PROBLEM STATEMENT - TO PREDICT/IDENTIFY THE NAME OF THE BREED BASED ON THE IMAGE OF THE DOG.

OVERVIEW:

1. Image recognition and classification have successfully applied in various domains, such as face recognition and scene understanding of autonomous driving.
2. At present, human face identification is successfully used for authentication and security purposes in many applications.
3. Therefore, there are attempts to extend studies from human to animal recognition. In particular, dogs are one of the most common animals.
4. Since there are more than 180 dog breeds, dog breed recognition can be an essential task in order to provide proper training and health treatment.
5. Previously, dog breed recognition is done by human experts. However, some dog breeds might be challenging to evaluate due to the lack of experts and the difficulty of breeds' patterns themselves. It also takes time for each evaluation.
6. The main objective of this case study is to create a classifier capable of determining a dog's breed from an image.
7. In this competition, a strictly canine subset of ImageNet has been provided in order to practice fine-grained image categorization.
8. We have been provided with training set and a test set of images of dogs and there are total of 20581 files.
9. Each image has a filename that is its unique id.
10. The data set contains 120 breeds of dogs.
11. For each image in the test data, we must predict a probability for each of the different breeds as part of the case study.
12. Multi class log loss between the predicted probability and the observed target has been used as the metric.

In [ ]:
```
!wget --header="Host: storage.googleapis.com" --header="User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleW
ebKit/537.36 (KHTML, like Gecko) Chrome/109.0.0.0 Safari/537.36" --header="Accept: text/html,application/xhtml+xml,a
pplication/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8" --header="Accept-Language: en-US,en;q=0.6" --header
="Referer: https://www.kaggle.com/" "https://storage.googleapis.com/kaggle-competitions-data/kaggle-v2/7327/861871/b
undle/archive.zip?GoogleAccessId=web-data@kaggle-161607.iam.gserviceaccount.com&Expires=1673850660&Signature=FcLZMSJ
VJxjtE2tsl49iuWYSLXLVz5r%2FNS4wvu6aA85rXfzDlUY5ljON9KulrBZqoF43HZqdJRTy%2FfqKuWfgLOanR7G1Axw28JC0GM0qjd%2FN96nDckmlP
qJYWSRSF%2B7Ca6hSkQkl1YA1%2BAJteVj37UY9U%2FB5tIcwxcYXUvclTa8lgvsUuTT8oPuvy1Vbo4kENJZ5BI%2BEgX23X3O77jDc5WKnn5WUavxpy
Z513BBfehOVKZfuAdf30z722ETvmExGHWGbRclESVJaoH1piGBOv5HuIIyDEyWQ%2BYxpNT3Zqbf8aNqFYEkqrjvcNF%2BUDCItRBbC2sp%2BT%2Frc9
t79YHoTKA%3D%3D&response-content-disposition=attachment%3B+filename%3Ddog-breed-identification.zip" -c -O 'dog-breed
-identification.zip'
```

In [3]:
```
import zipfile
extract = zipfile.ZipFile('/content/dog-breed-identification.zip')
extract.extractall()
```

In [4]:
```
import pandas as pd
import numpy as np
import tensorflow as tf
import matplotlib.pyplot as plt
from tensorflow import keras
import pickle
import os
```

In [5]:
```
labels = pd.read_csv('labels.csv')
labels.head()
```

Out[5]:

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

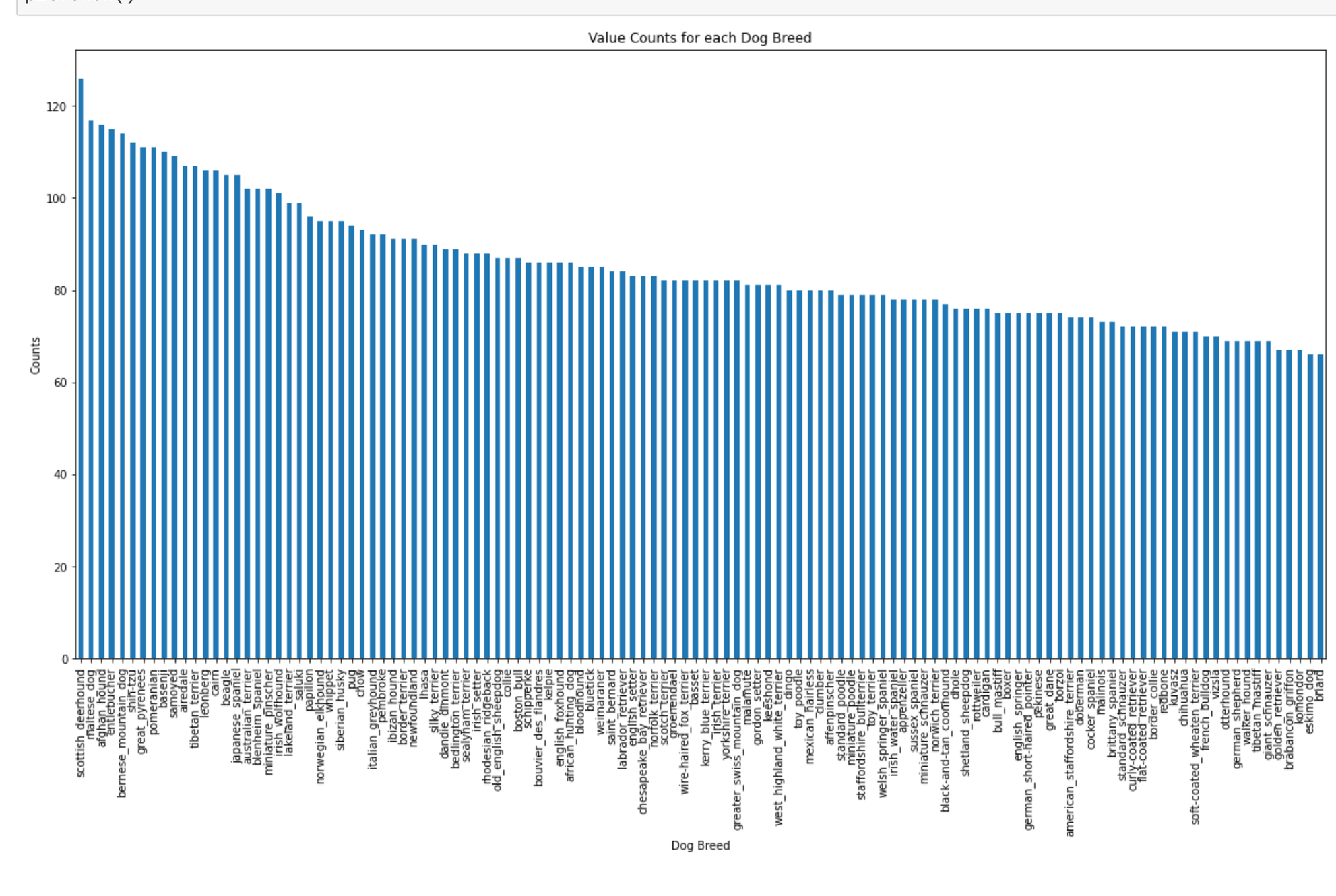
In [10]:
```
files_path = []
for root, dirs, files in os.walk("train", topdown=False):
   for name in sorted(files):
      files_path.append(os.path.join(root, name))
```

In [16]:
```
files = pd.DataFrame(list(zip(files_path,labels.breed.to_list())),columns=['path','label'])
files.head()
```

Out[16]:

	path	label
0	train/000bec180eb18c7604dcecc8fe0dba07.jpg	boston_bull
1	train/001513dfcb2ffafc82cccf4d8bbaba97.jpg	dingo
2	train/001cdf01b096e06d78e9e5112d419397.jpg	pekinese
3	train/00214f311d5d2247d5dfe4fe24b2303d.jpg	bluetick
4	train/0021f9ceb3235effd7fcde7f7538ed62.jpg	golden_retriever

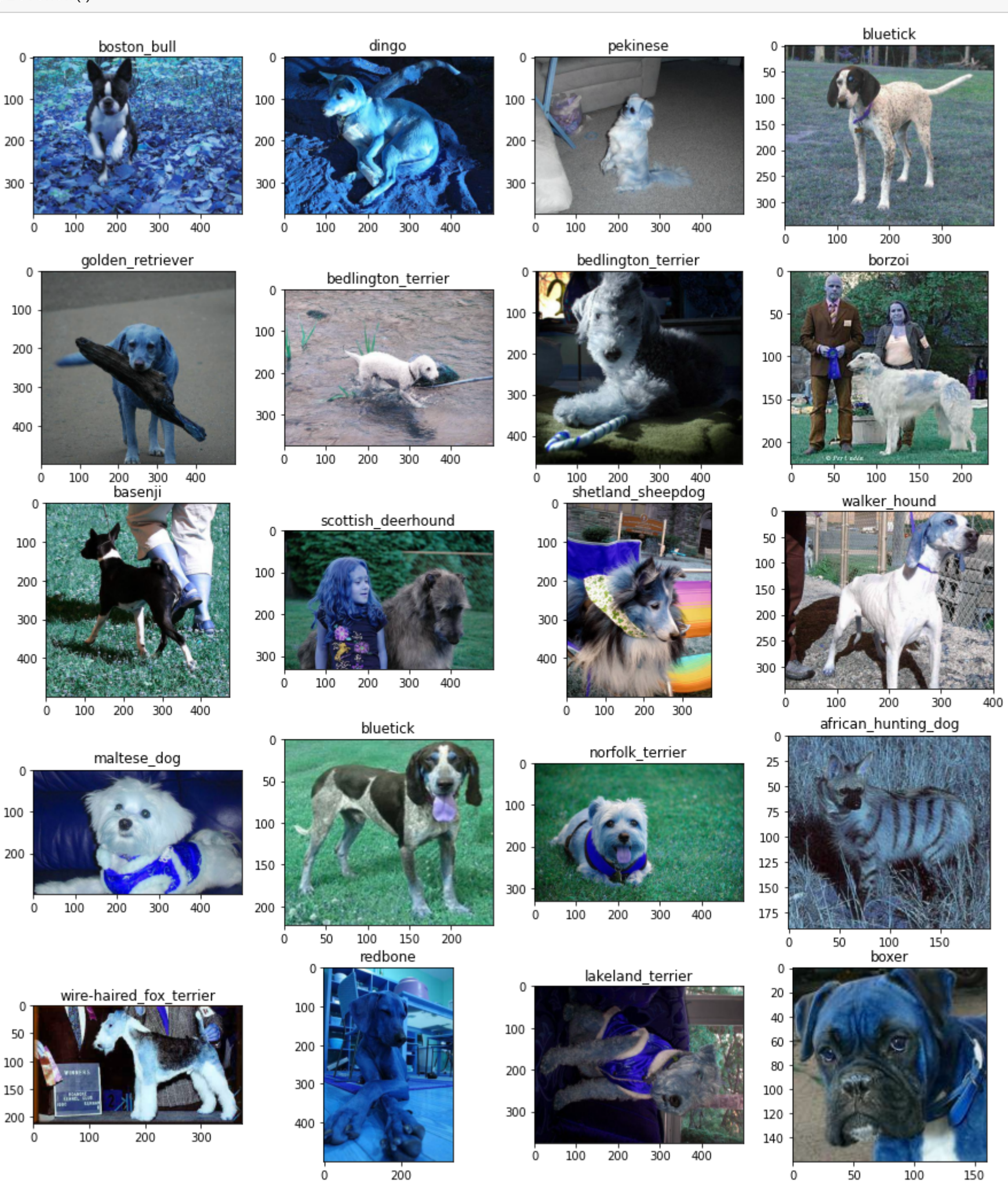
In [17]:
```
#Plotting the counts of each Dog Breed  using bar plot in descending order
plt.figure(figsize=(20,10))
files['label'].value_counts().plot(kind='bar')
plt.xlabel('Dog Breed')
plt.ylabel('Counts')
plt.title('Value Counts for each Dog Breed')
plt.show()
```



OBSERVATIONS:

1. Counts of each breed looks good and the dataset is nearly balanced.
2. The Scottish Deerhound Dog Breed is maximum in number.
3. The Eskimo Dog and Briard Dog Breeds are minimum in number.

In [18]:
```
#Plotting few images from the train data provided.
import cv2
plt.figure(figsize=(15,18))
for i in range(20):
  plt.subplot(5,4,i+1)
  image = cv2.imread(files['path'][i])
  plt.imshow(image)
  plt.title(files['label'][i])
plt.show()
```



TRAIN TEST SPLIT:

In [19]:
```
from sklearn.model_selection import train_test_split
Train, validation = train_test_split(files,test_size=0.33, stratify = files['label'],random_state=42)
```

ENCODING TARGET LABELS:

In [20]:
```
from sklearn import preprocessing
le = preprocessing.LabelEncoder()
le.fit(Train['label'].to_list())
Train_image_labels       = le.transform(Train['label'].to_list())
validation_image_labels  = le.transform(validation['label'].to_list())
```

In [21]:
```
with open('/content/drive/MyDrive/dog_breed/encoder','wb') as file:
  pickle.dump(le,file)
```

In [22]:
```
with open('/content/drive/MyDrive/dog_breed/labels','wb') as file:
  pickle.dump(list(le.classes_),file)
```

In [23]:
```
Train_image_paths        = Train['path'].tolist()
validation_image_paths   = validation['path'].tolist()
```

In [24]:
```
def tfdata_generator(images, labels, is_training, batch_size=16):
  def parse_function(filename,labels):
    #decoding JPG file
    image = tf.io.read_file(filename)
    image = tf.image.decode_jpeg(image, channels=3)
    image = image/255
    image = tf.image.convert_image_dtype(image, tf.float32)
    image = tf.image.resize(image, [400,400])
    y = tf.one_hot(tf.cast(labels, tf.uint8), 120)
    return image,y

  def augment(image,labels):
    image = tf.image.random_flip_left_right(image)
    image = tf.image.random_flip_up_down(image)

    image = tf.image.rot90(image, tf.random.uniform(shape=[], minval=0, maxval=6, dtype=tf.int32))
    image = tf.image.random_hue(image, 0.5)
    image = tf.image.random_saturation(image, 0.5, 2.5)
    image = tf.image.random_brightness(image, 0.5)
    image = tf.image.random_contrast(image, 0.1, 2)

    return image,labels

  dataset = tf.data.Dataset.from_tensor_slices((images,labels))
  if is_training:
    dataset = dataset.shuffle(18000) # depends on sample size
  # Transform and batch data at the same time
  dataset = dataset.map(parse_function)
  dataset = dataset.batch(batch_size, drop_remainder=True if is_training else False)

  if is_training:
    if np.random.uniform(0,1)>0.6:
      dataset = dataset.map(augment,num_parallel_calls=4)
  dataset = dataset.repeat()
  dataset = dataset.prefetch(tf.data.experimental.AUTOTUNE)
  return dataset
```

In [25]:
```
train_generator       = tfdata_generator(Train_image_paths, Train_image_labels, is_training=True)
validation_generator  = tfdata_generator(validation_image_paths, validation_image_labels, is_training=False)
```

In [26]:
```
steps_per_epoch  = np.ceil(len(Train_image_paths)/16)
validation_steps = np.ceil(len(validation_image_paths)/16)
```

In [27]:
```
from tensorflow import keras
from keras.applications.inception_v3 import InceptionV3
from keras.applications.resnet import ResNet152
from keras.layers import Dense,Input,Conv2D,MaxPool2D,Activation,Dropout,Flatten,GlobalAveragePooling2D,Concatenate,
BatchNormalization
from keras.models import Model
from keras.utils import plot_model
import os
import random as rn
os.environ['PYTHONHASHSEED'] = '0'
keras.backend.clear_session()
np.random.seed(0)
rn.seed(0)
```

In [28]:
```
input_shape = (400,400,3)
input_layer = Input(shape = (400,400,3))
#first model
base_inception = InceptionV3(weights = 'imagenet', include_top = False, input_shape = input_shape)
base_resnet    = ResNet152(weights = 'imagenet', include_top = False, input_shape = input_shape)
for layer in base_inception.layers:
    layer.trainable =  False
for layer in base_resnet.layers:
    layer.trainable = False
model_inception  = base_inception(input_layer)
model_inception  = GlobalAveragePooling2D()(model_inception)
output_inception = Flatten()(model_inception)
model_resnet     = base_resnet(input_layer)
model_resnet     = GlobalAveragePooling2D()(model_resnet)
output_resnet    = Flatten()(model_resnet)
merged = Concatenate()([output_inception, output_resnet])
x = BatchNormalization()(merged)
x = Dense(256, activation='relu')(x)
x = Dropout(0.5)(x)
x = Dense(120, activation = 'softmax')(x)
Inception_resnet_stacked = Model(inputs = input_layer, outputs = x)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/inception_v3/inception_v3_weights_
tf_dim_ordering_tf_kernels_notop.h5
87910968/87910968 [==============================] - 3s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet152_weights_tf_dim_or
dering_tf_kernels_notop.h5
234698864/234698864 [==============================] - 7s 0us/step
```

In [29]:
```
Inception_resnet_stacked.compile(optimizer=keras.optimizers.SGD(lr=0.001, momentum=0.9),
                                 loss='categorical_crossentropy',metrics=['categorical_accuracy'])
Inception_resnet_stacked.summary()
```

```
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, 400, 400, 3  0           []
                                )]

 inception_v3 (Functional)      (None, 11, 11, 2048  21802784    ['input_1[0][0]']
                                )

 resnet152 (Functional)         (None, 13, 13, 2048  58370944    ['input_1[0][0]']
                                )

 global_average_pooling2d (Glob  (None, 2048)        0           ['inception_v3[0][0]']
 alAveragePooling2D)

 global_average_pooling2d_1 (Gl  (None, 2048)        0           ['resnet152[0][0]']
 obalAveragePooling2D)

 flatten (Flatten)              (None, 2048)         0           ['global_average_pooling2d[0][0]'
                                                                 ]

 flatten_1 (Flatten)            (None, 2048)         0           ['global_average_pooling2d_1[0][0
                                                                 ]']

 concatenate_2 (Concatenate)    (None, 4096)         0           ['flatten[0][0]',
                                                                  'flatten_1[0][0]']

 batch_normalization_94 (BatchN  (None, 4096)        16384       ['concatenate_2[0][0]']
 ormalization)

 dense (Dense)                  (None, 256)          1048832     ['batch_normalization_94[0][0]']

 dropout (Dropout)              (None, 256)          0           ['dense[0][0]']

 dense_1 (Dense)                (None, 120)          30840       ['dropout[0][0]']

==================================================================================================
Total params: 81,269,784
Trainable params: 1,087,864
Non-trainable params: 80,181,920
__________________________________________________________________________________________________
```

```
/usr/local/lib/python3.8/dist-packages/keras/optimizers/optimizer_v2/gradient_descent.py:108: UserWarning: The `lr` a
rgument is deprecated, use `learning_rate` instead.
  super(SGD, self).__init__(name, **kwargs)
```

In [30]:
```
from keras.callbacks import ModelCheckpoint,ReduceLROnPlateau
mc        = ModelCheckpoint('/content/drive/MyDrive/dog_breed/Inception_resnet_stacked_weights.h5', monitor='val_los
s', mode='min', save_best_only=True,verbose=1)
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.9, patience=2,verbose=0)
```

In [ ]:
```
Inception_resnet_stacked.fit(train_generator,steps_per_epoch=steps_per_epoch,
                             validation_data  = validation_generator,epochs=10,
                             validation_steps = validation_steps,
                             callbacks        = [mc,reduce_lr])
```

```
Epoch 1/10
428/428 [==============================] - ETA: 0s - loss: 2.3110 - categorical_accuracy: 0.5076
Epoch 1: val_loss improved from inf to 0.62099, saving model to /content/drive/MyDrive/dog_breed/Inception_resnet_sta
cked_weights.h5
428/428 [==============================] - 310s 671ms/step - loss: 2.3110 - categorical_accuracy: 0.5076 - val_loss:
0.6210 - val_categorical_accuracy: 0.8889 - lr: 0.0010
Epoch 2/10
428/428 [==============================] - ETA: 0s - loss: 0.6635 - categorical_accuracy: 0.8331
Epoch 2: val_loss improved from 0.62099 to 0.31263, saving model to /content/drive/MyDrive/dog_breed/Inception_resnet
_stacked_weights.h5
428/428 [==============================] - 290s 678ms/step - loss: 0.6635 - categorical_accuracy: 0.8331 - val_loss:
0.3126 - val_categorical_accuracy: 0.9034 - lr: 0.0010
Epoch 3/10
428/428 [==============================] - ETA: 0s - loss: 0.4468 - categorical_accuracy: 0.8795
Epoch 3: val_loss improved from 0.31263 to 0.28231, saving model to /content/drive/MyDrive/dog_breed/Inception_resnet
_stacked_weights.h5
428/428 [==============================] - 288s 674ms/step - loss: 0.4468 - categorical_accuracy: 0.8795 - val_loss:
0.2823 - val_categorical_accuracy: 0.9090 - lr: 0.0010
Epoch 4/10
428/428 [==============================] - ETA: 0s - loss: 0.3417 - categorical_accuracy: 0.9039
Epoch 4: val_loss improved from 0.28231 to 0.27875, saving model to /content/drive/MyDrive/dog_breed/Inception_resnet
_stacked_weights.h5
428/428 [==============================] - 287s 672ms/step - loss: 0.3417 - categorical_accuracy: 0.9039 - val_loss:
0.2787 - val_categorical_accuracy: 0.9120 - lr: 0.0010
Epoch 5/10
428/428 [==============================] - ETA: 0s - loss: 0.3020 - categorical_accuracy: 0.9166
Epoch 5: val_loss improved from 0.27875 to 0.27035, saving model to /content/drive/MyDrive/dog_breed/Inception_resnet
_stacked_weights.h5
428/428 [==============================] - 287s 672ms/step - loss: 0.3020 - categorical_accuracy: 0.9166 - val_loss:
0.2704 - val_categorical_accuracy: 0.9102 - lr: 0.0010
Epoch 6/10
428/428 [==============================] - ETA: 0s - loss: 0.2630 - categorical_accuracy: 0.9229
Epoch 6: val_loss improved from 0.27035 to 0.26888, saving model to /content/drive/MyDrive/dog_breed/Inception_resnet
_stacked_weights.h5
428/428 [==============================] - 288s 672ms/step - loss: 0.2630 - categorical_accuracy: 0.9229 - val_loss:
0.2689 - val_categorical_accuracy: 0.9135 - lr: 0.0010
Epoch 7/10
428/428 [==============================] - ETA: 0s - loss: 0.2275 - categorical_accuracy: 0.9302
Epoch 7: val_loss improved from 0.26888 to 0.26617, saving model to /content/drive/MyDrive/dog_breed/Inception_resnet
_stacked_weights.h5
428/428 [==============================] - 287s 672ms/step - loss: 0.2275 - categorical_accuracy: 0.9302 - val_loss:
0.2662 - val_categorical_accuracy: 0.9173 - lr: 0.0010
Epoch 8/10
428/428 [==============================] - ETA: 0s - loss: 0.2010 - categorical_accuracy: 0.9416
Epoch 8: val_loss did not improve from 0.26617
428/428 [==============================] - 283s 662ms/step - loss: 0.2010 - categorical_accuracy: 0.9416 - val_loss:
0.2684 - val_categorical_accuracy: 0.9111 - lr: 0.0010
Epoch 9/10
428/428 [==============================] - ETA: 0s - loss: 0.1861 - categorical_accuracy: 0.9451
Epoch 9: val_loss improved from 0.26617 to 0.26105, saving model to /content/drive/MyDrive/dog_breed/Inception_resnet
_stacked_weights.h5
428/428 [==============================] - 287s 671ms/step - loss: 0.1861 - categorical_accuracy: 0.9451 - val_loss:
0.2611 - val_categorical_accuracy: 0.9146 - lr: 0.0010
Epoch 10/10
428/428 [==============================] - ETA: 0s - loss: 0.1685 - categorical_accuracy: 0.9492
Epoch 10: val_loss did not improve from 0.26105
428/428 [==============================] - 283s 662ms/step - loss: 0.1685 - categorical_accuracy: 0.9492 - val_loss:
0.2650 - val_categorical_accuracy: 0.9173 - lr: 0.0010
```

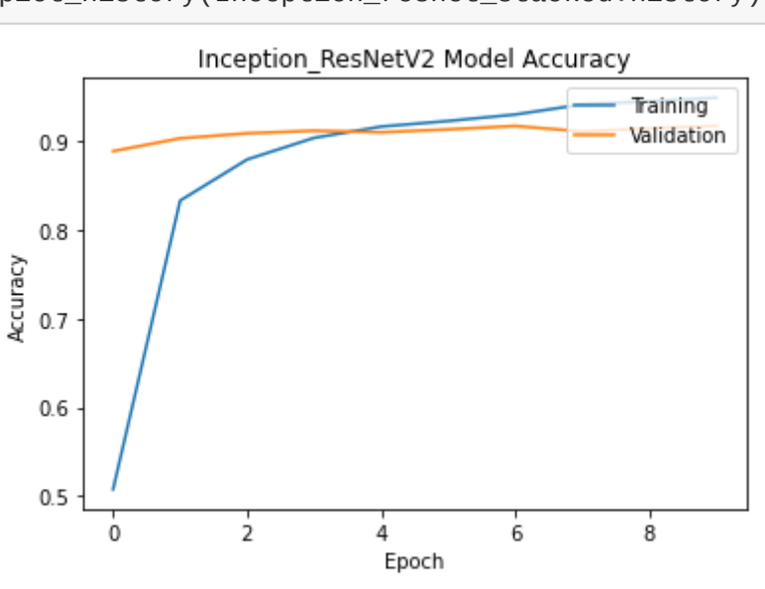
Out[ ]: <keras.callbacks.History at 0x7fcc81783250>

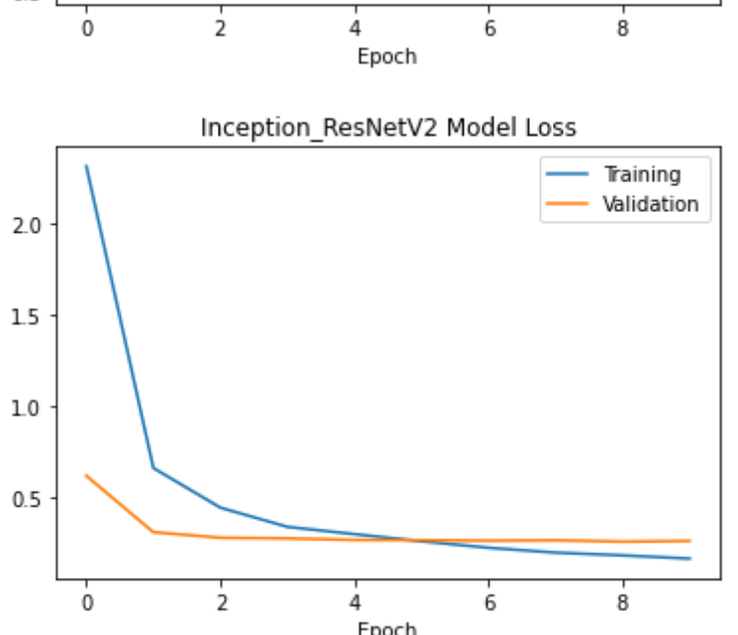
Plotting Loss:

In [ ]:
```
def plot_history(history):
    # summarize history for accuracy
    plt.plot(history.history['categorical_accuracy'])
    plt.plot(history.history['val_categorical_accuracy'])
    plt.title('Inception_ResNetV2 Model Accuracy')
    plt.ylabel('Accuracy')
    plt.xlabel('Epoch')
    plt.legend(['Training', 'Validation'], loc='upper right')
    plt.show()

    # summarize history for loss
    plt.plot(history.history['loss'])
    plt.plot(history.history['val_loss'])
    plt.title('Inception_ResNetV2 Model Loss')
    plt.ylabel('Loss')
    plt.xlabel('Epoch')
    plt.legend(['Training', 'Validation'], loc='upper right')
    plt.show()

plot_history(Inception_resnet_stacked.history)
```



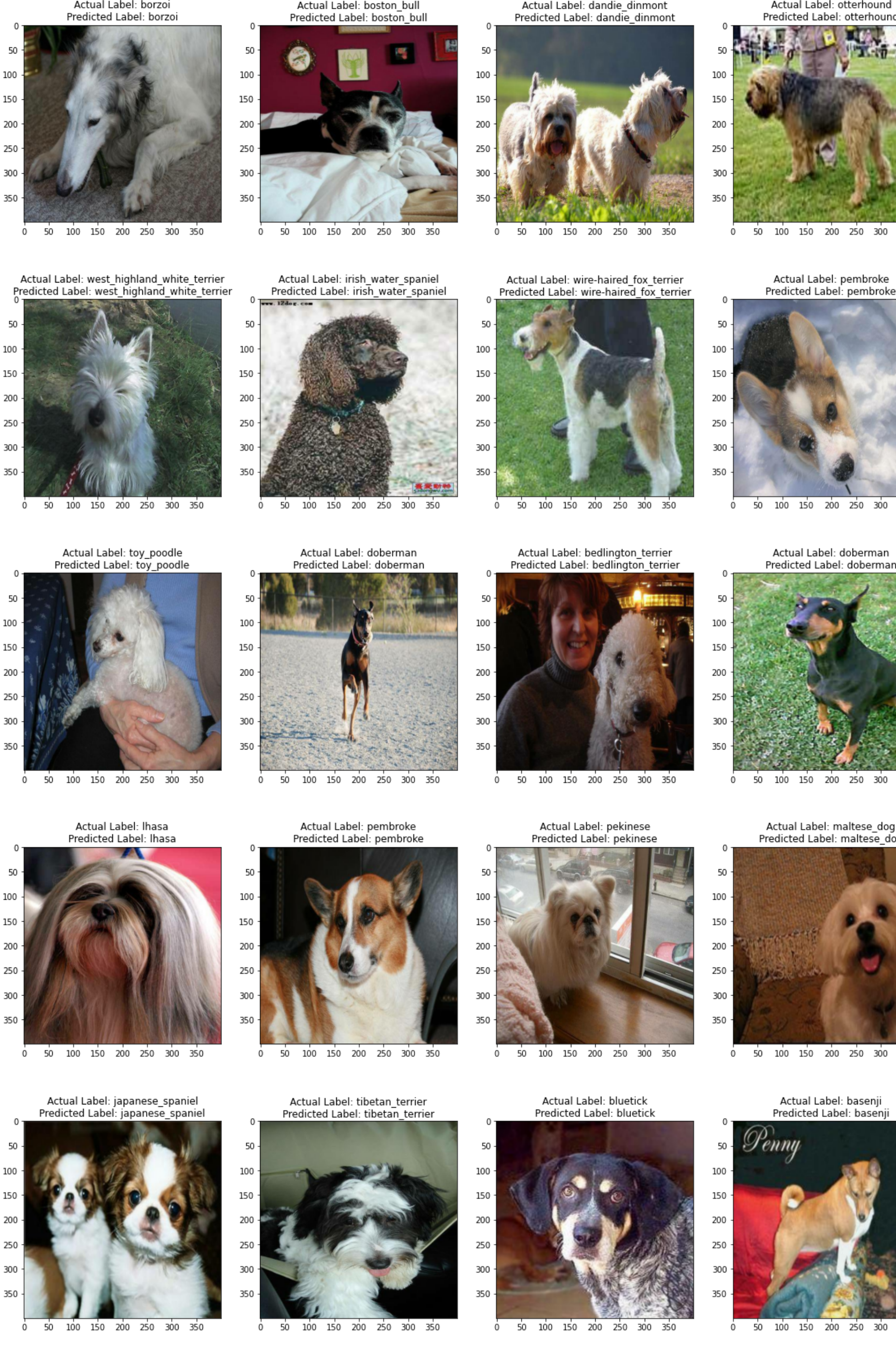


ACTUAL VS PREDICTED LABEL COMPARISON FOR SAMPLE VALIDATION DATA:

In [ ]:
```
from keras.models import load_model
Stacked_model_1 = load_model('/content/drive/MyDrive/dog_breed/Inception_resnet_stacked_weights.h5')
```

In [ ]:
```
plt.figure(figsize=(20,30))
for i in range(20):
  plt.subplot(5,4,i+1)
  image = tf.io.read_file(validation['path'].to_list()[i])
  image = tf.image.decode_jpeg(image, channels=3)
  image = image/255
  image = tf.image.convert_image_dtype(image, tf.float32)
  image = tf.image.resize(image, [400, 400])
  plt.imshow(image)
  actual_label = validation['label'].to_list()[i]
  predicted_label = list(le.classes_)[np.argmax(Stacked_model_1.predict(image[np.newaxis,:,:,:],verbose=0))]
  plt.title('Actual Label: '+ actual_label + '\n' + 'Predicted Label: ' + predicted_label)

plt.show()
```



PREDICTIONS ON TEST DATA:

In [33]:
```
test_files_path = []
for root, dirs, files in os.walk("test", topdown=False):
   for name in sorted(files):
      test_files_path.append(os.path.join(root, name))
```

In [ ]:
```
columns_list = ['Id'] + list(le.classes_)
```

In [ ]:
```
submission = pd.DataFrame(columns=columns_list)
```

In [ ]:
```
for i in test_files_path:
  image = tf.io.read_file(i)
  image = tf.image.decode_jpeg(image, channels=3)
  image = image/255
  image = tf.image.convert_image_dtype(image, tf.float32)
  image = tf.image.resize(image, [400, 400])
  predictions = Stacked_model_1.predict(image[np.newaxis,:,:,:],verbose=0)
  submission.loc[len(submission)] = [i.split('.')[0].split('/')[-1]] +list(predictions[0])
```

In [ ]:
```
submission.head()
```

Out[ ]:

	Id	affenpinscher	afghan_hound	african_hunting_dog	airedale	american_staffordshire_terrier	appenzeller	australian_terr
0	000621fb3cbb32d8935728e48679680e	2.139819e-07	1.094294e-07	8.954563e-08	1.002571e-07	3.719440e-07	1.680617e-08	2.825681e-
1	00102ee9d8eb90812350685311fe5890	3.361014e-10	1.019968e-09	6.128227e-09	7.880616e-10	5.106885e-09	9.120797e-09	2.045622e-
2	0012a730dfa437f5f3613fb75efcd4ce	1.964741e-07	1.458350e-05	2.704518e-06	3.504686e-06	2.694461e-07	2.097543e-06	9.825820e-
3	001510bc8570bbeee98c8d80c8a95ec1	1.648509e-06	5.883683e-07	1.190299e-08	1.076520e-08	1.619527e-07	5.936560e-06	1.734519e-
4	001a5f3114548acdefa3d4da05474c2e	2.960967e-03	6.666225e-06	3.472306e-07	1.341161e-07	4.204640e-06	1.091007e-06	3.490624e-

5 rows × 121 columns

In [ ]:
```
submission.to_csv('/content/drive/MyDrive/dog_breed/final_submission.csv',index=False)
```

In [ ]:
```
from google.colab import files
files.download('/content/drive/MyDrive/dog_breed/final_submission.csv')
```

Kaggle Submission Score: