path, Length: 10015, dtype: object
```

In [17]:

```
image = Image.open(df['path'][4])
    image=image.resize((100,100))
    imageoo=np.array(image)
```

In [19]:

```
print(len(data))
print(len(labels))
print(data[0].shape)
print(data[5].shape)
```

```
10015
10015
(71, 71, 3)
(71, 71, 3)
```

In [65]:

```
import csv
import numpy as np
from PIL import Image

with open("data.csv", mode="w") as file:
    writer = csv.writer(file, delimiter=",", quotechar='"', quoting=csv.QUOTE_MINIMAL)
    for filename, label in zip(data, labels):

        row_vector = filename.reshape(1, -1)

        # write the label and row vector to the file
        writer.writerow(row_vector.tolist()[0]+[label])
```

In [66]:

```
red=pd.read_csv("/kaggle/working/data.csv")
red.head()
```

Out[66]:

	190	153	195	192	155	197	191	153.1	196	192.1	...	187.289	157.311	185.333	186.292	158.309	186.293	179.301	149
0	24	13	22	24	14	24	25	14	28	30	...	27	15	29	26	14	26	23	
1	186	128	137	190	134	148	194	137	151	198	...	146	114	124	128	94	96	107	
2	24	11	17	25	12	22	36	21	30	53	...	26	12	16	24	11	16	23	
3	132	89	112	146	101	124	158	114	138	171	...	109	77	92	83	53	69	54	
4	4	0	1	6	0	2	9	1	4	11	...	4	0	0	4	0	0	4	

5 rows × 30001 columns

In [68]:

```
# define the column names as a list
column_names = ["pixel{}".format(i+1) for i in range(red.shape[1]-1)]+["label"]

# assign the column names to the DataFrame
red.columns = column_names

# write the DataFrame back to the CSV file
red.to_csv("data_columns_labels.csv", index=False)
```

In [71]:

```
res=pd.read_csv("data_columns_labels.csv")
red.head(5)
```

Out[71]:

	pixel1	pixel2	pixel3	pixel4	pixel5	pixel6	pixel7	pixel8	pixel9	pixel10	...	pixel29992	pixel29993	pixel29994	pixel2999
0	24	13	22	24	14	24	25	14	28	30	...	27	15	29	26
1	186	128	137	190	134	148	194	137	151	198	...	146	114	124	128
2	24	11	17	25	12	22	36	21	30	53	...	26	12	16	24
3	132	89	112	146	101	124	158	114	138	171	...	109	77	92	83
4	4	0	1	6	0	2	9	1	4	11	...	4	0	0	4

5 rows × 30001 columns

In [20]:

```
data=np.array(data)
labels=np.array(labels)
print(data.shape)
print(labels.shape)
```

```
(10015, 71, 71, 3)
(10015,)
```

In [21]:

```
X_train,X_test,Y_train,Y_test = train_test_split(data, labels, test_size=0.2, random_sta
te=49)
```

In [22]:

```
print(X_train.shape)
print(X_test.shape)
print(Y_test.shape)
print(Y_test.shape)
```

```
(8012, 71, 71, 3)
(2003, 71, 71, 3)
(2003,)
(2003,)
```

```
(2005,)
```

In [24]:

```
# scaling the data

X_train_scaled = X_train/255

X_test_scaled = X_test/255
```

In [25]:

```
import tensorflow as tf
from tensorflow import keras
```

In [26]:

```
num_of_classes = 7

# setting up the layers of Neural Network

model = keras.Sequential([

    keras.layers.Flatten(input_shape=(71,71,3)),
    keras.layers.Dense(64, activation='relu'),
    keras.layers.Dense(num_of_classes, activation='softmax')
])
```

In [27]:

```
# compile the neural network
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['acc'])
```

In [28]:

```
# training the neural network
model.fit(X_train_scaled, Y_train, validation_split=0.1, epochs=10)
```

```
Epoch 1/10
226/226 [==============================] - 5s 5ms/step - loss: 1.4694 - acc: 0.6506 - val
_loss: 1.0756 - val_acc: 0.6671
Epoch 2/10
226/226 [==============================] - 1s 4ms/step - loss: 1.0090 - acc: 0.6692 - val
_loss: 1.1351 - val_acc: 0.6646
Epoch 3/10
226/226 [==============================] - 1s 4ms/step - loss: 0.9881 - acc: 0.6720 - val
_loss: 1.0421 - val_acc: 0.6683
Epoch 4/10
226/226 [==============================] - 1s 4ms/step - loss: 0.9678 - acc: 0.6731 - val
_loss: 1.1016 - val_acc: 0.6696
Epoch 5/10
226/226 [==============================] - 1s 4ms/step - loss: 0.9388 - acc: 0.6745 - val
_loss: 1.0800 - val_acc: 0.6259
Epoch 6/10
226/226 [==============================] - 1s 5ms/step - loss: 0.9466 - acc: 0.6759 - val
_loss: 1.1725 - val_acc: 0.6696
Epoch 7/10
226/226 [==============================] - 1s 4ms/step - loss: 0.9552 - acc: 0.6735 - val
_loss: 0.9561 - val_acc: 0.6683
Epoch 8/10
226/226 [==============================] - 1s 4ms/step - loss: 0.9336 - acc: 0.6757 - val
_loss: 0.9561 - val_acc: 0.6733
Epoch 9/10
226/226 [==============================] - 1s 4ms/step - loss: 0.9242 - acc: 0.6764 - val
_loss: 0.9684 - val_acc: 0.6721
Epoch 10/10
226/226 [==============================] - 1s 4ms/step - loss: 0.9222 - acc: 0.6816 - val
_loss: 0.9432 - val_acc: 0.6683
```

Out[28]:

```
<keras.callbacks.History at 0x7fc9085c2390>
```

In [29]:

```
from tensorflow.keras import Sequential, models, layers
from tensorflow.keras.layers import Dense, Dropout, Flatten
from tensorflow.keras.layers import BatchNormalization
from tensorflow.keras.models import load_model
from tensorflow.keras.models import Model
from tensorflow.keras.applications.resnet50 import ResNet50
from tensorflow.keras import optimizers
```

In [41]:

```
convolutional_base = ResNet50(weights='imagenet', include_top=False, input_shape=(284,284
,3))
convolutional_base.summary()
```

```
Model: "resnet50"
__________________________________________________________________________________________
_________
 Layer (type)                   Output Shape         Param #     Connected to

==========================================================================================
=========
 input_2 (InputLayer)           [(None, 284, 284, 3  0           []
                                )]


 conv1_pad (ZeroPadding2D)      (None, 290, 290, 3)  0           ['input_2[0][0]']


 conv1_conv (Conv2D)            (None, 142, 142, 64  9472        ['conv1_pad[0][0]']
                                )


 conv1_bn (BatchNormalization)  (None, 142, 142, 64  256         ['conv1_conv[0][0]']
                                )


 conv1_relu (Activation)        (None, 142, 142, 64  0           ['conv1_bn[0][0]']
                                )


 pool1_pad (ZeroPadding2D)      (None, 144, 144, 64  0           ['conv1_relu[0][0]']
                                )


 pool1_pool (MaxPooling2D)      (None, 71, 71, 64)   0           ['pool1_pad[0][0]']


 conv2_block1_1_conv (Conv2D)   (None, 71, 71, 64)   4160        ['pool1_pool[0][0]']


 conv2_block1_1_bn (BatchNormal  (None, 71, 71, 64)  256         ['conv2_block1_1_conv[0]
[0]']
 ization)
 conv2_block1_1_relu (Activatio  (None, 71, 71, 64)  0           ['conv2_block1_1_bn[0][0
]']
 n)



 conv2_block1_2_conv (Conv2D)   (None, 71, 71, 64)   36928       ['conv2_block1_1_relu[0]
[0]']

 conv2_block1_2_bn (BatchNormal  (None, 71, 71, 64)  256         ['conv2_block1_2_conv[0]
[0]']
 ization)



 conv2_block1_2_relu (Activatio  (None, 71, 71, 64)  0           ['conv2_block1_2_bn[0][0
]']
 n)



 conv2_block1_0_conv (Conv2D)   (None, 71, 71, 256)  16640       ['pool1_pool[0][0]']



 conv2_block1_3_conv (Conv2D)   (None, 71, 71, 256)  16640       ['conv2_block1_2_relu[0]
[0]']

 conv2_block1_0_bn (BatchNormal  (None, 71, 71, 256)  1024       ['conv2_block1_0_conv[0]
[0]']
 ization)



 conv2_block1_3_bn (BatchNormal  (None, 71, 71, 256)  1024       ['conv2_block1_3_conv[0]
[0]']
 ization)



 conv2_block1_add (Add)         (None, 71, 71, 256)  0           ['conv2_block1_0_bn[0][
0]',
                                                                  'conv2_block1_3_bn[0]
[0]']

