<----- Self Case Study 2 ----- Hacker Earth Competition ----->

-------------------> Classification Of Lunar Rock <-------------------

- *Lunar landings by renowned space stations across the world have yielded an abundance of new scientific data on the Moon. The various experiments placed on the surface provided information on seismic, gravitational, and other lunar characteristics. But perhaps the most dramatic result of the missions was returning a total of more than 800 pounds of lunar rock and soil for analysis on Earth. These samples of the Moon offered a deeper appreciation of the evolution of our nearest planetary neighbor.*

- *Imagine you have been called by one of the largest space stations in the world (XYZ) space station and you are requested to make a Machine Learning model which classifies the different rocks present on the moon's surface. The purpose of this is to make the research process a lot easier. This will reduce the human effort of doing a monotonous task. There are basically two types of rocks to be classified:*

- *Small Rocks*
- *Large Rocks*

- *Competition link-1: https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/ (https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/)*

- *Competition Link-2: https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/machine-learning/lunar-rock-recognition-43274e07-04533c43/ (https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/machine-learning/lunar-rock-recognition-43274e07-04533c43/)*

In [0]:

Mounting Google Colab with drive

In [1]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client
_id=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&
redirect_uri=urn%3Aietf%3Awg%3Aoauth%3A2.0%3Aoob&scope=email%20https%3A%2F%2F
www.googleapis.com%2Fauth%2Fdocs.test%20https%3A%2F%2Fwww.googleapis.com%2Fau
th%2Fdrive%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive.photos.readonly%
20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fpeopleapi.readonly&response_type=
code

Enter your authorization code:
··········
Mounted at /content/drive
```

In [7]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns

import warnings
warnings.filterwarnings('ignore')
```

In [25]:
```
# !unzip 'drive/My Drive/Lunar Rock/Train Images.zip'
```

In [26]:
```
# !unzip 'drive/My Drive/Lunar Rock/Test Images.zip'
```

Taking Train Large, Train Small and Test images names in a list.

In [43]:
```
import os

tr_l_list = os.listdir('drive/My Drive/Lunar Rock/Train Images/Train Images/La
rge')

tr_s_list = os.listdir('drive/My Drive/Lunar Rock/Train Images/Train Images/Sm
all')

te_list = os.listdir('drive/My Drive/Lunar Rock/Test Images/Test Images')

print("\n -> Number of images in train large:", len(tr_l_list))
print("\n -> Number of images in train small:", len(tr_s_list))
print("\n -> Number of images in test:", len(te_list))
```

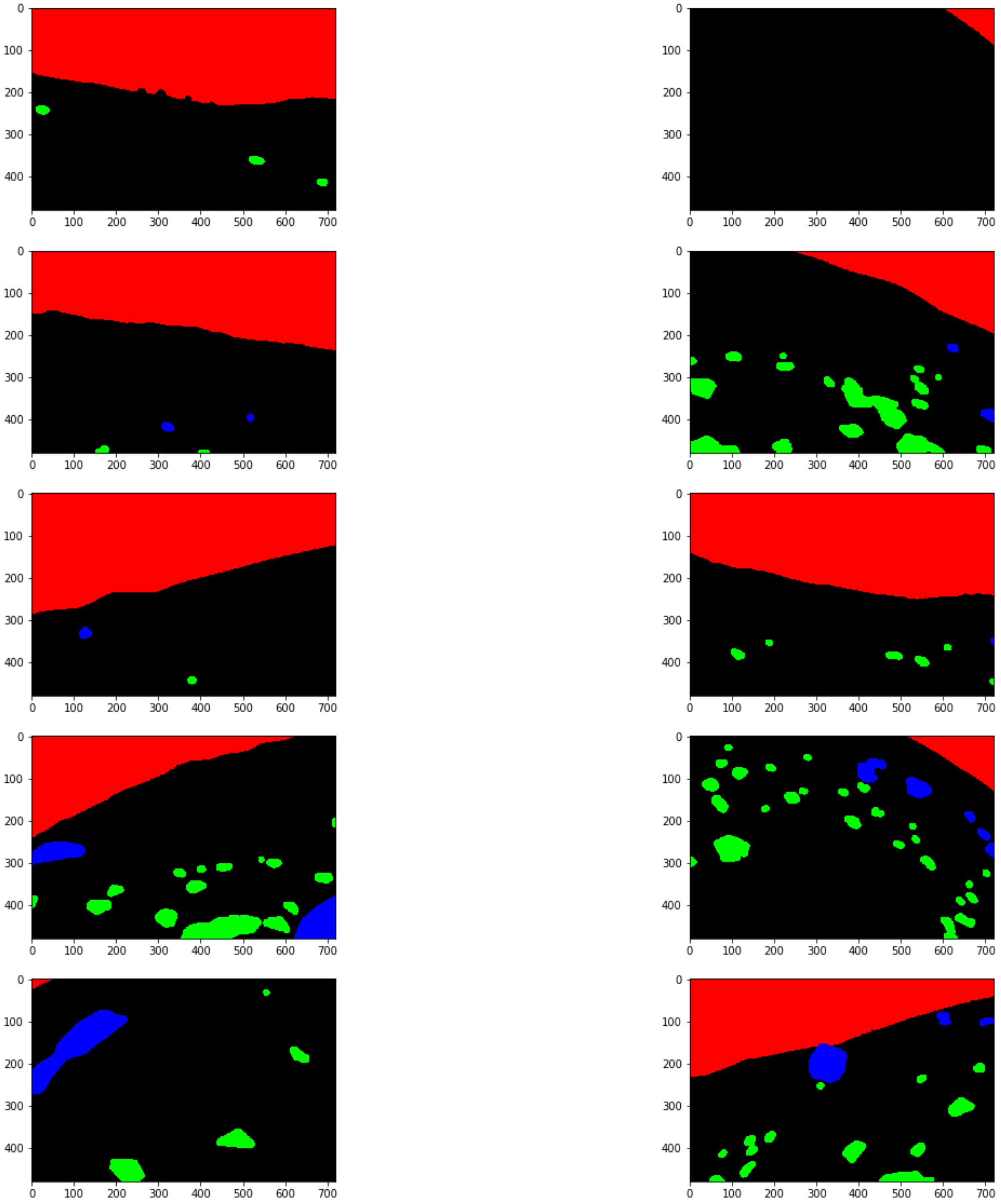
```
 -> Number of images in train large: 5999

 -> Number of images in train small: 6000

 -> Number of images in test: 7538
```

Displaying 10 Train Large images

In [0]:

```
import cv2

print("\nFirst 10 images from train large")
print('*'*35, '\n')

fig = plt.figure(figsize=(20,20))

for i in range(1, 11):

    fig.add_subplot(5,2,i)

    read = cv2.imread('drive/My Drive/Lunar Rock/Train Images/Train Images/Large/'+tr_l_list[i])
    img = cv2.cvtColor(read, cv2.COLOR_BGR2RGB)
    plt.imshow(img)

plt.show()
```

```
First 10 images from train large
***********************************
```

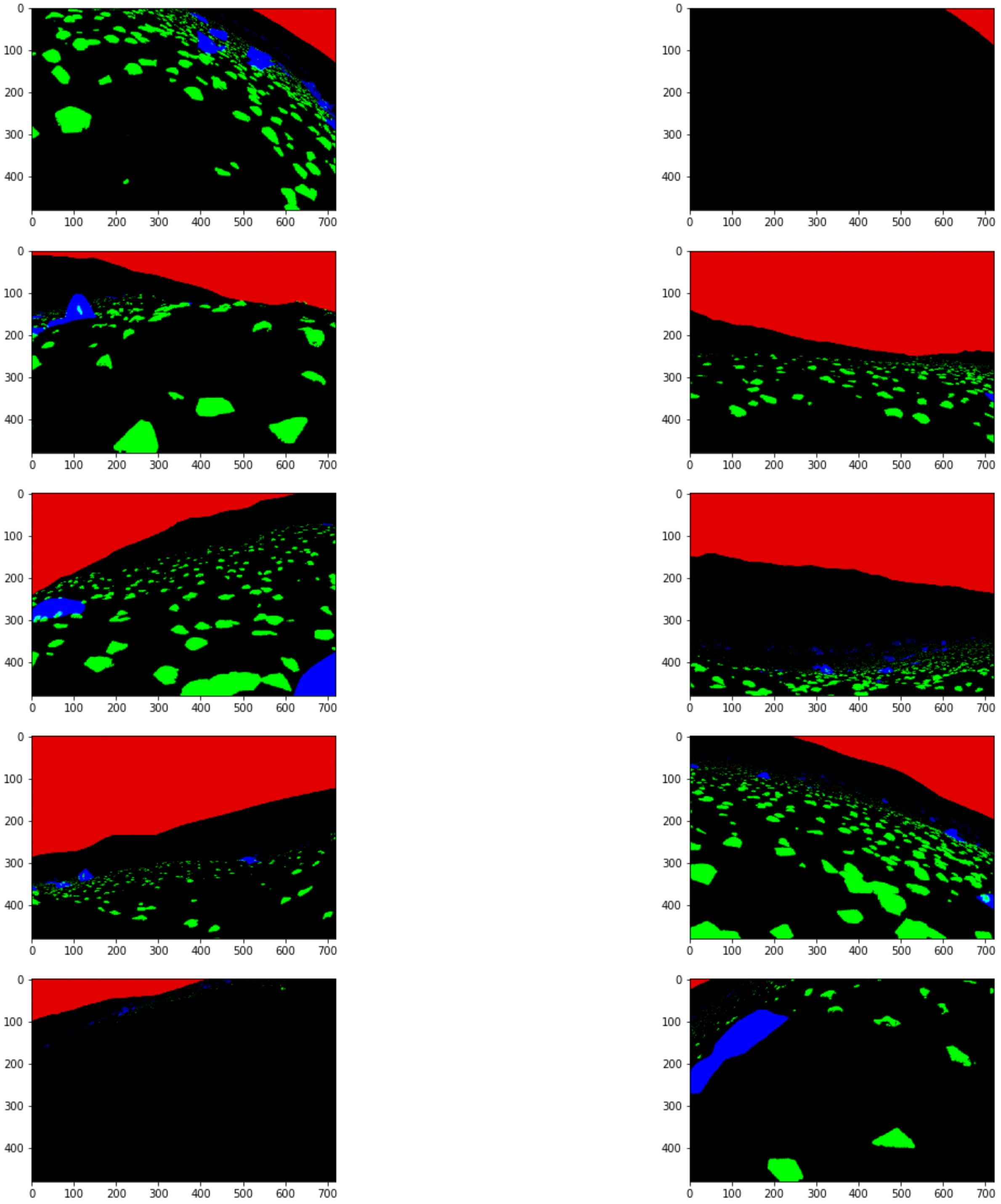


Displaying 10 Train Small images

In [0]:

```
import cv2

print("\nFirst 10 images from train small")
print('*'*35, '\n')

fig = plt.figure(figsize=(20,20))

for i in range(1, 11):

    fig.add_subplot(5,2,i)

    read = cv2.imread('drive/My Drive/Lunar Rock/Train Images/Train Images/Small/'+tr_s_list[i])
    img = cv2.cvtColor(read, cv2.COLOR_BGR2RGB)
    plt.imshow(img)

plt.show()
```

```
First 10 images from train small
***********************************
```



Importing train data

In [44]:

```
df = pd.read_csv('drive/My Drive/Lunar Rock/train.csv')

print("\n -> Displaying head of train dataframe.\n")

df.head()
```

```
 -> Displaying head of train dataframe.
```

Out[44]:

	Image_File	Class
0	clean2416.png	Large
1	ground4022.png	Small
2	ground0340.png	Small
3	ground2110.png	Small
4	clean1581.png	Large

In [48]:

```
print("\n -> Shape of train data:", df.shape)
print("\n -> Number of rows in train data:", df.shape[0])
print("\n -> Number of columns in train data:", df.shape[1])
print("\n -> Number of images in train data:", df.shape[0])
print("\n -> Number of images of class Large in train data:", df.Class.value_c
ounts()[1])
print("\n -> Number of images of class Small in train data:", df.Class.value_c
ounts()[0])
```

```
 -> Shape of train data: (11998, 2)

 -> Number of rows in train data: 11998

 -> Number of columns in train data: 2

 -> Number of images in train data: 11998

 -> Number of images of class Large in train data: 5999

 -> Number of images of class Small in train data: 5999
```

In [45]:

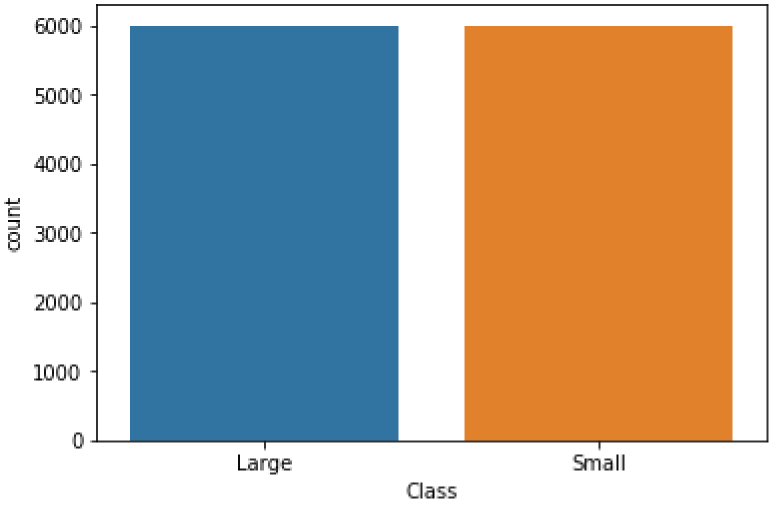
```
print("\n -> Count of Large and Small class.\n")
print(df.Class.value_counts())
```

```
 -> Count of Large and Small class.

Small    5999
Large    5999
Name: Class, dtype: int64
```

In [46]:

```
print("\n -> Graphically visualzing count of Large and Small class.\n")

sns.countplot(df.Class)
plt.show()
```

```
 -> Graphically visualzing count of Large and Small class.
```



In [0]:

Training Model

Generating images from existed images

Generating images from existed images such as rotating by certain degree, shifting width and height by certain value, rescaling and zoom-in and zoom-out by certain value.

In [15]:

```
import keras

from keras.preprocessing.image import ImageDataGenerator

img_gen = ImageDataGenerator(rotation_range = 30,
                             width_shift_range = 0.1,
                             height_shift_range = 0.1,
                             rescale = 1/255,
                             zoom_range = 0.2)
```

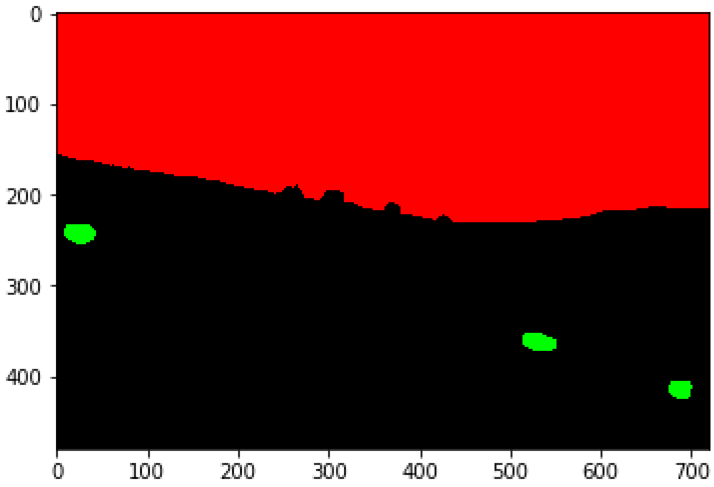
```
Using TensorFlow backend.
```

Displaying original image from Train Large

In [0]:
```
import cv2
```

In [13]:
```
print(" -> Original image from Train Large\n")

re = cv2.imread('drive/My Drive/Lunar Rock/Train Images/Train Images/Large/'+t
r_l_list[1])
re = cv2.cvtColor(re, cv2.COLOR_BGR2RGB)

plt.imshow(re)
plt.show()
```

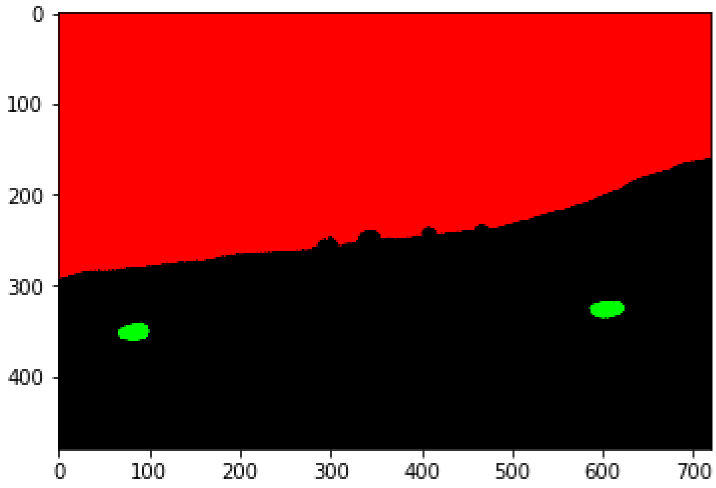
```
 -> Original image from Train Large
```



Displaying generated image

```
In [20]: print(" -> Generated image from Train Large\n")

         re = cv2.imread('drive/My Drive/Lunar Rock/Train Images/Train Images/Large/'+t
         r_l_list[1])
         re = cv2.cvtColor(re, cv2.COLOR_BGR2RGB)

         plt.imshow(img_gen.random_transform(re))
         plt.show()
```

```
 -> Generated image from Train Large
```



Observation:

- **If we compare above original image and generated image, we can clearly see the difference. Position of stone is changed and it is due to ImageGenerator by certain parameters.**

With 'flow_from_directory' we will see the number of classes

```
In [21]: print("\n -> Viewing number of classes in train data\n")

         print(img_gen.flow_from_directory('drive/My Drive/Lunar Rock/Train Images/Trai
         n Images'))
```

```
 -> Viewing number of classes in train data

Found 11999 images belonging to 2 classes.
<keras_preprocessing.image.directory_iterator.DirectoryIterator object at 0x7
f782862a320>
```

Observation:

- **There are 2 classes i.e Large and Small**

Details of image

In [26]:

```
print("\n -> Shape of image:", re.shape)
print("\n -> Width of image:", re.shape[0])
print("\n -> Width of image:", re.shape[1])
print("\n -> Number of color channels of image:", re.shape[2])
```

```
 -> Shape of image: (480, 720, 3)

 -> Width of image: 480

 -> Width of image: 720

 -> Number of color channels of image: 3
```

In [0]:

```
input_shape = (480, 480, 3)
```

Importing all required keras models

In [0]:

```
from keras.models import Sequential, Model

from keras import regularizers

from keras.layers import Activation, Conv2D, MaxPool2D, Dropout, Dense, Flatten
```

Creating callbacks such as TensorBoard, ModelCheckpoint and EarlyStopping

In [0]:

```
from keras.callbacks import TensorBoard, ModelCheckpoint, EarlyStopping

# Saves the model after every epoch
checkpoint_2 = ModelCheckpoint("lunar_model_2.h5", monitor = "train_loss", mod
e = "min",
                                save_best_only = True, verbose = 1)

# Stops training when a monitored quantity has stopped improving.
earlystop_2 = EarlyStopping(monitor = 'train_loss', mode = "min", patience = 5
,
                            verbose = 1, restore_best_weights = True)

# TensorBoard is a visualization tool provided with TensorFlow.
tensorboard_2 = TensorBoard(log_dir = "drive/My Drive/Lunar Rock/lunar_graph_
2",
                         histogram_freq = 0, batch_size = 500, write_graph = T
rue,
                         write_grads = False, write_images = False, embeddings
_freq = 0,
                         embeddings_layer_names = None, embeddings_metadata =
None,
                         embeddings_data = None, update_freq = 'epoch')

# Creating Callback
callback_2 = [checkpoint_2, earlystop_2, tensorboard_2]
```

Building Conv2d Model

- **kernel_size - (3,3)**
- **Activation - 'relu' and output 'sigmoid'**
- **kernel_regularizer - regularizers.l2(0.01)**
- **pool_size - (2,2)**
- **Dropout - 0.3**
- **loss - 'binary_crossentropy'**
- **Optimizer - 'adam'**

In [0]:

```
import warnings
warnings.filterwarnings('ignore')


model = Sequential()

model.add(Conv2D(filters = 128, kernel_size = (3,3), input_shape = input_shape
, activation = 'relu', kernel_regularizer = regularizers.l2(0.01)))
model.add(MaxPool2D(pool_size = (2,2)))
model.add(Dropout(0.3))

model.add(Conv2D(filters = 64, kernel_size = (3,3), input_shape = input_shape,
activation = 'relu', kernel_regularizer = regularizers.l2(0.01)))
model.add(MaxPool2D(pool_size = (2,2)))
model.add(Dropout(0.3))


model.add(Conv2D(filters = 64, kernel_size = (3,3), input_shape = input_shape,
activation = 'relu', kernel_regularizer = regularizers.l2(0.01)))
model.add(MaxPool2D(pool_size = (2,2)))
model.add(Dropout(0.3))

model.add(Flatten())

model.add(Dense(128))
model.add(Activation('relu'))
model.add(Dropout(0.3))

model.add(Dense(1))
model.add(Activation('sigmoid'))

model.compile(loss = 'binary_crossentropy', optimizer = 'adam', metrics = ['ac
curacy'])
```

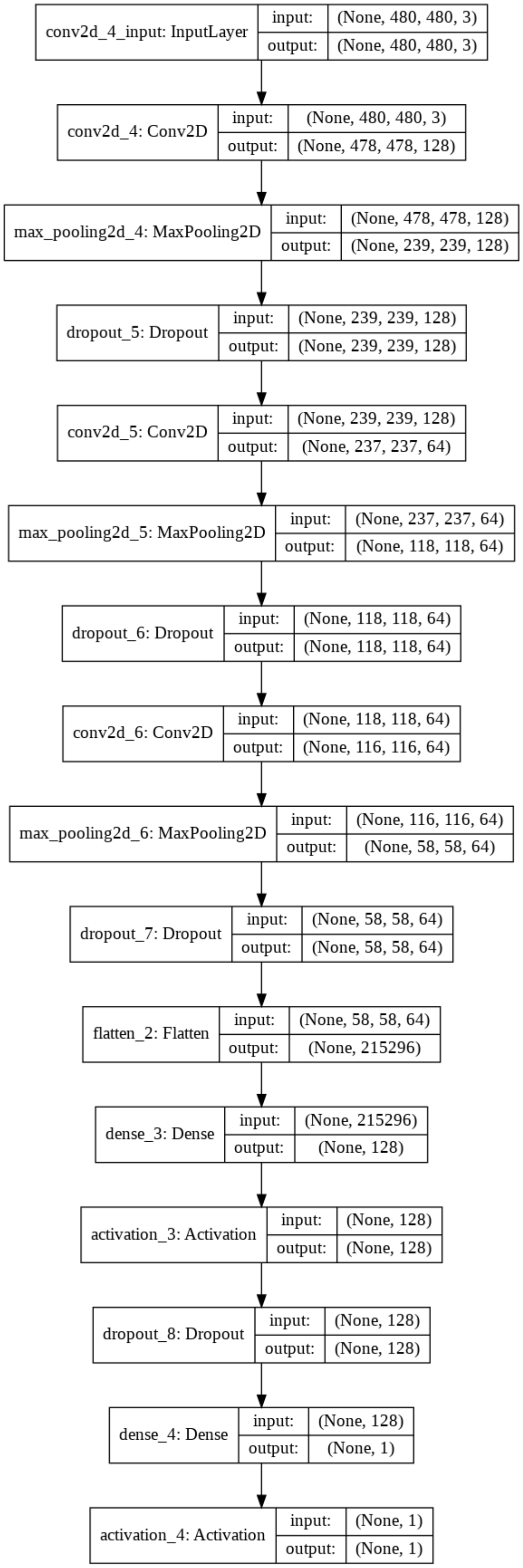
Displaying Network Architecture

Source: https://github.com/mmortazavi/EntityEmbedding-Working_Example/blob/master/EntityEmbedding.ipynb (https://github.com/mmortazavi/EntityEmbedding-Working_Example/blob/master/EntityEmbedding.ipynb)

In [33]:

```
# https://github.com/mmortazavi/EntityEmbedding-Working_Example/blob/master/EntityEmbedding.ipynb

import pydot_ng as pydot
from keras.utils import plot_model
from IPython.display import Image

plot_model(model, show_shapes = True, show_layer_names = True, to_file = 'lunar_model_1.png')

Image(retina = True, filename = 'lunar_model_1.png')
```

Out[33]:


conv2d_4_input: InputLayer
input: (None, 480, 480, 3)
output: (None, 480, 480, 3)
conv2d_4: Conv2D
input: (None, 480, 480, 3)
output: (None, 478, 478, 128)
max_pooling2d_4: MaxPooling2D
input: (None, 478, 478, 128)
output: (None, 239, 239, 128)
dropout_5: Dropout
input: (None, 239, 239, 128)
output: (None, 239, 239, 128)
conv2d_5: Conv2D
input: (None, 239, 239, 128)
output: (None, 237, 237, 64)
max_pooling2d_5: MaxPooling2D
input: (None, 237, 237, 64)
output: (None, 118, 118, 64)
dropout_6: Dropout
input: (None, 118, 118, 64)
output: (None, 118, 118, 64)
conv2d_6: Conv2D
input: (None, 118, 118, 64)
output: (None, 116, 116, 64)
max_pooling2d_6: MaxPooling2D
input: (None, 116, 116, 64)
output: (None, 58, 58, 64)
dropout_7: Dropout
input: (None, 58, 58, 64)
output: (None, 58, 58, 64)
flatten_2: Flatten
input: (None, 58, 58, 64)
output: (None, 215296)
dense_3: Dense
input: (None, 215296)
output: (None, 128)
activation_3: Activation
input: (None, 128)
output: (None, 128)
dropout_8: Dropout
input: (None, 128)
output: (None, 128)
dense_4: Dense
input: (None, 128)
output: (None, 1)
activation_4: Activation
input: (None, 1)
output: (None, 1)

Model Summary

In [0]:

```
model.summary()
```

```
Model: "sequential_7"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_16 (Conv2D)           (None, 478, 478, 128)     3584      
_________________________________________________________________
max_pooling2d_16 (MaxPooling (None, 239, 239, 128)     0         
_________________________________________________________________
dropout_20 (Dropout)         (None, 239, 239, 128)     0         
_________________________________________________________________
conv2d_17 (Conv2D)           (None, 237, 237, 64)      73792     
_________________________________________________________________
max_pooling2d_17 (MaxPooling (None, 118, 118, 64)      0         
_________________________________________________________________
dropout_21 (Dropout)         (None, 118, 118, 64)      0         
_________________________________________________________________
conv2d_18 (Conv2D)           (None, 116, 116, 64)      36928     
_________________________________________________________________
max_pooling2d_18 (MaxPooling (None, 58, 58, 64)        0         
_________________________________________________________________
dropout_22 (Dropout)         (None, 58, 58, 64)        0         
_________________________________________________________________
flatten_6 (Flatten)          (None, 215296)            0         
_________________________________________________________________
dense_10 (Dense)             (None, 128)               27558016  
_________________________________________________________________
activation_9 (Activation)    (None, 128)               0         
_________________________________________________________________
dropout_23 (Dropout)         (None, 128)               0         
_________________________________________________________________
dense_11 (Dense)             (None, 1)                 129       
_________________________________________________________________
activation_10 (Activation)   (None, 1)                 0         
=================================================================
Total params: 27,672,449
Trainable params: 27,672,449
Non-trainable params: 0
_________________________________________________________________
```

With 'flow_from_directory', getting all Train images (Large and Small class)

In [34]:

```
batch_size = 16

train_img_gen = img_gen.flow_from_directory(('drive/My Drive/Lunar Rock/Train Images/Train Images'),
                                           target_size = input_shape[:2],
                                           batch_size = batch_size,
                                           class_mode = 'binary')
```

```
Found 11999 images belonging to 2 classes.
```

Checking the indices of class (Large and Small)

In [37]:

```
print("\n -> Class indices.\n")

print(train_img_gen.class_indices)
```

```
 -> Class indices.

{'Large': 0, 'Small': 1}
```

Observation:

- **Large belongs to class - 0**
- **Small belongs to class - 1**

Training model with 'fit_generator'

In [0]:

```
import warnings
warnings.filterwarnings('ignore')

results = model.fit_generator(train_img_gen, epochs = 20, steps_per_epoch = 10
0, callbacks = callback_2)
```

```
Epoch 1/20
100/100 [==============================] - 475s 5s/step - loss: 1.3171 - acc:
0.7638
Epoch 2/20
100/100 [==============================] - 484s 5s/step - loss: 0.4561 - acc:
0.9519
Epoch 3/20
100/100 [==============================] - 493s 5s/step - loss: 0.2803 - acc:
0.9756
Epoch 4/20
100/100 [==============================] - 528s 5s/step - loss: 0.2588 - acc:
0.9656
Epoch 5/20
100/100 [==============================] - 484s 5s/step - loss: 0.1877 - acc:
0.9825
Epoch 6/20
100/100 [==============================] - 473s 5s/step - loss: 0.2470 - acc:
0.9650
Epoch 7/20
100/100 [==============================] - 489s 5s/step - loss: 0.1992 - acc:
0.9756
Epoch 8/20
100/100 [==============================] - 301s 3s/step - loss: 0.1687 - acc:
0.9781
Epoch 9/20
100/100 [==============================] - 118s 1s/step - loss: 0.1565 - acc:
0.9800
Epoch 10/20
100/100 [==============================] - 120s 1s/step - loss: 0.1568 - acc:
0.9787
Epoch 11/20
100/100 [==============================] - 121s 1s/step - loss: 0.1420 - acc:
0.9806
Epoch 12/20
100/100 [==============================] - 121s 1s/step - loss: 0.1788 - acc:
0.9731
Epoch 13/20
100/100 [==============================] - 115s 1s/step - loss: 0.1135 - acc:
0.9912
Epoch 14/20
100/100 [==============================] - 116s 1s/step - loss: 0.1060 - acc:
0.9887
Epoch 15/20
100/100 [==============================] - 126s 1s/step - loss: 0.1018 - acc:
0.9919
Epoch 16/20
100/100 [==============================] - 122s 1s/step - loss: 0.1565 - acc:
0.9769
Epoch 17/20
100/100 [==============================] - 127s 1s/step - loss: 0.1362 - acc:
0.9850
Epoch 18/20
100/100 [==============================] - 125s 1s/step - loss: 0.1351 - acc:
0.9881
Epoch 19/20
100/100 [==============================] - 125s 1s/step - loss: 0.2234 - acc:
0.9606
```

```
Epoch 20/20
100/100 [==============================] - 122s 1s/step - loss: 0.1655 - acc:
0.9794
```

In [0]:

```
print("Original small image after resizing\n")

r = cv2.imread('drive/My Drive/Lunar Rock/Train Images/Train Images/Small/'+tr
_s_list[1])
r = cv2.cvtColor(r, cv2.COLOR_BGR2RGB)
r = cv2.resize(r, (480, 480))
r = np.expand_dims(r, axis = 0)
```

```
Original small image after resizing
```

In [0]:

Test data

Importing test data

In [39]:

```
test = pd.read_csv('drive/My Drive/Lunar Rock/test.csv')

print("\n -> Displaying head of test data.\n")

test.head()
```

```
 -> Displaying head of test data.
```

Out[39]:

	Image_File	Class
0	lg 988 (1).png	NaN
1	lg 988 (10).png	NaN
2	lg 988 (100).png	NaN
3	lg 988 (101).png	NaN
4	lg 988 (102).png	NaN

In [40]:

```
print("\n -> Shape of test data:", test.shape)
print("\n -> Number of rows in test data:", test.shape[0])
print("\n -> Number of columns in test data:", test.shape[1])
print("\n -> Number of images in test data:", test.shape[0])
```

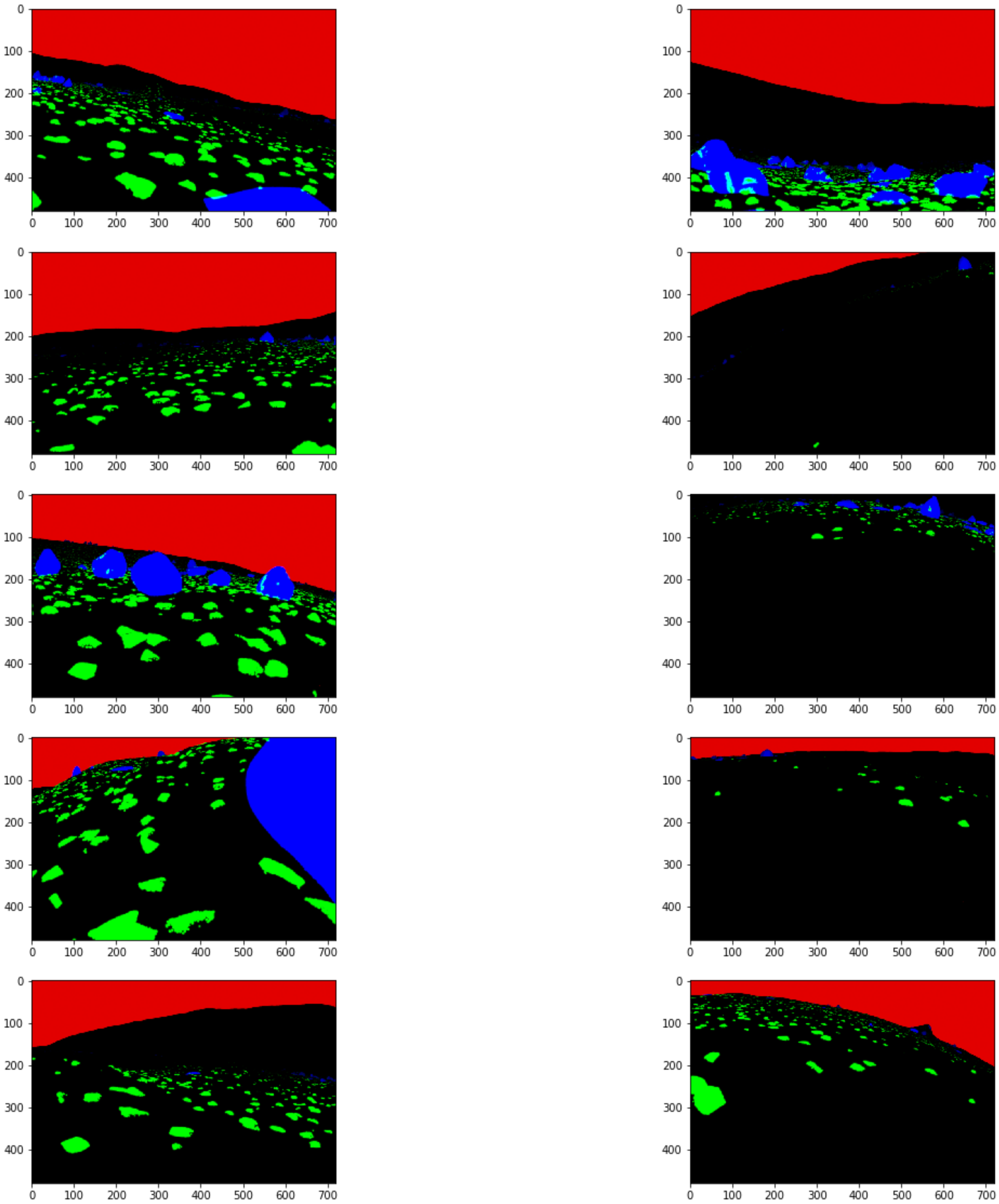
```
 -> Shape of test data: (7534, 2)

 -> Number of rows in test data: 7534

 -> Number of columns in test data: 2

 -> Number of images in test data: 7534
```

Displaying 10 test images

In [42]:

```
import cv2

print("\nFirst 10 images from test")
print('*'*35, '\n')

fig = plt.figure(figsize=(20,20))

for i in range(1, 11):

    fig.add_subplot(5,2,i)

    read = cv2.imread('drive/My Drive/Lunar Rock/Test Images/Test Images/'+te_list[i])
    img = cv2.cvtColor(read, cv2.COLOR_BGR2RGB)
    plt.imshow(img)

plt.show()
```

```
First 10 images from test
***********************************
```



Storing all test image names as an array

In [0]:

```
test_files = np.array(test['Image_File'])

test_files[:5]
```

Out[0]:

```
array(['lg 988 (1).png', 'lg 988 (10).png', 'lg 988 (100).png',
       'lg 988 (101).png', 'lg 988 (102).png'], dtype=object)
```

Resizing all test images and storing the image array

In [0]:

```
test_arr = []

for i in range(len(test_files)):

    t = cv2.imread('drive/My Drive/Lunar Rock/Test Images/Test Images/'+test_files[i])
    t = cv2.cvtColor(t, cv2.COLOR_BGR2RGB)
    t = cv2.resize(t, (480, 480))
    t = np.expand_dims(t, axis = 0)
    t = np.array(t)
    test_arr.append(t)
```

Predicting test images and storing in a list

In [0]:

```
predict = []

for i in range(len(test_arr)):

    pred = model.predict(test_arr[i])
    predict.append(pred)
```

In [0]:

```
test.head()
```

Out[0]:

	Image_File	Class
0	lg 988 (1).png	NaN
1	lg 988 (10).png	NaN
2	lg 988 (100).png	NaN
3	lg 988 (101).png	NaN
4	lg 988 (102).png	NaN

In [0]:

```
pred_list = []

for i in range(len(predict)):

    pred = int(predict[i][0][0])
    pred_list.append(pred)
```

Replacing 'nan' values with predicted class (1, 0)

In [0]:

```
test['Class'] = pred_list
```

Replacing class 1 with string 'Small' and class 0 with string 'Large'

In [41]:

```
print("\n -> Class indices.\n")
train_img_gen.class_indices
```

```

 -> Class indices.

```

Out[41]:

```
{'Large': 0, 'Small': 1}
```

In [0]:

```
test['Class'] = test['Class'].apply(lambda x: 'Large' if x == 0 else 'Small')
```

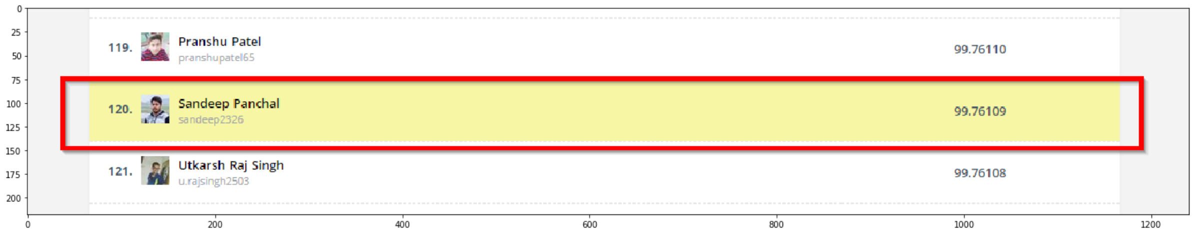
In [0]:

```
# test.to_csv('drive/My Drive/Lunar Rock/Lunar_Predict_2.csv', index = False)
```

Displaying test score and rank in HackerEarth

- *Competition link-1: https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/ (https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/)*
- *Competition Link-2: https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/machine-learning/lunar-rock-recognition-43274e07-04533c43/ (https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/machine-learning/lunar-rock-recognition-43274e07-04533c43/)*
- *Leaderboard Link: https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/leaderboard/lunar-rock-recognition-43274e07-04533c43/ (https://www.hackerearth.com/challenges/competitive/lunar-rock-hackerearth-data-science-competition/leaderboard/lunar-rock-recognition-43274e07-04533c43/)*

In [19]:
```
import cv2

plt.figure(figsize = (25,25))
rank_read = cv2.imread('Leaderboard_Lunar_Rock.png')
rank_cvt = cv2.cvtColor(rank_read, cv2.COLOR_BGR2RGB)
plt.imshow(rank_cvt)
plt.show()
```



119.	Pranshu Patel pranshupatel65	99.76110
120.	Sandeep Panchal sandeep2326	99.76109
121.	Utkarsh Raj Singh u.rajsingh2503	99.76108

Pretty Table:

In [24]:
```
from prettytable import PrettyTable

a = PrettyTable()

a.field_names = ['S.No', 'Model', 'Metric', 'Optimizer', 'Dropout', 'Test F1-S
core', 'HackerEarth Rank']

a.add_row([1, 'Conv2d', '100 * F1-Score', 'Adam', 0.3, 99.76109, 120])

print(a.get_string(title = "Classification of Lunar Rock"))
```

```
+------+--------+----------------+-----------+---------+---------------+-----
-------------+
| S.No | Model  |     Metric     | Optimizer | Dropout | Test F1-Score | Hack
erEarth Rank |
+------+--------+----------------+-----------+---------+---------------+-----
-------------+
|  1   | Conv2d | 100 * F1-Score |    Adam   |   0.3   |    99.76109   |
120        |
+------+--------+----------------+-----------+---------+---------------+-----
-------------+
```

In [ ]:

Conclusion:

- **Using Conv2d model, we got score of 99.76109 on test data and rank of 120 in HackerEarth.**

In [ ]:

Step-by-Step Procedure

- **Train Data Analysis and Preparation**
    - Extracted train large, train small and test images from the directory and saved in a list.
    - Displayed 10 train large images.
    - Dislayed 10 train small images.
    - Imported train.csv file.
    - Checked for shape, number of rows, columns, images and image count of 2 classes (Small and Large).
    - Graphically represented the count of 2 classes (Small and Large).

- **Training Model**
    - Image Data Generator:
        - Generating images from existed images such as rotating by certain degree, shifting width and height by certain value, rescaling, and zoom-in & zoom-out by certain value.
        - Displayed original and generated images to check the difference between images before and after Image Data Generator.
    - Flow From Directory:
        - It is to import images from the directory. In addition, it will import images with classification which is based on the sub-directory files inside directory.
        - Checked the indices of class i.e Large is labelled as 0 and Small as 1.
    - Shape of images
        - Checked the shape of images, width, height, and number of channels.
    - Callback:
        - Creating callback such ModelCheckpoint, EarlyStopping, and TensorBoard.
        - ModelCheckpoint is to save the best model which further can be used in future.
        - EarlyStopping is to stop running the model if there is no improvement in score.
        - TensorBoard is visualization tool.
    - Convolution 2d Model (Conv2d):
        - kernel_size - (3,3)
        - Activation - 'relu' and output 'sigmoid'
        - kernel_regularizer - regularizers.l2(0.01)
        - pool_size - (2,2)
        - Dropout - 0.3
        - Loss - 'binary_crossentropy'
        - Optimizer - 'adam'
    - Displaying model structure using pydot
    - Fit Generator
        - Running model using 'fit_generator'.
        - Epochs - 20
        - Batch Size - 16
        - Steps Per Epoch - 100

- **Test Data Analysis and Preparation**
    - Extracted test images from the directory and saved in a list.
    - Displayed 10 test images.
    - Imported train.csv file.
    - Checked for shape, number of rows, columns, and images.
    - Stored all test images names in a list of array.
    - Resizing test images and storing the array of images in an array.

- **Test Data Prediction**
  - With above trained model, test data images are predicted.
  - Predicted values are stored in a list of array.
  - Corresponding to test data image names, predicted values are filled in dataframe.
  - In the dataframe, under Class feature, Class 0 is replaced with Large and Class 1 is replaced with Small.
  - Saved the dataframe which contains test data image id and class of image.
- **Pretty Table**
  - Using pretty table, displayed our model performance in a tabular form.
- **Conclusion**
  - Using Conv2d model, we got score of 99.76109 on test data and rank of 120 in HackerEarth.

```
In [ ]:
```