Task 16

Registration ID : SIRSS1038

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Importing Libraries

In [1]:

```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
from datetime import datetime
from keras.preprocessing import image
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import Dense, Flatten, Conv2D, UpSampling2D, Dropout,BatchN
ormalization,GlobalAveragePooling2D
```

Importing the Cifar 100 Dataset

In [2]:

```
cifar100 = tf.keras.datasets.cifar100
(X_train, Y_train), (X_test,Y_test) = cifar100.load_data()
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-100-python.tar.gz
169009152/169001437 [==============================] - 6s 0us/step
```

In [3]:

```
def timer(start_time=None):
  #function to track time
  if not start_time:
      print(datetime.now())
      start_time = datetime.now()
      return start_time
  elif start_time:
      thour, temp_sec = divmod((datetime.now() - start_time).total_seconds(), 3600)
      tmin, tsec = divmod(temp_sec, 60)
      print('Time taken: %i hours %i minutes and %s seconds.' % (thour, tmin, round(tsec
, 2)))

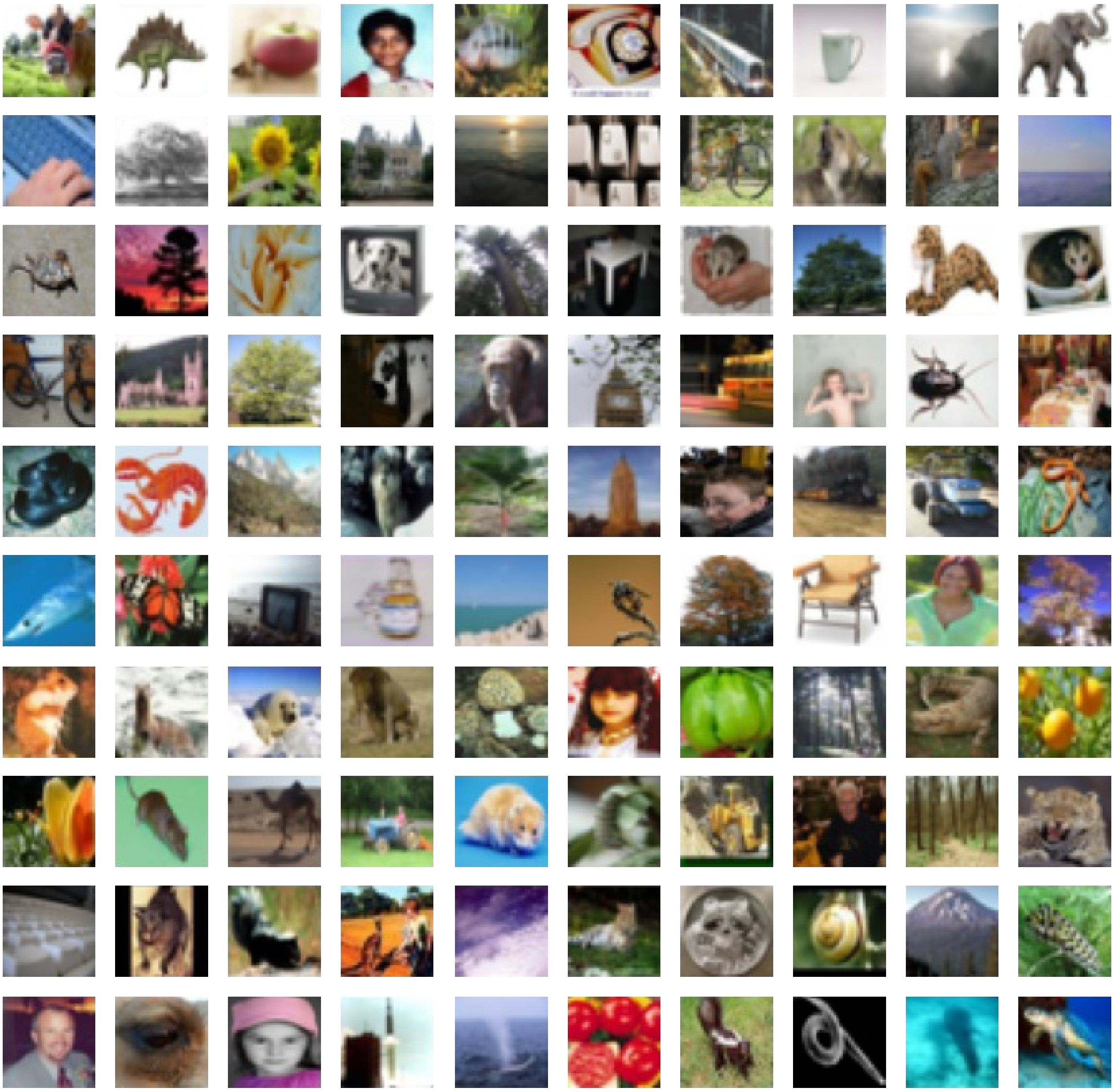
def plot_acc_loss(result):
  # function to plot the accuracy and loss graphs
  acc = result.history['accuracy']
  val_acc = result.history['val_accuracy']
  loss = result.history['loss']
  val_loss = result.history['val_loss']

  plt.figure(figsize=(20, 10))
  plt.subplot(1, 2, 1)
  plt.title("Training and Validation Accuracy")
  plt.plot(acc,color = 'green',label = 'Training Acuracy')
  plt.plot(val_acc,color = 'red',label = 'Validation Accuracy')
  plt.legend(loc='lower right')
  plt.ylabel('accuracy')
  plt.xlabel('epoch')
  plt.subplot(1, 2, 2)
  plt.title('Training and Validation Loss')
  plt.plot(loss,color = 'blue',label = 'Training Loss')
  plt.plot(val_loss,color = 'purple',label = 'Validation Loss')
  plt.ylabel('loss')
  plt.xlabel('epoch')
  plt.legend(loc='upper right')
  plt.show()
```

Plotting some images

In [4]:

```
plt.figure(figsize=(12,12))
for i in range(100):
  plt.subplot(10,10,1+i)
  plt.axis('off')
  plt.imshow(X_train[i],cmap='gray')
```



Splitting the train data again - we use the val set as test set and previous test set for final predictions

In [5]:

```
from sklearn.model_selection import train_test_split
x_train,x_val,y_train,y_val=train_test_split(X_train, Y_train,test_size=0.2)
```

Onehot encoding of the outputs

In [6]:

In [6]:

```
from keras.utils.np_utils import to_categorical
y_train=to_categorical(y_train,num_classes=100)
y_val=to_categorical(y_val,num_classes=100)
y_test=to_categorical(Y_test,num_classes=100)
```

In [7]:

```
x_train = x_train*1.0/255
  x_val = x_val*1.0/255
  X_test = X_test*1.0/255
```

In [8]:

```
print(x_train.shape,x_val.shape,X_test.shape)
print(y_train.shape,y_val.shape,y_test.shape)
```

```
(40000, 32, 32, 3) (10000, 32, 32, 3) (10000, 32, 32, 3)
(40000, 100) (10000, 100) (10000, 100)
```

Image Data Augmentation

In [9]:

```
train_datagen = ImageDataGenerator(
        rotation_range = 10,
        zoom_range = 0.1,
        width_shift_range = 0.1,
        height_shift_range = 0.1,
        shear_range = 0.1,
        horizontal_flip = True,
        vertical_flip = False
        )
train_datagen.fit(x_train)
```

Reduce Learning Rate if accuracy is not improving for 3 epochs

In [10]:

```
from keras.callbacks import ReduceLROnPlateau
learning_rate_reduction = ReduceLROnPlateau(
    monitor='val_accuracy',
    patience=3,
    verbose=1,
    factor=0.6,
    min_lr=1e-6)
```

Importing the Resnet Model

In [11]:

```
from tensorflow.keras.applications.resnet50 import ResNet50
resnet_model = ResNet50(
    include_top=False,
    weights='imagenet',
    input_shape=(224,224,3)
)

for layer in resnet_model.layers:
    if isinstance(layer, BatchNormalization):
        layer.trainable = True
    else:
        layer.trainable = False
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet
/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
```

```
94773248/94765736 [==============================] - 0s 0us/step
```

In [12]:

```
resnet_model.summary()
```

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

=========================================================================================
=========
input_1 (InputLayer)            [(None, 224, 224, 3) 0


_________________________________________________________________________________________
_________
conv1_pad (ZeroPadding2D)       (None, 230, 230, 3)  0           input_1[0][0]


_________________________________________________________________________________________
_________
conv1_conv (Conv2D)             (None, 112, 112, 64) 9472        conv1_pad[0][0]


_________________________________________________________________________________________
_________
conv1_bn (BatchNormalization)   (None, 112, 112, 64) 256         conv1_conv[0][0]


_________________________________________________________________________________________
_________
conv1_relu (Activation)         (None, 112, 112, 64) 0           conv1_bn[0][0]


_________________________________________________________________________________________
_________
pool1_pad (ZeroPadding2D)       (None, 114, 114, 64) 0           conv1_relu[0][0]


_________________________________________________________________________________________
_________
pool1_pool (MaxPooling2D)       (None, 56, 56, 64)   0           pool1_pad[0][0]


_________________________________________________________________________________________
_________
conv2_block1_1_conv (Conv2D)    (None, 56, 56, 64)   4160        pool1_pool[0][0]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_________
conv2_block1_1_bn (BatchNormali (None, 56, 56, 64)   256         conv2_block1_1_conv[0][0
]
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_________
conv2_block1_1_relu (Activation (None, 56, 56, 64)   0           conv2_block1_1_bn[0][0]


_________________________________________________________________________________________
_________
conv2_block1_2_conv (Conv2D)    (None, 56, 56, 64)   36928       conv2_block1_1_relu[0][0
]
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_________
conv2_block1_2_bn (BatchNormali (None, 56, 56, 64)   256         conv2_block1_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv2_block1_2_relu (Activation (None, 56, 56, 64)   0           conv2_block1_2_bn[0][0]


_________________________________________________________________________________________
_________
conv2_block1_0_conv (Conv2D)    (None, 56, 56, 256)  16640       pool1_pool[0][0]


_________________________________________________________________________________________
_________
conv2_block1_3_conv (Conv2D)    (None, 56, 56, 256)  16640       conv2_block1_2_relu[0][0
]
_________________________________________________________________________________________
```

```
_________
conv2_block1_0_bn (BatchNormali (None, 56, 56, 256)  1024        conv2_block1_0_conv[0][0
]
_________________________________________________________________________________________
_________
conv2_block1_3_bn (BatchNormali (None, 56, 56, 256)  1024        conv2_block1_3_conv[0][0
]
_________________________________________________________________________________________
_________
conv2_block1_add (Add)          (None, 56, 56, 256)  0           conv2_block1_0_bn[0][0]

                                                                 conv2_block1_3_bn[0][0
]
_________________________________________________________________________________________
_________
conv2_block1_out (Activation)   (None, 56, 56, 256)  0           conv2_block1_add[0][0]

_________________________________________________________________________________________
_________
conv2_block2_1_conv (Conv2D)    (None, 56, 56, 64)   16448       conv2_block1_out[0][0]

_________________________________________________________________________________________
_________
conv2_block2_1_bn (BatchNormali (None, 56, 56, 64)   256         conv2_block2_1_conv[0][0
]
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_________
conv2_block2_1_relu (Activation (None, 56, 56, 64)   0           conv2_block2_1_bn[0][0]

_________________________________________________________________________________________
_________
conv2_block2_2_conv (Conv2D)    (None, 56, 56, 64)   36928       conv2_block2_1_relu[0][0
]
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_________
conv2_block2_2_bn (BatchNormali (None, 56, 56, 64)   256         conv2_block2_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv2_block2_2_relu (Activation (None, 56, 56, 64)   0           conv2_block2_2_bn[0][0]

_________________________________________________________________________________________
_________
conv2_block2_3_conv (Conv2D)    (None, 56, 56, 256)  16640       conv2_block2_2_relu[0][0
]
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_________
conv2_block2_3_bn (BatchNormali (None, 56, 56, 256)  1024        conv2_block2_3_conv[0][0
]
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_________
conv2_block2_add (Add)          (None, 56, 56, 256)  0           conv2_block1_out[0][0]

                                                                 conv2_block2_3_bn[0][0
]
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_________
conv2_block2_out (Activation)   (None, 56, 56, 256)  0           conv2_block2_add[0][0]

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_________
conv2_block3_1_conv (Conv2D)    (None, 56, 56, 64)   16448       conv2_block2_out[0][0]

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_________
conv2_block3_1_bn (BatchNormali (None, 56, 56, 64)   256         conv2_block3_1_conv[0][0
]
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_________
conv2_block3_1_relu (Activation (None, 56, 56, 64)   0           conv2_block3_1_bn[0][0]

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```

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__________
conv2_block3_2_conv (Conv2D)    (None, 56, 56, 64)   36928       conv2_block3_1_relu[0][0
]
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__________
conv2_block3_2_bn (BatchNormali (None, 56, 56, 64)   256         conv2_block3_2_conv[0][0
]
__________________________________________________________________________________________
__________
conv2_block3_2_relu (Activation (None, 56, 56, 64)   0           conv2_block3_2_bn[0][0]

__________________________________________________________________________________________
__________
conv2_block3_3_conv (Conv2D)    (None, 56, 56, 256)  16640       conv2_block3_2_relu[0][0
]
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__________
conv2_block3_3_bn (BatchNormali (None, 56, 56, 256)  1024        conv2_block3_3_conv[0][0
]
__________________________________________________________________________________________
__________
conv2_block3_add (Add)          (None, 56, 56, 256)  0           conv2_block2_out[0][0]

                                                                 conv2_block3_3_bn[0][0
]
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__________
conv2_block3_out (Activation)   (None, 56, 56, 256)  0           conv2_block3_add[0][0]

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__________
conv3_block1_1_conv (Conv2D)    (None, 28, 28, 128)  32896       conv2_block3_out[0][0]

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__________
conv3_block1_1_bn (BatchNormali (None, 28, 28, 128)  512         conv3_block1_1_conv[0][0
]
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__________
conv3_block1_1_relu (Activation (None, 28, 28, 128)  0           conv3_block1_1_bn[0][0]

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__________
conv3_block1_2_conv (Conv2D)    (None, 28, 28, 128)  147584      conv3_block1_1_relu[0][0
]
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__________
conv3_block1_2_bn (BatchNormali (None, 28, 28, 128)  512         conv3_block1_2_conv[0][0
]
__________________________________________________________________________________________
__________
conv3_block1_2_relu (Activation (None, 28, 28, 128)  0           conv3_block1_2_bn[0][0]

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__________
conv3_block1_0_conv (Conv2D)    (None, 28, 28, 512)  131584      conv2_block3_out[0][0]

__________________________________________________________________________________________
__________
conv3_block1_3_conv (Conv2D)    (None, 28, 28, 512)  66048       conv3_block1_2_relu[0][0
]
__________________________________________________________________________________________
__________
conv3_block1_0_bn (BatchNormali (None, 28, 28, 512)  2048        conv3_block1_0_conv[0][0
]
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__________
conv3_block1_3_bn (BatchNormali (None, 28, 28, 512)  2048        conv3_block1_3_conv[0][0
]
__________________________________________________________________________________________
__________
conv3_block1_add (Add)          (None, 28, 28, 512)  0           conv3_block1_0_bn[0][0]
```

```
                                                                 conv3_block1_3_bn[0][0
]
_________________________________________________________________________________________
_________
conv3_block1_out (Activation)   (None, 28, 28, 512)  0           conv3_block1_add[0][0]

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_________
conv3_block2_1_conv (Conv2D)    (None, 28, 28, 128)  65664       conv3_block1_out[0][0]

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_________
conv3_block2_1_bn (BatchNormali (None, 28, 28, 128)  512         conv3_block2_1_conv[0][0
]
_________________________________________________________________________________________
_________
conv3_block2_1_relu (Activation (None, 28, 28, 128)  0           conv3_block2_1_bn[0][0]

_________________________________________________________________________________________
_________
conv3_block2_2_conv (Conv2D)    (None, 28, 28, 128)  147584      conv3_block2_1_relu[0][0
]
_________________________________________________________________________________________
_________
conv3_block2_2_bn (BatchNormali (None, 28, 28, 128)  512         conv3_block2_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv3_block2_2_relu (Activation (None, 28, 28, 128)  0           conv3_block2_2_bn[0][0]

_________________________________________________________________________________________
_________
conv3_block2_3_conv (Conv2D)    (None, 28, 28, 512)  66048       conv3_block2_2_relu[0][0
]
_________________________________________________________________________________________
_________
conv3_block2_3_bn (BatchNormali (None, 28, 28, 512)  2048        conv3_block2_3_conv[0][0
]
_________________________________________________________________________________________
_________
conv3_block2_add (Add)          (None, 28, 28, 512)  0           conv3_block1_out[0][0]

                                                                 conv3_block2_3_bn[0][0
]
_________________________________________________________________________________________
_________
conv3_block2_out (Activation)   (None, 28, 28, 512)  0           conv3_block2_add[0][0]

_________________________________________________________________________________________
_________
conv3_block3_1_conv (Conv2D)    (None, 28, 28, 128)  65664       conv3_block2_out[0][0]

_________________________________________________________________________________________
_________
conv3_block3_1_bn (BatchNormali (None, 28, 28, 128)  512         conv3_block3_1_conv[0][0
]
_________________________________________________________________________________________
_________
conv3_block3_1_relu (Activation (None, 28, 28, 128)  0           conv3_block3_1_bn[0][0]

_________________________________________________________________________________________
_________
conv3_block3_2_conv (Conv2D)    (None, 28, 28, 128)  147584      conv3_block3_1_relu[0][0
]
_________________________________________________________________________________________
_________
conv3_block3_2_bn (BatchNormali (None, 28, 28, 128)  512         conv3_block3_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv3_block3_2_relu (Activation (None, 28, 28, 128)  0           conv3_block3_2_bn[0][0]
__________________________________________________________________________________________
_________
conv3_block3_3_conv (Conv2D)    (None, 28, 28, 512)  66048       conv3_block3_2_relu[0][0
]
__________________________________________________________________________________________
_________
conv3_block3_3_bn (BatchNormali (None, 28, 28, 512)  2048        conv3_block3_3_conv[0][0
]
__________________________________________________________________________________________
_________
conv3_block3_add (Add)          (None, 28, 28, 512)  0           conv3_block2_out[0][0]

                                                                 conv3_block3_3_bn[0][0
]
__________________________________________________________________________________________
_________
conv3_block3_out (Activation)   (None, 28, 28, 512)  0           conv3_block3_add[0][0]

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_________
conv3_block4_1_conv (Conv2D)    (None, 28, 28, 128)  65664       conv3_block3_out[0][0]

__________________________________________________________________________________________
_________
conv3_block4_1_bn (BatchNormali (None, 28, 28, 128)  512         conv3_block4_1_conv[0][0
]
__________________________________________________________________________________________
_________
conv3_block4_1_relu (Activation (None, 28, 28, 128)  0           conv3_block4_1_bn[0][0]

__________________________________________________________________________________________
_________
conv3_block4_2_conv (Conv2D)    (None, 28, 28, 128)  147584      conv3_block4_1_relu[0][0
]
__________________________________________________________________________________________
_________
conv3_block4_2_bn (BatchNormali (None, 28, 28, 128)  512         conv3_block4_2_conv[0][0
]
__________________________________________________________________________________________
_________
conv3_block4_2_relu (Activation (None, 28, 28, 128)  0           conv3_block4_2_bn[0][0]

__________________________________________________________________________________________
_________
conv3_block4_3_conv (Conv2D)    (None, 28, 28, 512)  66048       conv3_block4_2_relu[0][0
]
__________________________________________________________________________________________
_________
conv3_block4_3_bn (BatchNormali (None, 28, 28, 512)  2048        conv3_block4_3_conv[0][0
]
__________________________________________________________________________________________
_________
conv3_block4_add (Add)          (None, 28, 28, 512)  0           conv3_block3_out[0][0]

                                                                 conv3_block4_3_bn[0][0
]
__________________________________________________________________________________________
_________
conv3_block4_out (Activation)   (None, 28, 28, 512)  0           conv3_block4_add[0][0]

__________________________________________________________________________________________
_________
conv4_block1_1_conv (Conv2D)    (None, 14, 14, 256)  131328      conv3_block4_out[0][0]

__________________________________________________________________________________________
_________
conv4_block1_1_bn (BatchNormali (None, 14, 14, 256)  1024        conv4_block1_1_conv[0][0
]
__________________________________________________________________________________________
_________
conv4_block1_1_relu (Activation (None, 14, 14, 256)  0           conv4_block1_1_bn[0][0]
_________________________________________________________________________________________
_________
conv4_block1_2_conv (Conv2D)    (None, 14, 14, 256)  590080      conv4_block1_1_relu[0][0
]
_________________________________________________________________________________________
_________
conv4_block1_2_bn (BatchNormali (None, 14, 14, 256)  1024        conv4_block1_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv4_block1_2_relu (Activation (None, 14, 14, 256)  0           conv4_block1_2_bn[0][0]

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_________
conv4_block1_0_conv (Conv2D)    (None, 14, 14, 1024) 525312      conv3_block4_out[0][0]

_________________________________________________________________________________________
_________
conv4_block1_3_conv (Conv2D)    (None, 14, 14, 1024) 263168      conv4_block1_2_relu[0][0
]
_________________________________________________________________________________________
_________
conv4_block1_0_bn (BatchNormali (None, 14, 14, 1024) 4096        conv4_block1_0_conv[0][0
]
_________________________________________________________________________________________
_________
conv4_block1_3_bn (BatchNormali (None, 14, 14, 1024) 4096        conv4_block1_3_conv[0][0
]
_________________________________________________________________________________________
_________
conv4_block1_add (Add)          (None, 14, 14, 1024) 0           conv4_block1_0_bn[0][0]

                                                                 conv4_block1_3_bn[0][0
]
_________________________________________________________________________________________
_________
conv4_block1_out (Activation)   (None, 14, 14, 1024) 0           conv4_block1_add[0][0]

_________________________________________________________________________________________
_________
conv4_block2_1_conv (Conv2D)    (None, 14, 14, 256)  262400      conv4_block1_out[0][0]

_________________________________________________________________________________________
_________
conv4_block2_1_bn (BatchNormali (None, 14, 14, 256)  1024        conv4_block2_1_conv[0][0
]
_________________________________________________________________________________________
_________
conv4_block2_1_relu (Activation (None, 14, 14, 256)  0           conv4_block2_1_bn[0][0]

_________________________________________________________________________________________
_________
conv4_block2_2_conv (Conv2D)    (None, 14, 14, 256)  590080      conv4_block2_1_relu[0][0
]
_________________________________________________________________________________________
_________
conv4_block2_2_bn (BatchNormali (None, 14, 14, 256)  1024        conv4_block2_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv4_block2_2_relu (Activation (None, 14, 14, 256)  0           conv4_block2_2_bn[0][0]

_________________________________________________________________________________________
_________
conv4_block2_3_conv (Conv2D)    (None, 14, 14, 1024) 263168      conv4_block2_2_relu[0][0
]
_________________________________________________________________________________________
_________
conv4_block2_3_bn (BatchNormali (None, 14, 14, 1024) 4096        conv4_block2_3_conv[0][0
]
_________________________________________________________________________________________
```

```
________
conv4_block2_add (Add)          (None, 14, 14, 1024)  0           conv4_block1_out[0][0]

                                                                  conv4_block2_3_bn[0][0
]
__________________________________________________________________________________________
________
conv4_block2_out (Activation)   (None, 14, 14, 1024)  0           conv4_block2_add[0][0]

__________________________________________________________________________________________
________
conv4_block3_1_conv (Conv2D)    (None, 14, 14, 256)   262400      conv4_block2_out[0][0]

__________________________________________________________________________________________
________
conv4_block3_1_bn (BatchNormali (None, 14, 14, 256)   1024        conv4_block3_1_conv[0][0
]
__________________________________________________________________________________________
________
conv4_block3_1_relu (Activation (None, 14, 14, 256)   0           conv4_block3_1_bn[0][0]

__________________________________________________________________________________________
________
conv4_block3_2_conv (Conv2D)    (None, 14, 14, 256)   590080      conv4_block3_1_relu[0][0
]
__________________________________________________________________________________________
________
conv4_block3_2_bn (BatchNormali (None, 14, 14, 256)   1024        conv4_block3_2_conv[0][0
]
__________________________________________________________________________________________
________
conv4_block3_2_relu (Activation (None, 14, 14, 256)   0           conv4_block3_2_bn[0][0]

__________________________________________________________________________________________
________
conv4_block3_3_conv (Conv2D)    (None, 14, 14, 1024)  263168      conv4_block3_2_relu[0][0
]
__________________________________________________________________________________________
________
conv4_block3_3_bn (BatchNormali (None, 14, 14, 1024)  4096        conv4_block3_3_conv[0][0
]
__________________________________________________________________________________________
________
conv4_block3_add (Add)          (None, 14, 14, 1024)  0           conv4_block2_out[0][0]

                                                                  conv4_block3_3_bn[0][0
]
__________________________________________________________________________________________
________
conv4_block3_out (Activation)   (None, 14, 14, 1024)  0           conv4_block3_add[0][0]

__________________________________________________________________________________________
________
conv4_block4_1_conv (Conv2D)    (None, 14, 14, 256)   262400      conv4_block3_out[0][0]

__________________________________________________________________________________________
________
conv4_block4_1_bn (BatchNormali (None, 14, 14, 256)   1024        conv4_block4_1_conv[0][0
]
__________________________________________________________________________________________
________
conv4_block4_1_relu (Activation (None, 14, 14, 256)   0           conv4_block4_1_bn[0][0]

__________________________________________________________________________________________
________
conv4_block4_2_conv (Conv2D)    (None, 14, 14, 256)   590080      conv4_block4_1_relu[0][0
]
__________________________________________________________________________________________
________
conv4_block4_2_bn (BatchNormali (None, 14, 14, 256)   1024        conv4_block4_2_conv[0][0
]
__________________________________________________________________________________________
```

```
__________
conv4_block4_2_relu (Activation (None, 14, 14, 256)  0           conv4_block4_2_bn[0][0]

__________________________________________________________________________________________________
__________
conv4_block4_3_conv (Conv2D)    (None, 14, 14, 1024) 263168      conv4_block4_2_relu[0][0
]
__________________________________________________________________________________________________
__________
conv4_block4_3_bn (BatchNormali (None, 14, 14, 1024) 4096        conv4_block4_3_conv[0][0
]
__________________________________________________________________________________________________
__________
conv4_block4_add (Add)          (None, 14, 14, 1024) 0           conv4_block3_out[0][0]

                                                                 conv4_block4_3_bn[0][0
]
__________________________________________________________________________________________________
__________
conv4_block4_out (Activation)   (None, 14, 14, 1024) 0           conv4_block4_add[0][0]

__________________________________________________________________________________________________
__________
conv4_block5_1_conv (Conv2D)    (None, 14, 14, 256)  262400      conv4_block4_out[0][0]

__________________________________________________________________________________________________
__________
conv4_block5_1_bn (BatchNormali (None, 14, 14, 256)  1024        conv4_block5_1_conv[0][0
]
__________________________________________________________________________________________________
__________
conv4_block5_1_relu (Activation (None, 14, 14, 256)  0           conv4_block5_1_bn[0][0]

__________________________________________________________________________________________________
__________
conv4_block5_2_conv (Conv2D)    (None, 14, 14, 256)  590080      conv4_block5_1_relu[0][0
]
__________________________________________________________________________________________________
__________
conv4_block5_2_bn (BatchNormali (None, 14, 14, 256)  1024        conv4_block5_2_conv[0][0
]
__________________________________________________________________________________________________
__________
conv4_block5_2_relu (Activation (None, 14, 14, 256)  0           conv4_block5_2_bn[0][0]

__________________________________________________________________________________________________
__________
conv4_block5_3_conv (Conv2D)    (None, 14, 14, 1024) 263168      conv4_block5_2_relu[0][0
]
__________________________________________________________________________________________________
__________
conv4_block5_3_bn (BatchNormali (None, 14, 14, 1024) 4096        conv4_block5_3_conv[0][0
]
__________________________________________________________________________________________________
__________
conv4_block5_add (Add)          (None, 14, 14, 1024) 0           conv4_block4_out[0][0]

                                                                 conv4_block5_3_bn[0][0
]
__________________________________________________________________________________________________
__________
conv4_block5_out (Activation)   (None, 14, 14, 1024) 0           conv4_block5_add[0][0]

__________________________________________________________________________________________________
__________
conv4_block6_1_conv (Conv2D)    (None, 14, 14, 256)  262400      conv4_block5_out[0][0]

__________________________________________________________________________________________________
__________
conv4_block6_1_bn (BatchNormali (None, 14, 14, 256)  1024        conv4_block6_1_conv[0][0
]
__________________________________________________________________________________________________
```

```
_________
conv4_block6_1_relu (Activation (None, 14, 14, 256)  0           conv4_block6_1_bn[0][0]

_________________________________________________________________________________________
_________
conv4_block6_2_conv (Conv2D)    (None, 14, 14, 256)  590080      conv4_block6_1_relu[0][0
]
_________________________________________________________________________________________
_________
conv4_block6_2_bn (BatchNormali (None, 14, 14, 256)  1024        conv4_block6_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv4_block6_2_relu (Activation (None, 14, 14, 256)  0           conv4_block6_2_bn[0][0]

_________________________________________________________________________________________
_________
conv4_block6_3_conv (Conv2D)    (None, 14, 14, 1024) 263168      conv4_block6_2_relu[0][0
]
_________________________________________________________________________________________
_________
conv4_block6_3_bn (BatchNormali (None, 14, 14, 1024) 4096        conv4_block6_3_conv[0][0
]
_________________________________________________________________________________________
_________
conv4_block6_add (Add)          (None, 14, 14, 1024) 0           conv4_block5_out[0][0]

                                                                 conv4_block6_3_bn[0][0
]
_________________________________________________________________________________________
_________
conv4_block6_out (Activation)   (None, 14, 14, 1024) 0           conv4_block6_add[0][0]

_________________________________________________________________________________________
_________
conv5_block1_1_conv (Conv2D)    (None, 7, 7, 512)    524800      conv4_block6_out[0][0]

_________________________________________________________________________________________
_________
conv5_block1_1_bn (BatchNormali (None, 7, 7, 512)    2048        conv5_block1_1_conv[0][0
]
_________________________________________________________________________________________
_________
conv5_block1_1_relu (Activation (None, 7, 7, 512)    0           conv5_block1_1_bn[0][0]

_________________________________________________________________________________________
_________
conv5_block1_2_conv (Conv2D)    (None, 7, 7, 512)    2359808     conv5_block1_1_relu[0][0
]
_________________________________________________________________________________________
_________
conv5_block1_2_bn (BatchNormali (None, 7, 7, 512)    2048        conv5_block1_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv5_block1_2_relu (Activation (None, 7, 7, 512)    0           conv5_block1_2_bn[0][0]

_________________________________________________________________________________________
_________
conv5_block1_0_conv (Conv2D)    (None, 7, 7, 2048)   2099200     conv4_block6_out[0][0]

_________________________________________________________________________________________
_________
conv5_block1_3_conv (Conv2D)    (None, 7, 7, 2048)   1050624     conv5_block1_2_relu[0][0
]
_________________________________________________________________________________________
_________
conv5_block1_0_bn (BatchNormali (None, 7, 7, 2048)   8192        conv5_block1_0_conv[0][0
]
_________________________________________________________________________________________
_________
conv5_block1_3_bn (BatchNormali (None, 7, 7, 2048)   8192        conv5_block1_3_conv[0][0
]
```

```
]
_________________________________________________________________________________________
_________
conv5_block1_add (Add)          (None, 7, 7, 2048)   0           conv5_block1_0_bn[0][0]

                                                                 conv5_block1_3_bn[0][0
]
_________________________________________________________________________________________
_________
conv5_block1_out (Activation)   (None, 7, 7, 2048)   0           conv5_block1_add[0][0]

_________________________________________________________________________________________
_________
conv5_block2_1_conv (Conv2D)    (None, 7, 7, 512)    1049088     conv5_block1_out[0][0]

_________________________________________________________________________________________
_________
conv5_block2_1_bn (BatchNormali (None, 7, 7, 512)    2048        conv5_block2_1_conv[0][0
]
_________________________________________________________________________________________
_________
conv5_block2_1_relu (Activation (None, 7, 7, 512)    0           conv5_block2_1_bn[0][0]

_________________________________________________________________________________________
_________
conv5_block2_2_conv (Conv2D)    (None, 7, 7, 512)    2359808     conv5_block2_1_relu[0][0
]
_________________________________________________________________________________________
_________
conv5_block2_2_bn (BatchNormali (None, 7, 7, 512)    2048        conv5_block2_2_conv[0][0
]
_________________________________________________________________________________________
_________
conv5_block2_2_relu (Activation (None, 7, 7, 512)    0           conv5_block2_2_bn[0][0]

_________________________________________________________________________________________
_________
conv5_block2_3_conv (Conv2D)    (None, 7, 7, 2048)   1050624     conv5_block2_2_relu[0][0
]
_________________________________________________________________________________________
_________
conv5_block2_3_bn (BatchNormali (None, 7, 7, 2048)   8192        conv5_block2_3_conv[0][0
]
_________________________________________________________________________________________
_________
conv5_block2_add (Add)          (None, 7, 7, 2048)   0           conv5_block1_out[0][0]

                                                                 conv5_block2_3_bn[0][0
]
_________________________________________________________________________________________
_________
conv5_block2_out (Activation)   (None, 7, 7, 2048)   0           conv5_block2_add[0][0]

_________________________________________________________________________________________
_________
conv5_block3_1_conv (Conv2D)    (None, 7, 7, 512)    1049088     conv5_block2_out[0][0]

_________________________________________________________________________________________
_________
conv5_block3_1_bn (BatchNormali (None, 7, 7, 512)    2048        conv5_block3_1_conv[0][0
]
_________________________________________________________________________________________
_________
conv5_block3_1_relu (Activation (None, 7, 7, 512)    0           conv5_block3_1_bn[0][0]

_________________________________________________________________________________________
_________
conv5_block3_2_conv (Conv2D)    (None, 7, 7, 512)    2359808     conv5_block3_1_relu[0][0
]
_________________________________________________________________________________________
_________
conv5_block3_2_bn (BatchNormali (None, 7, 7, 512)    2048        conv5_block3_2_conv[0][0
]
__________________________________________________________________________________________
_________
conv5_block3_2_relu (Activation (None, 7, 7, 512)    0           conv5_block3_2_bn[0][0]

__________________________________________________________________________________________
_________
conv5_block3_3_conv (Conv2D)    (None, 7, 7, 2048)   1050624     conv5_block3_2_relu[0][0
]
__________________________________________________________________________________________
_________
conv5_block3_3_bn (BatchNormali (None, 7, 7, 2048)   8192        conv5_block3_3_conv[0][0
]
__________________________________________________________________________________________
_________
conv5_block3_add (Add)          (None, 7, 7, 2048)   0           conv5_block2_out[0][0]

                                                                 conv5_block3_3_bn[0][0
]
__________________________________________________________________________________________
_________
conv5_block3_out (Activation)   (None, 7, 7, 2048)   0           conv5_block3_add[0][0]

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

Converting the output layer as per our dataset

In [13]:

```
model=tf.keras.models.Sequential()
model.add(UpSampling2D(size=(7, 7),interpolation='bilinear'))
model.add(resnet_model)
model.add(GlobalAveragePooling2D())
model.add(Dropout(.25))
model.add(Dense(256, activation='relu'))
model.add(BatchNormalization())
model.add(Dense(100, activation='softmax'))
```

In [14]:

```
optimizer = tf.keras.optimizers.SGD(learning_rate=1e-3, momentum=0.9)
```

In [15]:

```
model.compile(
    optimizer = optimizer,
    loss='categorical_crossentropy',
    metrics=['accuracy']
)
```

In [16]:

```
start_time=timer(None)
result=model.fit(
    train_datagen.flow(x_train, y_train, batch_size = 128),
    validation_data = (x_val, y_val),
    epochs = 50,
    verbose = 1,
    callbacks = [learning_rate_reduction]
)
timer(start_time)
```

```
2021-08-13 22:27:11.100467
Epoch 1/50
```

```
313/313 [==============================] - 169s 525ms/step - loss: 4.7197 - accuracy: 0.0
497 - val_loss: 12.7910 - val_accuracy: 0.0102
Epoch 2/50
313/313 [==============================] - 162s 517ms/step - loss: 3.2714 - accuracy: 0.2
299 - val_loss: 6.4920 - val_accuracy: 0.0116
Epoch 3/50
313/313 [==============================] - 162s 517ms/step - loss: 2.7051 - accuracy: 0.3
344 - val_loss: 3.2080 - val_accuracy: 0.2347
Epoch 4/50
313/313 [==============================] - 162s 517ms/step - loss: 2.3692 - accuracy: 0.4
049 - val_loss: 2.0134 - val_accuracy: 0.4748
Epoch 5/50
313/313 [==============================] - 162s 517ms/step - loss: 2.1650 - accuracy: 0.4
417 - val_loss: 1.8416 - val_accuracy: 0.5116
Epoch 6/50
313/313 [==============================] - 162s 517ms/step - loss: 1.9954 - accuracy: 0.4
801 - val_loss: 1.7502 - val_accuracy: 0.5280
Epoch 7/50
313/313 [==============================] - 162s 517ms/step - loss: 1.8640 - accuracy: 0.5
034 - val_loss: 1.6559 - val_accuracy: 0.5506
Epoch 8/50
313/313 [==============================] - 162s 517ms/step - loss: 1.7697 - accuracy: 0.5
286 - val_loss: 1.5733 - val_accuracy: 0.5723
Epoch 9/50
313/313 [==============================] - 162s 517ms/step - loss: 1.6839 - accuracy: 0.5
445 - val_loss: 1.5109 - val_accuracy: 0.5861
Epoch 10/50
313/313 [==============================] - 162s 518ms/step - loss: 1.6186 - accuracy: 0.5
599 - val_loss: 1.4509 - val_accuracy: 0.5997
Epoch 11/50
313/313 [==============================] - 162s 517ms/step - loss: 1.5624 - accuracy: 0.5
749 - val_loss: 1.4044 - val_accuracy: 0.6083
Epoch 12/50
313/313 [==============================] - 162s 517ms/step - loss: 1.5044 - accuracy: 0.5
848 - val_loss: 1.3655 - val_accuracy: 0.6195
Epoch 13/50
313/313 [==============================] - 162s 517ms/step - loss: 1.4539 - accuracy: 0.5
971 - val_loss: 1.3278 - val_accuracy: 0.6288
Epoch 14/50
313/313 [==============================] - 162s 517ms/step - loss: 1.4150 - accuracy: 0.6
058 - val_loss: 1.2960 - val_accuracy: 0.6368
Epoch 15/50
313/313 [==============================] - 162s 517ms/step - loss: 1.3943 - accuracy: 0.6
100 - val_loss: 1.2632 - val_accuracy: 0.6430
Epoch 16/50
313/313 [==============================] - 161s 516ms/step - loss: 1.3572 - accuracy: 0.6
201 - val_loss: 1.2345 - val_accuracy: 0.6523
Epoch 17/50
313/313 [==============================] - 161s 516ms/step - loss: 1.3109 - accuracy: 0.6
288 - val_loss: 1.2104 - val_accuracy: 0.6568
Epoch 18/50
313/313 [==============================] - 162s 516ms/step - loss: 1.2867 - accuracy: 0.6
378 - val_loss: 1.1907 - val_accuracy: 0.6613
Epoch 19/50
313/313 [==============================] - 161s 516ms/step - loss: 1.2602 - accuracy: 0.6
420 - val_loss: 1.1700 - val_accuracy: 0.6660
Epoch 20/50
313/313 [==============================] - 162s 516ms/step - loss: 1.2423 - accuracy: 0.6
461 - val_loss: 1.1539 - val_accuracy: 0.6710
Epoch 21/50
313/313 [==============================] - 162s 516ms/step - loss: 1.2215 - accuracy: 0.6
506 - val_loss: 1.1359 - val_accuracy: 0.6734
Epoch 22/50
313/313 [==============================] - 162s 517ms/step - loss: 1.1983 - accuracy: 0.6
591 - val_loss: 1.1219 - val_accuracy: 0.6768
Epoch 23/50
313/313 [==============================] - 162s 516ms/step - loss: 1.1791 - accuracy: 0.6
630 - val_loss: 1.1059 - val_accuracy: 0.6793
Epoch 24/50
313/313 [==============================] - 162s 516ms/step - loss: 1.1657 - accuracy: 0.6
650 - val_loss: 1.0918 - val_accuracy: 0.6825
Epoch 25/50
```

```
313/313 [==============================] - 162s 516ms/step - loss: 1.1404 - accuracy: 0.6
715 - val_loss: 1.0809 - val_accuracy: 0.6857
Epoch 26/50
313/313 [==============================] - 162s 516ms/step - loss: 1.1255 - accuracy: 0.6
753 - val_loss: 1.0686 - val_accuracy: 0.6888
Epoch 27/50
313/313 [==============================] - 162s 516ms/step - loss: 1.1262 - accuracy: 0.6
732 - val_loss: 1.0565 - val_accuracy: 0.6928
Epoch 28/50
313/313 [==============================] - 162s 517ms/step - loss: 1.0848 - accuracy: 0.6
855 - val_loss: 1.0448 - val_accuracy: 0.6941
Epoch 29/50
313/313 [==============================] - 162s 516ms/step - loss: 1.0941 - accuracy: 0.6
871 - val_loss: 1.0365 - val_accuracy: 0.6980
Epoch 30/50
313/313 [==============================] - 162s 517ms/step - loss: 1.0771 - accuracy: 0.6
869 - val_loss: 1.0258 - val_accuracy: 0.6990
Epoch 31/50
313/313 [==============================] - 162s 516ms/step - loss: 1.0673 - accuracy: 0.6
907 - val_loss: 1.0173 - val_accuracy: 0.7024
Epoch 32/50
313/313 [==============================] - 162s 517ms/step - loss: 1.0362 - accuracy: 0.7
001 - val_loss: 1.0111 - val_accuracy: 0.7040
Epoch 33/50
313/313 [==============================] - 162s 516ms/step - loss: 1.0268 - accuracy: 0.7
024 - val_loss: 1.0026 - val_accuracy: 0.7066
Epoch 34/50
313/313 [==============================] - 162s 517ms/step - loss: 1.0151 - accuracy: 0.7
076 - val_loss: 0.9936 - val_accuracy: 0.7085
Epoch 35/50
313/313 [==============================] - 162s 517ms/step - loss: 1.0074 - accuracy: 0.7
026 - val_loss: 0.9865 - val_accuracy: 0.7107
Epoch 36/50
313/313 [==============================] - 162s 517ms/step - loss: 1.0065 - accuracy: 0.7
046 - val_loss: 0.9836 - val_accuracy: 0.7125
Epoch 37/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9891 - accuracy: 0.7
117 - val_loss: 0.9720 - val_accuracy: 0.7171
Epoch 38/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9835 - accuracy: 0.7
086 - val_loss: 0.9715 - val_accuracy: 0.7166
Epoch 39/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9734 - accuracy: 0.7
155 - val_loss: 0.9626 - val_accuracy: 0.7182
Epoch 40/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9610 - accuracy: 0.7
212 - val_loss: 0.9585 - val_accuracy: 0.7185
Epoch 41/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9576 - accuracy: 0.7
187 - val_loss: 0.9522 - val_accuracy: 0.7205
Epoch 42/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9417 - accuracy: 0.7
225 - val_loss: 0.9427 - val_accuracy: 0.7229
Epoch 43/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9391 - accuracy: 0.7
209 - val_loss: 0.9394 - val_accuracy: 0.7238
Epoch 44/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9363 - accuracy: 0.7
217 - val_loss: 0.9325 - val_accuracy: 0.7256
Epoch 45/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9105 - accuracy: 0.7
316 - val_loss: 0.9308 - val_accuracy: 0.7278
Epoch 46/50
313/313 [==============================] - 162s 517ms/step - loss: 0.8966 - accuracy: 0.7
355 - val_loss: 0.9274 - val_accuracy: 0.7265
Epoch 47/50
313/313 [==============================] - 162s 517ms/step - loss: 0.9023 - accuracy: 0.7
337 - val_loss: 0.9256 - val_accuracy: 0.7271
Epoch 48/50
313/313 [==============================] - 161s 516ms/step - loss: 0.8994 - accuracy: 0.7
326 - val_loss: 0.9194 - val_accuracy: 0.7282
Epoch 49/50
```

```
313/313 [==============================] - 162s 517ms/step - loss: 0.8868 - accuracy: 0.7
373 - val_loss: 0.9162 - val_accuracy: 0.7279
Epoch 50/50
313/313 [==============================] - 162s 516ms/step - loss: 0.8902 - accuracy: 0.7
358 - val_loss: 0.9101 - val_accuracy: 0.7309
Time taken: 2 hours 15 minutes and 4.86 seconds.
```

In [17]:

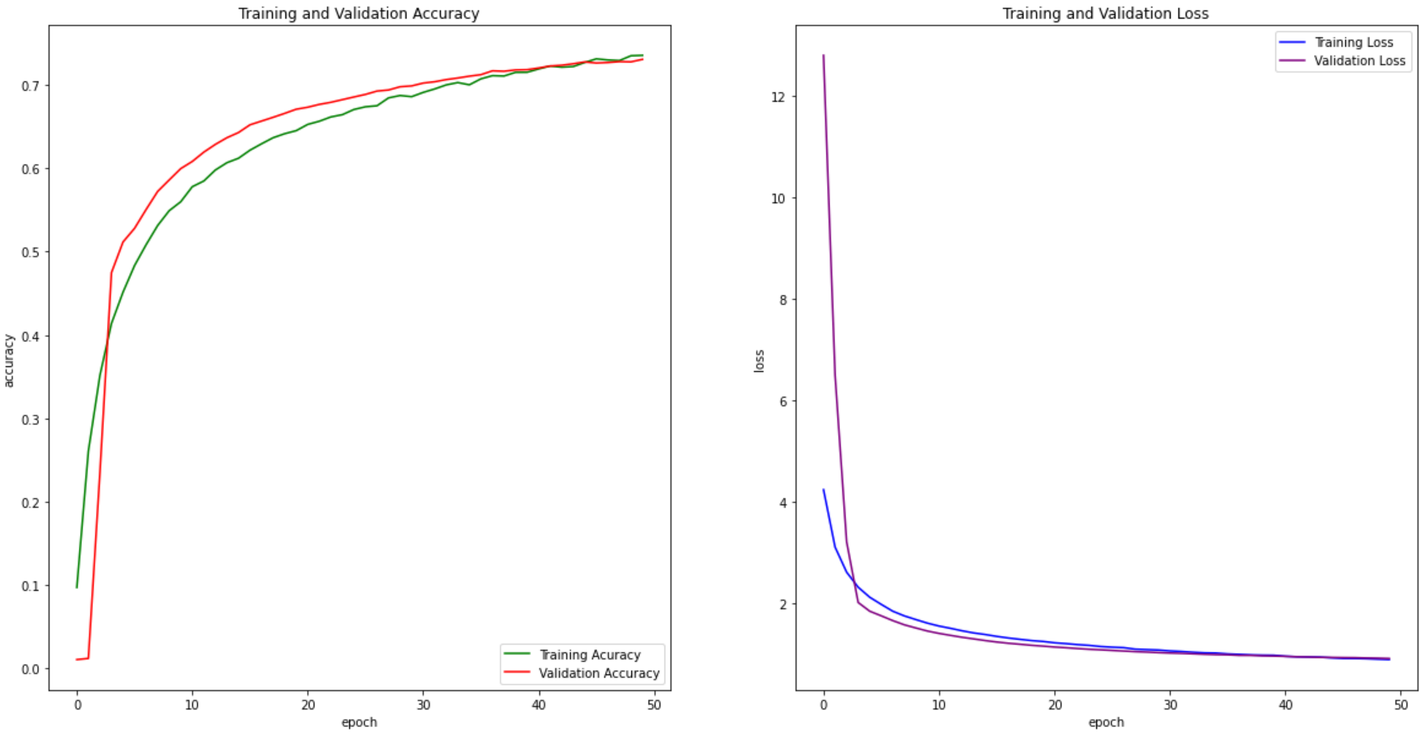
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
up_sampling2d (UpSampling2D) (None, None, None, None)  0         
_________________________________________________________________
resnet50 (Functional)        (None, 7, 7, 2048)        23587712  
_________________________________________________________________
global_average_pooling2d (Gl (None, 2048)              0         
_________________________________________________________________
dropout (Dropout)            (None, 2048)              0         
_________________________________________________________________
dense (Dense)                (None, 256)               524544    
_________________________________________________________________
batch_normalization (BatchNo (None, 256)               1024      
_________________________________________________________________
dense_1 (Dense)              (None, 100)               25700     
=================================================================
Total params: 24,138,980
Trainable params: 603,876
Non-trainable params: 23,535,104
_________________________________________________________________
```

Plot accuracy and Loss

In [18]:

```
plot_acc_loss(result)
```



Predictions,Accuracy and Confusion Matrix

In [19]:

```
y_pred = model.predict_classes(X_test)
y_true = Y_test.ravel()
print(y_pred.shape)
print(y_true.shape)
```

```
/opt/conda/lib/python3.7/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.pre
dict(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 '
```

```
(10000,)
(10000,)
```

In [20]:

```
from sklearn.metrics import accuracy_score,confusion_matrix
print("Testing Accuracy: ", accuracy_score(y_true,y_pred))
```

```
Testing Accuracy:  0.7193
```

In [21]:

```
cm = confusion_matrix(y_true,y_pred)
cm
```

Out[21]:

```
array([[88,  0,  0, ...,  0,  0,  0],
       [ 0, 75,  1, ...,  0,  0,  0],
       [ 0,  1, 67, ...,  0,  2,  0],
       ...,
       [ 0,  0,  0, ..., 68,  0,  0],
       [ 0,  0,  4, ...,  0, 48,  0],
       [ 0,  0,  1, ...,  0,  0, 79]])
```