 conv2_block1_out (Activation)  (None, 71, 71, 256)  0           ['conv2_block1_add[0][0]
']

 conv2_block2_1_conv (Conv2D)   (None, 71, 71, 64)   16448       ['conv2_block1_out[0][0]
']

 conv2_block2_1_bn (BatchNormal  (None, 71, 71, 64)  256         ['conv2_block2_1_conv[0]
[0]']
 ization)



 conv2_block2_1_relu (Activatio  (None, 71, 71, 64)  0           ['conv2_block2_1_bn[0][0
]']
 n)



 conv2_block2_2_conv (Conv2D)   (None, 71, 71, 64)   36928       ['conv2_block2_1_relu[0]
[0]']
```

```
 conv2_block2_2_bn (BatchNormal  (None, 71, 71, 64)  256         ['conv2_block2_2_conv[0]
[0]']
 ization)



 conv2_block2_2_relu (Activatio  (None, 71, 71, 64)  0           ['conv2_block2_2_bn[0][0
]']
 n)



 conv2_block2_3_conv (Conv2D)   (None, 71, 71, 256)  16640       ['conv2_block2_2_relu[0]
[0]']


 conv2_block2_3_bn (BatchNormal  (None, 71, 71, 256)  1024       ['conv2_block2_3_conv[0]
[0]']
 ization)



 conv2_block2_add (Add)         (None, 71, 71, 256)  0           ['conv2_block1_out[0][0
]',
                                                                  'conv2_block2_3_bn[0]
[0]']


 conv2_block2_out (Activation)  (None, 71, 71, 256)  0           ['conv2_block2_add[0][0]
']


 conv2_block3_1_conv (Conv2D)   (None, 71, 71, 64)   16448       ['conv2_block2_out[0][0]
']


 conv2_block3_1_bn (BatchNormal  (None, 71, 71, 64)  256         ['conv2_block3_1_conv[0]
[0]']
 ization)



 conv2_block3_1_relu (Activatio  (None, 71, 71, 64)  0           ['conv2_block3_1_bn[0][0
]']
 n)



 conv2_block3_2_conv (Conv2D)   (None, 71, 71, 64)   36928       ['conv2_block3_1_relu[0]
[0]']


 conv2_block3_2_bn (BatchNormal  (None, 71, 71, 64)  256         ['conv2_block3_2_conv[0]
[0]']
 ization)



 conv2_block3_2_relu (Activatio  (None, 71, 71, 64)  0           ['conv2_block3_2_bn[0][0
]']
 n)



 conv2_block3_3_conv (Conv2D)   (None, 71, 71, 256)  16640       ['conv2_block3_2_relu[0]
[0]']


 conv2_block3_3_bn (BatchNormal  (None, 71, 71, 256)  1024       ['conv2_block3_3_conv[0]
[0]']
```

```
 ization)



 conv2_block3_add (Add)         (None, 71, 71, 256)  0            ['conv2_block2_out[0][0
]',
                                                                   'conv2_block3_3_bn[0]
[0]']


 conv2_block3_out (Activation)  (None, 71, 71, 256)  0            ['conv2_block3_add[0][0]
']


 conv3_block1_1_conv (Conv2D)   (None, 36, 36, 128)  32896        ['conv2_block3_out[0][0]
']


 conv3_block1_1_bn (BatchNormal  (None, 36, 36, 128)  512         ['conv3_block1_1_conv[0]
[0]']
 ization)



 conv3_block1_1_relu (Activatio  (None, 36, 36, 128)  0           ['conv3_block1_1_bn[0][0
]']
 n)



 conv3_block1_2_conv (Conv2D)   (None, 36, 36, 128)  147584       ['conv3_block1_1_relu[0]
[0]']


 conv3_block1_2_bn (BatchNormal  (None, 36, 36, 128)  512         ['conv3_block1_2_conv[0]
[0]']
 ization)



 conv3_block1_2_relu (Activatio  (None, 36, 36, 128)  0           ['conv3_block1_2_bn[0][0
]']
 n)



 conv3_block1_0_conv (Conv2D)   (None, 36, 36, 512)  131584       ['conv2_block3_out[0][0]
']


 conv3_block1_3_conv (Conv2D)   (None, 36, 36, 512)  66048        ['conv3_block1_2_relu[0]
[0]']


 conv3_block1_0_bn (BatchNormal  (None, 36, 36, 512)  2048        ['conv3_block1_0_conv[0]
[0]']
 ization)



 conv3_block1_3_bn (BatchNormal  (None, 36, 36, 512)  2048        ['conv3_block1_3_conv[0]
[0]']
 ization)



 conv3_block1_add (Add)         (None, 36, 36, 512)  0            ['conv3_block1_0_bn[0][
0]',
                                                                   'conv3_block1_3_bn[0]
[0]']
```

```
 conv3_block1_out (Activation)  (None, 36, 36, 512)  0           ['conv3_block1_add[0][0]
']


 conv3_block2_1_conv (Conv2D)   (None, 36, 36, 128)  65664       ['conv3_block1_out[0][0]
']


 conv3_block2_1_bn (BatchNormal  (None, 36, 36, 128)  512        ['conv3_block2_1_conv[0]
[0]']
 ization)



 conv3_block2_1_relu (Activatio  (None, 36, 36, 128)  0          ['conv3_block2_1_bn[0][0
]']
 n)



 conv3_block2_2_conv (Conv2D)   (None, 36, 36, 128)  147584      ['conv3_block2_1_relu[0]
[0]']


 conv3_block2_2_bn (BatchNormal  (None, 36, 36, 128)  512        ['conv3_block2_2_conv[0]
[0]']
 ization)



 conv3_block2_2_relu (Activatio  (None, 36, 36, 128)  0          ['conv3_block2_2_bn[0][0
]']
 n)



 conv3_block2_3_conv (Conv2D)   (None, 36, 36, 512)  66048       ['conv3_block2_2_relu[0]
[0]']


 conv3_block2_3_bn (BatchNormal  (None, 36, 36, 512)  2048       ['conv3_block2_3_conv[0]
[0]']
 ization)



 conv3_block2_add (Add)         (None, 36, 36, 512)  0           ['conv3_block1_out[0][0
]',
                                                                  'conv3_block2_3_bn[0]
[0]']


 conv3_block2_out (Activation)  (None, 36, 36, 512)  0           ['conv3_block2_add[0][0]
']


 conv3_block3_1_conv (Conv2D)   (None, 36, 36, 128)  65664       ['conv3_block2_out[0][0]
']


 conv3_block3_1_bn (BatchNormal  (None, 36, 36, 128)  512        ['conv3_block3_1_conv[0]
[0]']
 ization)



 conv3_block3_1_relu (Activatio  (None, 36, 36, 128)  0          ['conv3_block3_1_bn[0][0
]']
 n)
 conv3_block3_2_conv (Conv2D)   (None, 36, 36, 128)  147584      ['conv3_block3_1_relu[0]
[0]']


 conv3_block3_2_bn (BatchNormal  (None, 36, 36, 128)  512         ['conv3_block3_2_conv[0]
[0]']
 ization)



 conv3_block3_2_relu (Activatio  (None, 36, 36, 128)  0           ['conv3_block3_2_bn[0][0
]']
 n)



 conv3_block3_3_conv (Conv2D)   (None, 36, 36, 512)  66048       ['conv3_block3_2_relu[0]
[0]']


 conv3_block3_3_bn (BatchNormal  (None, 36, 36, 512)  2048        ['conv3_block3_3_conv[0]
[0]']
 ization)



 conv3_block3_add (Add)         (None, 36, 36, 512)  0           ['conv3_block2_out[0][0
]',
                                                                  'conv3_block3_3_bn[0]
[0]']


 conv3_block3_out (Activation)  (None, 36, 36, 512)  0           ['conv3_block3_add[0][0]
']


 conv3_block4_1_conv (Conv2D)   (None, 36, 36, 128)  65664       ['conv3_block3_out[0][0]
']


 conv3_block4_1_bn (BatchNormal  (None, 36, 36, 128)  512         ['conv3_block4_1_conv[0]
[0]']
 ization)



 conv3_block4_1_relu (Activatio  (None, 36, 36, 128)  0           ['conv3_block4_1_bn[0][0
]']
 n)



 conv3_block4_2_conv (Conv2D)   (None, 36, 36, 128)  147584      ['conv3_block4_1_relu[0]
[0]']


 conv3_block4_2_bn (BatchNormal  (None, 36, 36, 128)  512         ['conv3_block4_2_conv[0]
[0]']
 ization)



 conv3_block4_2_relu (Activatio  (None, 36, 36, 128)  0           ['conv3_block4_2_bn[0][0
]']
 n)



 conv3_block4_3_conv (Conv2D)   (None, 36, 36, 512)  66048       ['conv3_block4_2_relu[0]
[0]']
```

```
 conv3_block4_3_bn (BatchNormal  (None, 36, 36, 512)  2048        ['conv3_block4_3_conv[0]
[0]']
 ization)


 conv3_block4_add (Add)         (None, 36, 36, 512)  0           ['conv3_block3_out[0][0
]',
                                                                  'conv3_block4_3_bn[0]
[0]']

 conv3_block4_out (Activation)  (None, 36, 36, 512)  0           ['conv3_block4_add[0][0]
']

 conv4_block1_1_conv (Conv2D)   (None, 18, 18, 256)  131328      ['conv3_block4_out[0][0]
']

 conv4_block1_1_bn (BatchNormal  (None, 18, 18, 256)  1024        ['conv4_block1_1_conv[0]
[0]']
 ization)


 conv4_block1_1_relu (Activatio  (None, 18, 18, 256)  0           ['conv4_block1_1_bn[0][0
]']
 n)


 conv4_block1_2_conv (Conv2D)   (None, 18, 18, 256)  590080      ['conv4_block1_1_relu[0]
[0]']

 conv4_block1_2_bn (BatchNormal  (None, 18, 18, 256)  1024        ['conv4_block1_2_conv[0]
[0]']
 ization)


 conv4_block1_2_relu (Activatio  (None, 18, 18, 256)  0           ['conv4_block1_2_bn[0][0
]']
 n)


 conv4_block1_0_conv (Conv2D)   (None, 18, 18, 1024  525312      ['conv3_block4_out[0][0]
']
                                )


 conv4_block1_3_conv (Conv2D)   (None, 18, 18, 1024  263168      ['conv4_block1_2_relu[0]
[0]']
                                )


 conv4_block1_0_bn (BatchNormal  (None, 18, 18, 1024  4096        ['conv4_block1_0_conv[0]
[0]']
 ization)                       )


 conv4_block1_3_bn (BatchNormal  (None, 18, 18, 1024  4096        ['conv4_block1_3_conv[0]
[0]']
 ization)                       )
 conv4_block1_add (Add)         (None, 18, 18, 1024  0           ['conv4_block1_0_bn[0][
0]',
                                )                                 'conv4_block1_3_bn[0]
[0]']

 conv4_block1_out (Activation)  (None, 18, 18, 1024  0           ['conv4_block1_add[0][0]
']
                                )


 conv4_block2_1_conv (Conv2D)   (None, 18, 18, 256)  262400      ['conv4_block1_out[0][0]
']

 conv4_block2_1_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block2_1_conv[0]
[0]']
 ization)


 conv4_block2_1_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block2_1_bn[0][0
]']
 n)


 conv4_block2_2_conv (Conv2D)   (None, 18, 18, 256)  590080      ['conv4_block2_1_relu[0]
[0]']

 conv4_block2_2_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block2_2_conv[0]
[0]']
 ization)


 conv4_block2_2_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block2_2_bn[0][0
]']
 n)


 conv4_block2_3_conv (Conv2D)   (None, 18, 18, 1024  263168      ['conv4_block2_2_relu[0]
[0]']
                                )


 conv4_block2_3_bn (BatchNormal  (None, 18, 18, 1024  4096       ['conv4_block2_3_conv[0]
[0]']
 ization)                       )


 conv4_block2_add (Add)         (None, 18, 18, 1024  0           ['conv4_block1_out[0][0
]',
                                )                                 'conv4_block2_3_bn[0]
[0]']

 conv4_block2_out (Activation)  (None, 18, 18, 1024  0           ['conv4_block2_add[0][0]
']
                                )


 conv4_block3_1_conv (Conv2D)   (None, 18, 18, 256)  262400      ['conv4_block2_out[0][0]
']
```

```
 conv4_block3_1_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block3_1_conv[0]
[0]']
 ization)



 conv4_block3_1_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block3_1_bn[0][0
]']
 n)



 conv4_block3_2_conv (Conv2D)   (None, 18, 18, 256)  590080     ['conv4_block3_1_relu[0]
[0]']


 conv4_block3_2_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block3_2_conv[0]
[0]']
 ization)



 conv4_block3_2_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block3_2_bn[0][0
]']
 n)



 conv4_block3_3_conv (Conv2D)   (None, 18, 18, 1024  263168     ['conv4_block3_2_relu[0]
[0]']
                                )



 conv4_block3_3_bn (BatchNormal  (None, 18, 18, 1024  4096       ['conv4_block3_3_conv[0]
[0]']
 ization)                       )



 conv4_block3_add (Add)         (None, 18, 18, 1024  0          ['conv4_block2_out[0][0
]',
                                )                                 'conv4_block3_3_bn[0]
[0]']


 conv4_block3_out (Activation)  (None, 18, 18, 1024  0          ['conv4_block3_add[0][0]
']
                                )



 conv4_block4_1_conv (Conv2D)   (None, 18, 18, 256)  262400     ['conv4_block3_out[0][0]
']


 conv4_block4_1_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block4_1_conv[0]
[0]']
 ization)



 conv4_block4_1_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block4_1_bn[0][0
]']
 n)



 conv4_block4_2_conv (Conv2D)   (None, 18, 18, 256)  590080     ['conv4_block4_1_relu[0]
[0]']
```

```
 conv4_block4_2_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block4_2_conv[0]
[0]']
 ization)


 conv4_block4_2_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block4_2_bn[0][0
]']
 n)


 conv4_block4_3_conv (Conv2D)   (None, 18, 18, 1024  263168      ['conv4_block4_2_relu[0]
[0]']
                                )


 conv4_block4_3_bn (BatchNormal  (None, 18, 18, 1024  4096       ['conv4_block4_3_conv[0]
[0]']
 ization)                       )


 conv4_block4_add (Add)         (None, 18, 18, 1024  0           ['conv4_block3_out[0][0
]',
                                )                                 'conv4_block4_3_bn[0]
[0]']

 conv4_block4_out (Activation)  (None, 18, 18, 1024  0           ['conv4_block4_add[0][0]
']
                                )


 conv4_block5_1_conv (Conv2D)   (None, 18, 18, 256)  262400      ['conv4_block4_out[0][0]
']

 conv4_block5_1_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block5_1_conv[0]
[0]']
 ization)


 conv4_block5_1_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block5_1_bn[0][0
]']
 n)


 conv4_block5_2_conv (Conv2D)   (None, 18, 18, 256)  590080      ['conv4_block5_1_relu[0]
[0]']

 conv4_block5_2_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block5_2_conv[0]
[0]']
 ization)


 conv4_block5_2_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block5_2_bn[0][0
]']
 n)


 conv4_block5_3_conv (Conv2D)   (None, 18, 18, 1024  263168      ['conv4_block5_2_relu[0]
[0]']
                                )
 conv4_block5_3_bn (BatchNormal  (None, 18, 18, 1024  4096       ['conv4_block5_3_conv[0]
[0]']
 ization)                       )


 conv4_block5_add (Add)         (None, 18, 18, 1024  0          ['conv4_block4_out[0][0
]',
                                )                                'conv4_block5_3_bn[0]
[0]']

 conv4_block5_out (Activation)  (None, 18, 18, 1024  0          ['conv4_block5_add[0][0]
']
                                )


 conv4_block6_1_conv (Conv2D)   (None, 18, 18, 256)  262400     ['conv4_block5_out[0][0]
']

 conv4_block6_1_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block6_1_conv[0]
[0]']
 ization)


 conv4_block6_1_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block6_1_bn[0][0
]']
 n)


 conv4_block6_2_conv (Conv2D)   (None, 18, 18, 256)  590080     ['conv4_block6_1_relu[0]
[0]']

 conv4_block6_2_bn (BatchNormal  (None, 18, 18, 256)  1024       ['conv4_block6_2_conv[0]
[0]']
 ization)


 conv4_block6_2_relu (Activatio  (None, 18, 18, 256)  0          ['conv4_block6_2_bn[0][0
]']
 n)


 conv4_block6_3_conv (Conv2D)   (None, 18, 18, 1024  263168     ['conv4_block6_2_relu[0]
[0]']
                                )


 conv4_block6_3_bn (BatchNormal  (None, 18, 18, 1024  4096       ['conv4_block6_3_conv[0]
[0]']
 ization)                       )


 conv4_block6_add (Add)         (None, 18, 18, 1024  0          ['conv4_block5_out[0][0
]',
                                )                                'conv4_block6_3_bn[0]
[0]']

 conv4_block6_out (Activation)  (None, 18, 18, 1024  0          ['conv4_block6_add[0][0]
']
```

```
                                )


 conv5_block1_1_conv (Conv2D)   (None, 9, 9, 512)    524800      ['conv4_block6_out[0][0]
']

 conv5_block1_1_bn (BatchNormal  (None, 9, 9, 512)   2048        ['conv5_block1_1_conv[0]
[0]']
 ization)


 conv5_block1_1_relu (Activatio  (None, 9, 9, 512)   0           ['conv5_block1_1_bn[0][0
]']
 n)


 conv5_block1_2_conv (Conv2D)   (None, 9, 9, 512)    2359808     ['conv5_block1_1_relu[0]
[0]']

 conv5_block1_2_bn (BatchNormal  (None, 9, 9, 512)   2048        ['conv5_block1_2_conv[0]
[0]']
 ization)


 conv5_block1_2_relu (Activatio  (None, 9, 9, 512)   0           ['conv5_block1_2_bn[0][0
]']
 n)


 conv5_block1_0_conv (Conv2D)   (None, 9, 9, 2048)   2099200     ['conv4_block6_out[0][0]
']

 conv5_block1_3_conv (Conv2D)   (None, 9, 9, 2048)   1050624     ['conv5_block1_2_relu[0]
[0]']

 conv5_block1_0_bn (BatchNormal  (None, 9, 9, 2048)  8192        ['conv5_block1_0_conv[0]
[0]']
 ization)


 conv5_block1_3_bn (BatchNormal  (None, 9, 9, 2048)  8192        ['conv5_block1_3_conv[0]
[0]']
 ization)


 conv5_block1_add (Add)         (None, 9, 9, 2048)   0           ['conv5_block1_0_bn[0][
0]',
                                                                  'conv5_block1_3_bn[0]
[0]']

 conv5_block1_out (Activation)  (None, 9, 9, 2048)   0           ['conv5_block1_add[0][0]
']

 conv5_block2_1_conv (Conv2D)   (None, 9, 9, 512)    1049088     ['conv5_block1_out[0][0]
']

 conv5_block2_1_bn (BatchNormal  (None, 9, 9, 512)   2048        ['conv5_block2_1_conv[0]
[0]']
```

```
 ization)


 conv5_block2_1_relu (Activatio  (None, 9, 9, 512)   0           ['conv5_block2_1_bn[0][0
]']
 n)


 conv5_block2_2_conv (Conv2D)   (None, 9, 9, 512)    2359808     ['conv5_block2_1_relu[0]
[0]']

 conv5_block2_2_bn (BatchNormal  (None, 9, 9, 512)   2048        ['conv5_block2_2_conv[0]
[0]']
 ization)


 conv5_block2_2_relu (Activatio  (None, 9, 9, 512)   0           ['conv5_block2_2_bn[0][0
]']
 n)


 conv5_block2_3_conv (Conv2D)   (None, 9, 9, 2048)   1050624     ['conv5_block2_2_relu[0]
[0]']

 conv5_block2_3_bn (BatchNormal  (None, 9, 9, 2048)  8192        ['conv5_block2_3_conv[0]
[0]']
 ization)


 conv5_block2_add (Add)         (None, 9, 9, 2048)   0           ['conv5_block1_out[0][0
]',
                                                                  'conv5_block2_3_bn[0]
[0]']

 conv5_block2_out (Activation)  (None, 9, 9, 2048)   0           ['conv5_block2_add[0][0]
']

 conv5_block3_1_conv (Conv2D)   (None, 9, 9, 512)    1049088     ['conv5_block2_out[0][0]
']

 conv5_block3_1_bn (BatchNormal  (None, 9, 9, 512)   2048        ['conv5_block3_1_conv[0]
[0]']
 ization)


 conv5_block3_1_relu (Activatio  (None, 9, 9, 512)   0           ['conv5_block3_1_bn[0][0
]']
 n)


 conv5_block3_2_conv (Conv2D)   (None, 9, 9, 512)    2359808     ['conv5_block3_1_relu[0]
[0]']

 conv5_block3_2_bn (BatchNormal  (None, 9, 9, 512)   2048        ['conv5_block3_2_conv[0]
[0]']
 ization)
 conv5_block3_2_relu (Activatio  (None, 9, 9, 512)   0           ['conv5_block3_2_bn[0][0
]']
 n)



 conv5_block3_3_conv (Conv2D)   (None, 9, 9, 2048)   1050624     ['conv5_block3_2_relu[0]
[0]']


 conv5_block3_3_bn (BatchNormal  (None, 9, 9, 2048)  8192        ['conv5_block3_3_conv[0]
[0]']
 ization)



 conv5_block3_add (Add)         (None, 9, 9, 2048)   0           ['conv5_block2_out[0][0
]',

                                                                  'conv5_block3_3_bn[0]
[0]']


 conv5_block3_out (Activation)  (None, 9, 9, 2048)   0           ['conv5_block3_add[0][0]
']


==========================================================================================
=========
Total params: 23,587,712
Trainable params: 23,534,592
Non-trainable params: 53,120
__________________________________________________________________________________________
_________
```

In [45]:

```
num_of_classes = 7

model = models.Sequential()
model.add(layers.UpSampling2D((2,2)))
model.add(layers.UpSampling2D((2,2)))
model.add(convolutional_base)
model.add(layers.Flatten())
model.add(layers.BatchNormalization())
model.add(layers.Dense(128, activation='relu'))
model.add(layers.Dropout(0.2))
model.add(layers.BatchNormalization())
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dropout(0.2))
model.add(layers.BatchNormalization())
model.add(layers.Dense(num_of_classes, activation='softmax'))
```

In [46]:

```
model.compile(optimizer='Adam', loss='sparse_categorical_crossentropy', metrics=['acc'])
```

In [47]:

```
history = model.fit(X_train_scaled, Y_train, validation_split=0.1, epochs=1,batch_size =
20)
```

```
361/361 [==============================] - 115s 208ms/step - loss: 1.3596 - acc: 0.5720 -
val_loss: 1.3405 - val_acc: 0.6683
```

In [49]:

```
adam = tf.keras.optimizers.Adam(learning_rate=0.01)
model.compile(optimizer=adam, loss='sparse_categorical_crossentropy', metrics=['acc'])
history = model.fit(X_train_scaled, Y_train, validation_split=0.1, epochs=10,batch_size
= 20)
```

```
Epoch 1/10
Epoch 1/10
361/361 [==============================] - 109s 206ms/step - loss: 1.0910 - acc: 0.6666 -
val_loss: 1.2488 - val_acc: 0.6683
Epoch 2/10
361/361 [==============================] - 73s 203ms/step - loss: 1.0367 - acc: 0.6681 -
val_loss: 144.9303 - val_acc: 0.6072
Epoch 3/10
361/361 [==============================] - 73s 203ms/step - loss: 1.0419 - acc: 0.6738 -
val_loss: 2.5688 - val_acc: 0.6459
Epoch 4/10
361/361 [==============================] - 73s 203ms/step - loss: 0.9573 - acc: 0.6714 -
val_loss: 0.9371 - val_acc: 0.6633
Epoch 5/10
361/361 [==============================] - 73s 202ms/step - loss: 0.9307 - acc: 0.6774 -
val_loss: 11834.2900 - val_acc: 0.4726
Epoch 6/10
361/361 [==============================] - 73s 203ms/step - loss: 0.9353 - acc: 0.6748 -
val_loss: 599517.5625 - val_acc: 0.1072
Epoch 7/10
361/361 [==============================] - 73s 202ms/step - loss: 0.9253 - acc: 0.6713 -
val_loss: 49401.1680 - val_acc: 0.4476
Epoch 8/10
361/361 [==============================] - 73s 203ms/step - loss: 0.9134 - acc: 0.6724 -
val_loss: 841.6473 - val_acc: 0.6147
Epoch 9/10
361/361 [==============================] - 73s 202ms/step - loss: 0.9041 - acc: 0.6766 -
val_loss: 3435.3132 - val_acc: 0.6185
Epoch 10/10
361/361 [==============================] - 73s 202ms/step - loss: 0.8997 - acc: 0.6723 -
val_loss: 599.8070 - val_acc: 0.6646
```

In [50]:

```python
loss, accuracy = model.evaluate(X_test_scaled, Y_test)
print('Test Accuracy =', accuracy)
```

```
63/63 [==============================] - 6s 86ms/step - loss: 403.3801 - acc: 0.6500
Test Accuracy = 0.650024950504303
```

In [51]:

```python
SGD = tf.keras.optimizers.SGD(learning_rate=0.01)
model.compile(optimizer=SGD, loss='sparse_categorical_crossentropy', metrics=['acc'])
history = model.fit(X_train_scaled, Y_train, validation_split=0.1, epochs=1,batch_size =
20)
```

```
361/361 [==============================] - 88s 204ms/step - loss: 0.8807 - acc: 0.6839 -
val_loss: 2998.7778 - val_acc: 0.6883
```

In [52]:

```python
loss, accuracy = model.evaluate(X_test_scaled, Y_test)
print('Test Accuracy using SGD =', accuracy)
```

```
63/63 [==============================] - 5s 83ms/step - loss: 3407.6001 - acc: 0.6665
Test Accuracy using SGD = 0.6665002703666687
```

In [ ]: