

CNN on CIFAR 10 DATASET:

1. Please visit this link to access the state-of-art DenseNet code for reference - DenseNet - cifar10 notebook link
2. You need to create a copy of this and "retrain" this model to achieve 90+ test accuracy.
3. You cannot use Dense Layers (also called fully connected layers), or DropOut.
4. You MUST use Image Augmentation Techniques.
5. You cannot use an already trained model as a beginning points, you have to initialize as your own
6. You cannot run the program for more than 300 Epochs, and it should be clear from your log, that you have only used 300 Epochs
7. You cannot use test images for training the model.
8. You cannot change the general architecture of DenseNet (which means you must use Dense Block, Transition and Output blocks as mentioned in the code)
9. You are free to change Convolution types (e.g. from 3x3 normal convolution to Depthwise Separable, etc)
10. You cannot have more than 1 Million parameters in total
11. You are free to move the code from Keras to Tensorflow, Pytorch, MXNET etc.
12. You can use any optimization algorithm you need.
13. You can checkpoint your model and retrain the model from that checkpoint so that no need of training the model from first if you lost at any epoch while training. You can directly load that model and Train from that epoch.

In [0]:

```
# import keras
# from keras.datasets import cifar10
# from keras.models import Model, Sequential
# from keras.layers import Dense, Dropout, Flatten, Input, AveragePooling2D, merge, Activation
# from keras.layers import Conv2D, MaxPooling2D, BatchNormalization
# from keras.layers import Concatenate
# from keras.optimizers import Adam
from tensorflow.keras import models, layers
from tensorflow.keras.models import Model
from tensorflow.keras.layers import BatchNormalization, Activation, Flatten
from tensorflow.keras.optimizers import Adam
```

In [5]:

```
from google.colab import drive
drive.mount('/content/gdrive')
```

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.O%b&scope=email%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdocs.test%20https%3A%2F%2Fwww.googleapis.com%2Fauth%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/gdrive

In [0]:

```
import os
os.chdir('/content/gdrive/My Drive')
```

In [0]:

```
# Hyperparameters
batch_size = 128
num_classes = 10
epochs = 10
l = 6
num_filter = 35
compression = 1
dropout_rate = 0.2
```

In [4]:

```
import tensorflow as tf
# Load CIFAR10 Data
(X_train, y_train), (X_test, y_test) = tf.keras.datasets.cifar10.load_data()
img_height, img_width, channel = X_train.shape[1], X_train.shape[2], X_train.shape[3]

# convert to one hot encoding
y_train = tf.keras.utils.to_categorical(y_train, num_classes)
y_test = tf.keras.utils.to_categorical(y_test, num_classes)
```

Downloading data from <https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz>
170500096/170498071 [=====] - 6s 0us/step

About the dataset:

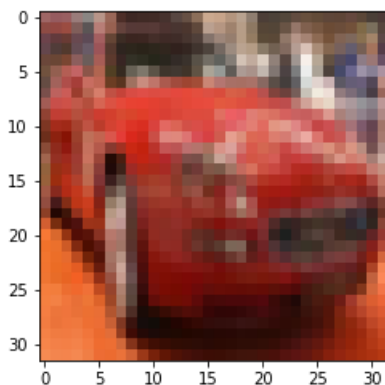
- Download the data from <https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz>
- The CIFAR-10 dataset (Canadian Institute For Advanced Research) is a collection of images that are commonly used to train machine learning and computer vision algorithms. It is one of the most widely used datasets for machine learning research.
- The CIFAR-10 dataset contains 60,000 32x32 color images in 10 different classes.
- The 10 different classes represent airplanes, cars, birds, cats, deer, dogs, frogs, horses, ships, and trucks.
- There are 6,000 images of each class.
- Let's look at a few images in the dataset.

In [4]:

```
plt.imshow(X_train[5])
```

Out[4]:

<matplotlib.image.AxesImage at 0x7f77a924efd0>

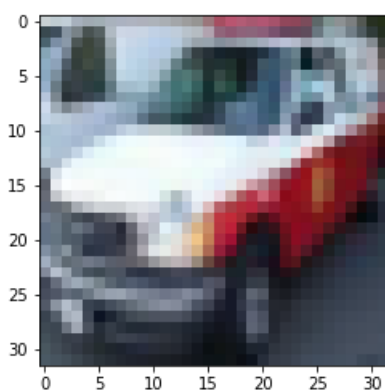


In [5]:

```
plt.imshow(X_train[60])
```

Out[5]:

<matplotlib.image.AxesImage at 0x7f77a91c1c18>

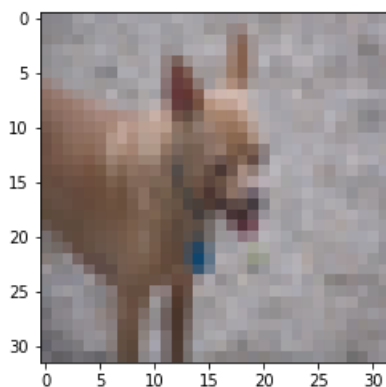


In [6]:

```
plt.imshow(X_train[260])
```

Out[6]:

<matplotlib.image.AxesImage at 0x7f77a91ab3c8>

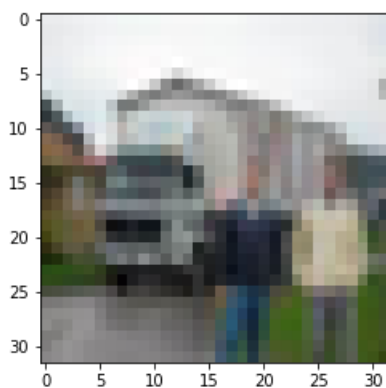


In [7]:

```
plt.imshow(X_train[16])
```

Out[7]:

<matplotlib.image.AxesImage at 0x7f77a9104978>



In [0]:

```
# Dense Block
def denseblock(input, num_filter = 12, dropout_rate = 0.2):
    global compression
    temp = input
    for _ in range(1):
        BatchNorm = layers.BatchNormalization()(temp)
        relu = layers.Activation('relu')(BatchNorm)
        Conv2D_3_3 = layers.Conv2D(int(num_filter*compression), (3,3), use_bias=False, padding='same')(relu)
        if dropout_rate>0:
            Conv2D_3_3 = layers.Dropout(dropout_rate)(Conv2D_3_3)
        concat = layers.Concatenate(axis=-1)([temp, Conv2D_3_3])

        temp = concat

    return temp

## transition Block
def transition(input, num_filter = 12, dropout_rate = 0.2):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    Conv2D_BottleNeck = layers.Conv2D(int(num_filter*compression), (1,1), use_bias=False, padding='same')(relu)
```

```

same')(relu)
    if dropout_rate>0:
        Conv2D_BottleNeck = layers.Dropout(dropout_rate)(Conv2D_BottleNeck)
    avg = layers.AveragePooling2D(pool_size=(2,2))(Conv2D_BottleNeck)
    return avg

#output layer
def output_layer(input):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    AvgPooling = layers.AveragePooling2D(pool_size=(2,2))(relu)
    #output layer - FCN
    conv_layer = layers.Conv2D(10, (1,1), use_bias=False, padding='same')(AvgPooling)
    last = layers.GlobalMaxPooling2D()(conv_layer)
    output = layers.Activation('softmax')(last)
    return output

```

In [10]:

```

dropout_rate = 0.2

input = layers.Input(shape=(img_height, img_width, channel,))
First_Conv2D = layers.Conv2D(num_filter, (3,3), use_bias=False, padding='same')(input)

First_Block = denseblock(First_Conv2D, num_filter, dropout_rate)
First_Transition = transition(First_Block, num_filter, dropout_rate)

Second_Block = denseblock(First_Transition, num_filter, dropout_rate)
Second_Transition = transition(Second_Block, num_filter, dropout_rate)

Third_Block = denseblock(Second_Transition, num_filter, dropout_rate)
Third_Transition = transition(Third_Block, num_filter, dropout_rate)

Last_Block = denseblock(Third_Transition, num_filter, dropout_rate)
output = output_layer(Last_Block)

```

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow/python/ops/init_ops.py:1251: calling VarianceScaling.__init__ (from tensorflow.python.ops.init_ops) with dtype is deprecated and will be removed in a future version. Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the constructor

In [11]:

```

model = Model(inputs=[input], outputs=[output])
model.summary()

```

Model: "model"

Layer (type)	Output Shape	Param #	Connected to
=====			
input_1 (InputLayer)	[(None, 32, 32, 3)]	0	
conv2d (Conv2D)	(None, 32, 32, 35)	945	input_1[0][0]
batch_normalization (BatchNorma	(None, 32, 32, 35)	140	conv2d[0][0]
activation (Activation)	(None, 32, 32, 35)	0	batch_normalization[0][0]
conv2d_1 (Conv2D)	(None, 32, 32, 35)	11025	activation[0][0]
dropout (Dropout)	(None, 32, 32, 35)	0	conv2d_1[0][0]
concatenate (Concatenate)	(None, 32, 32, 70)	0	conv2d[0][0] dropout[0][0]
batch_normalization_1 (BatchNor	(None, 32, 32, 70)	280	concatenate[0][0]
activation_1 (Activation)	(None, 32, 32, 70)	0	batch_normalization_1[0][0]
conv2d_2 (Conv2D)	(None, 32, 32, 35)	22050	activation_1[0][0]
dropout_1 (Dropout)	(None, 32, 32, 35)	0	conv2d_2[0][0]

dropout_1 (Dropout)	(None, 32, 32, 105)	0	dropout_1[0][0]
concatenate_1 (Concatenate)	(None, 32, 32, 105)	0	concatenate[0][0] dropout_1[0][0]
batch_normalization_2 (BatchNor	(None, 32, 32, 105)	420	concatenate_1[0][0]
activation_2 (Activation)	(None, 32, 32, 105)	0	batch_normalization_2[0][0]
conv2d_3 (Conv2D)	(None, 32, 32, 35)	33075	activation_2[0][0]
dropout_2 (Dropout)	(None, 32, 32, 35)	0	conv2d_3[0][0]
concatenate_2 (Concatenate)	(None, 32, 32, 140)	0	concatenate_1[0][0] dropout_2[0][0]
batch_normalization_3 (BatchNor	(None, 32, 32, 140)	560	concatenate_2[0][0]
activation_3 (Activation)	(None, 32, 32, 140)	0	batch_normalization_3[0][0]
conv2d_4 (Conv2D)	(None, 32, 32, 35)	44100	activation_3[0][0]
dropout_3 (Dropout)	(None, 32, 32, 35)	0	conv2d_4[0][0]
concatenate_3 (Concatenate)	(None, 32, 32, 175)	0	concatenate_2[0][0] dropout_3[0][0]
batch_normalization_4 (BatchNor	(None, 32, 32, 175)	700	concatenate_3[0][0]
activation_4 (Activation)	(None, 32, 32, 175)	0	batch_normalization_4[0][0]
conv2d_5 (Conv2D)	(None, 32, 32, 35)	55125	activation_4[0][0]
dropout_4 (Dropout)	(None, 32, 32, 35)	0	conv2d_5[0][0]
concatenate_4 (Concatenate)	(None, 32, 32, 210)	0	concatenate_3[0][0] dropout_4[0][0]
batch_normalization_5 (BatchNor	(None, 32, 32, 210)	840	concatenate_4[0][0]
activation_5 (Activation)	(None, 32, 32, 210)	0	batch_normalization_5[0][0]
conv2d_6 (Conv2D)	(None, 32, 32, 35)	66150	activation_5[0][0]
dropout_5 (Dropout)	(None, 32, 32, 35)	0	conv2d_6[0][0]
concatenate_5 (Concatenate)	(None, 32, 32, 245)	0	concatenate_4[0][0] dropout_5[0][0]
batch_normalization_6 (BatchNor	(None, 32, 32, 245)	980	concatenate_5[0][0]
activation_6 (Activation)	(None, 32, 32, 245)	0	batch_normalization_6[0][0]
conv2d_7 (Conv2D)	(None, 32, 32, 35)	8575	activation_6[0][0]
dropout_6 (Dropout)	(None, 32, 32, 35)	0	conv2d_7[0][0]
average_pooling2d (AveragePooli	(None, 16, 16, 35)	0	dropout_6[0][0]
batch_normalization_7 (BatchNor	(None, 16, 16, 35)	140	average_pooling2d[0][0]
activation_7 (Activation)	(None, 16, 16, 35)	0	batch_normalization_7[0][0]
conv2d_8 (Conv2D)	(None, 16, 16, 35)	11025	activation_7[0][0]
dropout_7 (Dropout)	(None, 16, 16, 35)	0	conv2d_8[0][0]
concatenate_6 (Concatenate)	(None, 16, 16, 70)	0	average_pooling2d[0][0] dropout_7[0][0]
batch_normalization_8 (BatchNor	(None, 16, 16, 70)	280	concatenate_6[0][0]
activation_8 (Activation)	(None, 16, 16, 70)	0	batch_normalization_8[0][0]
conv2d_9 (Conv2D)	(None, 16, 16, 35)	22050	activation_8[0][0]
dropout_8 (Dropout)	(None, 16, 16, 35)	0	conv2d_9[0][0]

concatenate_7 (Concatenate)	(None, 16, 16, 105)	0	concatenate_6[0][0] dropout_8[0][0]
batch_normalization_9 (BatchNor	(None, 16, 16, 105)	420	concatenate_7[0][0]
activation_9 (Activation)	(None, 16, 16, 105)	0	batch_normalization_9[0][0]
conv2d_10 (Conv2D)	(None, 16, 16, 35)	33075	activation_9[0][0]
dropout_9 (Dropout)	(None, 16, 16, 35)	0	conv2d_10[0][0]
concatenate_8 (Concatenate)	(None, 16, 16, 140)	0	concatenate_7[0][0] dropout_9[0][0]
batch_normalization_10 (BatchNo	(None, 16, 16, 140)	560	concatenate_8[0][0]
activation_10 (Activation)	(None, 16, 16, 140)	0	batch_normalization_10[0][0]
conv2d_11 (Conv2D)	(None, 16, 16, 35)	44100	activation_10[0][0]
dropout_10 (Dropout)	(None, 16, 16, 35)	0	conv2d_11[0][0]
concatenate_9 (Concatenate)	(None, 16, 16, 175)	0	concatenate_8[0][0] dropout_10[0][0]
batch_normalization_11 (BatchNo	(None, 16, 16, 175)	700	concatenate_9[0][0]
activation_11 (Activation)	(None, 16, 16, 175)	0	batch_normalization_11[0][0]
conv2d_12 (Conv2D)	(None, 16, 16, 35)	55125	activation_11[0][0]
dropout_11 (Dropout)	(None, 16, 16, 35)	0	conv2d_12[0][0]
concatenate_10 (Concatenate)	(None, 16, 16, 210)	0	concatenate_9[0][0] dropout_11[0][0]
batch_normalization_12 (BatchNo	(None, 16, 16, 210)	840	concatenate_10[0][0]
activation_12 (Activation)	(None, 16, 16, 210)	0	batch_normalization_12[0][0]
conv2d_13 (Conv2D)	(None, 16, 16, 35)	66150	activation_12[0][0]
dropout_12 (Dropout)	(None, 16, 16, 35)	0	conv2d_13[0][0]
concatenate_11 (Concatenate)	(None, 16, 16, 245)	0	concatenate_10[0][0] dropout_12[0][0]
batch_normalization_13 (BatchNo	(None, 16, 16, 245)	980	concatenate_11[0][0]
activation_13 (Activation)	(None, 16, 16, 245)	0	batch_normalization_13[0][0]
conv2d_14 (Conv2D)	(None, 16, 16, 35)	8575	activation_13[0][0]
dropout_13 (Dropout)	(None, 16, 16, 35)	0	conv2d_14[0][0]
average_pooling2d_1 (AveragePoo	(None, 8, 8, 35)	0	dropout_13[0][0]
batch_normalization_14 (BatchNo	(None, 8, 8, 35)	140	average_pooling2d_1[0][0]
activation_14 (Activation)	(None, 8, 8, 35)	0	batch_normalization_14[0][0]
conv2d_15 (Conv2D)	(None, 8, 8, 35)	11025	activation_14[0][0]
dropout_14 (Dropout)	(None, 8, 8, 35)	0	conv2d_15[0][0]
concatenate_12 (Concatenate)	(None, 8, 8, 70)	0	average_pooling2d_1[0][0] dropout_14[0][0]
batch_normalization_15 (BatchNo	(None, 8, 8, 70)	280	concatenate_12[0][0]
activation_15 (Activation)	(None, 8, 8, 70)	0	batch_normalization_15[0][0]
conv2d_16 (Conv2D)	(None, 8, 8, 35)	22050	activation_15[0][0]
dropout_15 (Dropout)	(None, 8, 8, 35)	0	conv2d_16[0][0]
concatenate_13 (Concatenate)	(None, 8, 8, 105)	0	concatenate_12[0][0]

concatenate_13 (Concatenate)	(None, 8, 8, 105)	0	concatenate_12[0][0] dropout_15[0][0]
batch_normalization_16 (BatchNormalizatio	(None, 8, 8, 105)	420	concatenate_13[0][0]
activation_16 (Activation)	(None, 8, 8, 105)	0	batch_normalization_16[0][0]
conv2d_17 (Conv2D)	(None, 8, 8, 35)	33075	activation_16[0][0]
dropout_16 (Dropout)	(None, 8, 8, 35)	0	conv2d_17[0][0]
concatenate_14 (Concatenate)	(None, 8, 8, 140)	0	concatenate_13[0][0] dropout_16[0][0]
batch_normalization_17 (BatchNormalizatio	(None, 8, 8, 140)	560	concatenate_14[0][0]
activation_17 (Activation)	(None, 8, 8, 140)	0	batch_normalization_17[0][0]
conv2d_18 (Conv2D)	(None, 8, 8, 35)	44100	activation_17[0][0]
dropout_17 (Dropout)	(None, 8, 8, 35)	0	conv2d_18[0][0]
concatenate_15 (Concatenate)	(None, 8, 8, 175)	0	concatenate_14[0][0] dropout_17[0][0]
batch_normalization_18 (BatchNormalizatio	(None, 8, 8, 175)	700	concatenate_15[0][0]
activation_18 (Activation)	(None, 8, 8, 175)	0	batch_normalization_18[0][0]
conv2d_19 (Conv2D)	(None, 8, 8, 35)	55125	activation_18[0][0]
dropout_18 (Dropout)	(None, 8, 8, 35)	0	conv2d_19[0][0]
concatenate_16 (Concatenate)	(None, 8, 8, 210)	0	concatenate_15[0][0] dropout_18[0][0]
batch_normalization_19 (BatchNormalizatio	(None, 8, 8, 210)	840	concatenate_16[0][0]
activation_19 (Activation)	(None, 8, 8, 210)	0	batch_normalization_19[0][0]
conv2d_20 (Conv2D)	(None, 8, 8, 35)	66150	activation_19[0][0]
dropout_19 (Dropout)	(None, 8, 8, 35)	0	conv2d_20[0][0]
concatenate_17 (Concatenate)	(None, 8, 8, 245)	0	concatenate_16[0][0] dropout_19[0][0]
batch_normalization_20 (BatchNormalizatio	(None, 8, 8, 245)	980	concatenate_17[0][0]
activation_20 (Activation)	(None, 8, 8, 245)	0	batch_normalization_20[0][0]
conv2d_21 (Conv2D)	(None, 8, 8, 35)	8575	activation_20[0][0]
dropout_20 (Dropout)	(None, 8, 8, 35)	0	conv2d_21[0][0]
average_pooling2d_2 (AveragePooling2D)	(None, 4, 4, 35)	0	dropout_20[0][0]
batch_normalization_21 (BatchNormalizatio	(None, 4, 4, 35)	140	average_pooling2d_2[0][0]
activation_21 (Activation)	(None, 4, 4, 35)	0	batch_normalization_21[0][0]
conv2d_22 (Conv2D)	(None, 4, 4, 35)	11025	activation_21[0][0]
dropout_21 (Dropout)	(None, 4, 4, 35)	0	conv2d_22[0][0]
concatenate_18 (Concatenate)	(None, 4, 4, 70)	0	average_pooling2d_2[0][0] dropout_21[0][0]
batch_normalization_22 (BatchNormalizatio	(None, 4, 4, 70)	280	concatenate_18[0][0]
activation_22 (Activation)	(None, 4, 4, 70)	0	batch_normalization_22[0][0]
conv2d_23 (Conv2D)	(None, 4, 4, 35)	22050	activation_22[0][0]
dropout_22 (Dropout)	(None, 4, 4, 35)	0	conv2d_23[0][0]
concatenate_19 (Concatenate)	(None, 4, 4, 105)	0	concatenate_18[0][0] dropout_22[0][0]

				dropout_22[0][0]
batch_normalization_23 (BatchNo	(None, 4, 4, 105)	420	concatenate_19[0][0]	
activation_23 (Activation)	(None, 4, 4, 105)	0	batch_normalization_23[0][0]	
conv2d_24 (Conv2D)	(None, 4, 4, 35)	33075	activation_23[0][0]	
dropout_23 (Dropout)	(None, 4, 4, 35)	0	conv2d_24[0][0]	
concatenate_20 (Concatenate)	(None, 4, 4, 140)	0	concatenate_19[0][0] dropout_23[0][0]	
batch_normalization_24 (BatchNo	(None, 4, 4, 140)	560	concatenate_20[0][0]	
activation_24 (Activation)	(None, 4, 4, 140)	0	batch_normalization_24[0][0]	
conv2d_25 (Conv2D)	(None, 4, 4, 35)	44100	activation_24[0][0]	
dropout_24 (Dropout)	(None, 4, 4, 35)	0	conv2d_25[0][0]	
concatenate_21 (Concatenate)	(None, 4, 4, 175)	0	concatenate_20[0][0] dropout_24[0][0]	
batch_normalization_25 (BatchNo	(None, 4, 4, 175)	700	concatenate_21[0][0]	
activation_25 (Activation)	(None, 4, 4, 175)	0	batch_normalization_25[0][0]	
conv2d_26 (Conv2D)	(None, 4, 4, 35)	55125	activation_25[0][0]	
dropout_25 (Dropout)	(None, 4, 4, 35)	0	conv2d_26[0][0]	
concatenate_22 (Concatenate)	(None, 4, 4, 210)	0	concatenate_21[0][0] dropout_25[0][0]	
batch_normalization_26 (BatchNo	(None, 4, 4, 210)	840	concatenate_22[0][0]	
activation_26 (Activation)	(None, 4, 4, 210)	0	batch_normalization_26[0][0]	
conv2d_27 (Conv2D)	(None, 4, 4, 35)	66150	activation_26[0][0]	
dropout_26 (Dropout)	(None, 4, 4, 35)	0	conv2d_27[0][0]	
concatenate_23 (Concatenate)	(None, 4, 4, 245)	0	concatenate_22[0][0] dropout_26[0][0]	
batch_normalization_27 (BatchNo	(None, 4, 4, 245)	980	concatenate_23[0][0]	
activation_27 (Activation)	(None, 4, 4, 245)	0	batch_normalization_27[0][0]	
average_pooling2d_3 (AveragePoo	(None, 2, 2, 245)	0	activation_27[0][0]	
conv2d_28 (Conv2D)	(None, 2, 2, 10)	2450	average_pooling2d_3[0][0]	
global_max_pooling2d (GlobalMax	(None, 10)	0	conv2d_28[0][0]	
activation_28 (Activation)	(None, 10)	0	global_max_pooling2d[0][0]	
=====				
Total params: 970,900				
Trainable params: 963,060				
Non-trainable params: 7,840				

In [12]:

```
#checkpoint your model after every epoch
#and retrain the model from that checkpoint so that there won't be a need of
#training the model from first if you lost at any epoch while training.
#You can directly load that model and Train from that epoch.
import os
from keras.callbacks import ModelCheckpoint
import datetime

save_dir = os.getcwd()
file_name = str(datetime.datetime.now()).split(' ')[0] + '_{epoch:02d}.hdf5'
filepath = os.path.join(save_dir, file_name)
```



```
checkpoints = ModelCheckpoint(filepath, monitor='val_acc', verbose=1,
                              save_best_only=False, save_weights_only=False,
                              mode='auto', period=1)
```

Using TensorFlow backend.

In [0]:

```
# create data generator
from keras.preprocessing.image import ImageDataGenerator
datagen = ImageDataGenerator(
    featurewise_center=False,
    samplewise_center=False,
    featurewise_std_normalization=False,
    samplewise_std_normalization=False,
    zca_whitening=False,
    rotation_range=15,
    width_shift_range=0.1,
    height_shift_range=0.1,
    horizontal_flip=True,
    vertical_flip=False
)
datagen.fit(X_train)
# prepare iterator
it_train = datagen.flow(X_train, y_train, batch_size=batch_size)
steps = int(X_train.shape[0] / batch_size)
```

In [0]:

```
# determine Loss function and Optimizer
model.compile(loss='categorical_crossentropy',
              optimizer=Adam(),
              metrics=['accuracy'])
```

In [15]:

```
#####Fit Model #####
history = model.fit_generator(
    it_train, steps_per_epoch=steps,
    epochs = 100,
    validation_data=(X_test, y_test),
    callbacks = [checkpoints],
    shuffle= True)
```

```
Epoch 1/100
389/390 [=====>.] - ETA: 0s - loss: 1.5346 - acc: 0.4364
Epoch 00001: saving model to /content/gdrive/My Drive/2019-09-26_01.hdf5
390/390 [=====] - 191s 489ms/step - loss: 1.5336 - acc: 0.4367 -
val_loss: 1.7033 - val_acc: 0.4601
Epoch 2/100
389/390 [=====>.] - ETA: 0s - loss: 1.1160 - acc: 0.6014
Epoch 00002: saving model to /content/gdrive/My Drive/2019-09-26_02.hdf5
390/390 [=====] - 167s 427ms/step - loss: 1.1154 - acc: 0.6016 -
val_loss: 2.0776 - val_acc: 0.4789
Epoch 3/100
389/390 [=====>.] - ETA: 0s - loss: 0.9490 - acc: 0.6609
Epoch 00003: saving model to /content/gdrive/My Drive/2019-09-26_03.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.9486 - acc: 0.6611 -
val_loss: 2.8773 - val_acc: 0.4386
Epoch 4/100
389/390 [=====>.] - ETA: 0s - loss: 0.8375 - acc: 0.7033
Epoch 00004: saving model to /content/gdrive/My Drive/2019-09-26_04.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.8374 - acc: 0.7033 -
val_loss: 1.4773 - val_acc: 0.5926
Epoch 5/100
389/390 [=====>.] - ETA: 0s - loss: 0.7573 - acc: 0.7320
Epoch 00005: saving model to /content/gdrive/My Drive/2019-09-26_05.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.7570 - acc: 0.7321 -
val_loss: 1.0904 - val_acc: 0.6637
Epoch 6/100
```

```
389/390 [=====>.] - ETA: 0s - loss: 0.7022 - acc: 0.7543
Epoch 00006: saving model to /content/gdrive/My Drive/2019-09-26_06.hdf5
390/390 [=====>.] - 166s 427ms/step - loss: 0.7023 - acc: 0.7543 -
val_loss: 1.1286 - val_acc: 0.6674
Epoch 7/100
389/390 [=====>.] - ETA: 0s - loss: 0.6514 - acc: 0.7717
Epoch 00007: saving model to /content/gdrive/My Drive/2019-09-26_07.hdf5
390/390 [=====>.] - 166s 427ms/step - loss: 0.6512 - acc: 0.7718 -
val_loss: 0.8332 - val_acc: 0.7477
Epoch 8/100
389/390 [=====>.] - ETA: 0s - loss: 0.6124 - acc: 0.7869
Epoch 00008: saving model to /content/gdrive/My Drive/2019-09-26_08.hdf5
390/390 [=====>.] - 167s 428ms/step - loss: 0.6121 - acc: 0.7870 -
val_loss: 0.7259 - val_acc: 0.7664
Epoch 9/100
389/390 [=====>.] - ETA: 0s - loss: 0.5855 - acc: 0.7970
Epoch 00009: saving model to /content/gdrive/My Drive/2019-09-26_09.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.5857 - acc: 0.7970 -
val_loss: 0.8130 - val_acc: 0.7616
Epoch 10/100
389/390 [=====>.] - ETA: 0s - loss: 0.5607 - acc: 0.8051
Epoch 00010: saving model to /content/gdrive/My Drive/2019-09-26_10.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.5604 - acc: 0.8051 -
val_loss: 1.0310 - val_acc: 0.7102
Epoch 11/100
389/390 [=====>.] - ETA: 0s - loss: 0.5385 - acc: 0.8136
Epoch 00011: saving model to /content/gdrive/My Drive/2019-09-26_11.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.5383 - acc: 0.8136 -
val_loss: 0.8857 - val_acc: 0.7374
Epoch 12/100
389/390 [=====>.] - ETA: 0s - loss: 0.5156 - acc: 0.8209
Epoch 00012: saving model to /content/gdrive/My Drive/2019-09-26_12.hdf5
390/390 [=====>.] - 166s 427ms/step - loss: 0.5157 - acc: 0.8209 -
val_loss: 0.8463 - val_acc: 0.7575
Epoch 13/100
389/390 [=====>.] - ETA: 0s - loss: 0.4937 - acc: 0.8277
Epoch 00013: saving model to /content/gdrive/My Drive/2019-09-26_13.hdf5
390/390 [=====>.] - 166s 426ms/step - loss: 0.4935 - acc: 0.8278 -
val_loss: 0.6678 - val_acc: 0.8057
Epoch 14/100
389/390 [=====>.] - ETA: 0s - loss: 0.4780 - acc: 0.8348
Epoch 00014: saving model to /content/gdrive/My Drive/2019-09-26_14.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.4779 - acc: 0.8348 -
val_loss: 0.7851 - val_acc: 0.7668
Epoch 15/100
389/390 [=====>.] - ETA: 0s - loss: 0.4637 - acc: 0.8391
Epoch 00015: saving model to /content/gdrive/My Drive/2019-09-26_15.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.4640 - acc: 0.8390 -
val_loss: 0.9952 - val_acc: 0.7104
Epoch 16/100
389/390 [=====>.] - ETA: 0s - loss: 0.4478 - acc: 0.8447
Epoch 00016: saving model to /content/gdrive/My Drive/2019-09-26_16.hdf5
390/390 [=====>.] - 166s 427ms/step - loss: 0.4477 - acc: 0.8447 -
val_loss: 0.5420 - val_acc: 0.8350
Epoch 17/100
389/390 [=====>.] - ETA: 0s - loss: 0.4396 - acc: 0.8471
Epoch 00017: saving model to /content/gdrive/My Drive/2019-09-26_17.hdf5
390/390 [=====>.] - 166s 427ms/step - loss: 0.4398 - acc: 0.8470 -
val_loss: 0.6049 - val_acc: 0.8184
Epoch 18/100
389/390 [=====>.] - ETA: 0s - loss: 0.4262 - acc: 0.8511
Epoch 00018: saving model to /content/gdrive/My Drive/2019-09-26_18.hdf5
390/390 [=====>.] - 167s 428ms/step - loss: 0.4259 - acc: 0.8513 -
val_loss: 0.6074 - val_acc: 0.8151
Epoch 19/100
389/390 [=====>.] - ETA: 0s - loss: 0.4148 - acc: 0.8579
Epoch 00019: saving model to /content/gdrive/My Drive/2019-09-26_19.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.4147 - acc: 0.8580 -
val_loss: 0.5161 - val_acc: 0.8371
Epoch 20/100
389/390 [=====>.] - ETA: 0s - loss: 0.4086 - acc: 0.8598
Epoch 00020: saving model to /content/gdrive/My Drive/2019-09-26_20.hdf5
390/390 [=====>.] - 167s 429ms/step - loss: 0.4085 - acc: 0.8598 -
val_loss: 0.6316 - val_acc: 0.8160
Epoch 21/100
389/390 [=====>.] - ETA: 0s - loss: 0.3898 - acc: 0.8644
Epoch 00021: saving model to /content/gdrive/My Drive/2019-09-26_21.hdf5
```

```
390/390 [=====] - 167s 428ms/step - loss: 0.3898 - acc: 0.8645 -  
val_loss: 0.5486 - val_acc: 0.8317  
Epoch 22/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3842 - acc: 0.8683  
Epoch 00022: saving model to /content/gdrive/My Drive/2019-09-26_22.hdf5  
390/390 [=====] - 167s 428ms/step - loss: 0.3848 - acc: 0.8681 -  
val_loss: 0.5020 - val_acc: 0.8391  
Epoch 23/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3775 - acc: 0.8696  
Epoch 00023: saving model to /content/gdrive/My Drive/2019-09-26_23.hdf5  
390/390 [=====] - 167s 427ms/step - loss: 0.3774 - acc: 0.8696 -  
val_loss: 0.4449 - val_acc: 0.8625  
Epoch 24/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3675 - acc: 0.8719  
Epoch 00024: saving model to /content/gdrive/My Drive/2019-09-26_24.hdf5  
390/390 [=====] - 167s 428ms/step - loss: 0.3675 - acc: 0.8720 -  
val_loss: 0.6022 - val_acc: 0.8277  
Epoch 25/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3619 - acc: 0.8754  
Epoch 00025: saving model to /content/gdrive/My Drive/2019-09-26_25.hdf5  
390/390 [=====] - 167s 428ms/step - loss: 0.3619 - acc: 0.8754 -  
val_loss: 0.4935 - val_acc: 0.8516  
Epoch 26/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3571 - acc: 0.8766  
Epoch 00026: saving model to /content/gdrive/My Drive/2019-09-26_26.hdf5  
390/390 [=====] - 167s 429ms/step - loss: 0.3570 - acc: 0.8767 -  
val_loss: 0.5204 - val_acc: 0.8444  
Epoch 27/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3465 - acc: 0.8793  
Epoch 00027: saving model to /content/gdrive/My Drive/2019-09-26_27.hdf5  
390/390 [=====] - 167s 428ms/step - loss: 0.3470 - acc: 0.8792 -  
val_loss: 0.5635 - val_acc: 0.8296  
Epoch 28/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3364 - acc: 0.8830  
Epoch 00028: saving model to /content/gdrive/My Drive/2019-09-26_28.hdf5  
390/390 [=====] - 167s 427ms/step - loss: 0.3364 - acc: 0.8831 -  
val_loss: 0.5390 - val_acc: 0.8427  
Epoch 29/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3364 - acc: 0.8850  
Epoch 00029: saving model to /content/gdrive/My Drive/2019-09-26_29.hdf5  
390/390 [=====] - 167s 428ms/step - loss: 0.3363 - acc: 0.8850 -  
val_loss: 0.5241 - val_acc: 0.8466  
Epoch 30/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3293 - acc: 0.8863  
Epoch 00030: saving model to /content/gdrive/My Drive/2019-09-26_30.hdf5  
390/390 [=====] - 167s 428ms/step - loss: 0.3295 - acc: 0.8862 -  
val_loss: 0.4889 - val_acc: 0.8617  
Epoch 31/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3198 - acc: 0.8892  
Epoch 00031: saving model to /content/gdrive/My Drive/2019-09-26_31.hdf5  
390/390 [=====] - 167s 428ms/step - loss: 0.3198 - acc: 0.8892 -  
val_loss: 0.6912 - val_acc: 0.8250  
Epoch 32/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3159 - acc: 0.8900  
Epoch 00032: saving model to /content/gdrive/My Drive/2019-09-26_32.hdf5  
390/390 [=====] - 167s 427ms/step - loss: 0.3157 - acc: 0.8900 -  
val_loss: 0.4858 - val_acc: 0.8527  
Epoch 33/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3134 - acc: 0.8900  
Epoch 00033: saving model to /content/gdrive/My Drive/2019-09-26_33.hdf5  
390/390 [=====] - 167s 427ms/step - loss: 0.3137 - acc: 0.8899 -  
val_loss: 0.5726 - val_acc: 0.8325  
Epoch 34/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3057 - acc: 0.8944  
Epoch 00034: saving model to /content/gdrive/My Drive/2019-09-26_34.hdf5  
390/390 [=====] - 167s 427ms/step - loss: 0.3058 - acc: 0.8943 -  
val_loss: 0.5116 - val_acc: 0.8579  
Epoch 35/100  
389/390 [=====>.] - ETA: 0s - loss: 0.3030 - acc: 0.8953  
Epoch 00035: saving model to /content/gdrive/My Drive/2019-09-26_35.hdf5  
390/390 [=====] - 167s 427ms/step - loss: 0.3030 - acc: 0.8953 -  
val_loss: 0.4119 - val_acc: 0.8697  
Epoch 36/100  
389/390 [=====>.] - ETA: 0s - loss: 0.2941 - acc: 0.8969  
Epoch 00036: saving model to /content/gdrive/My Drive/2019-09-26_36.hdf5  
390/390 [=====] - 167s 428ms/step - loss: 0.2943 - acc: 0.8968 -  
val_loss: 0.4729 - val_acc: 0.8688
```

Epoch 37/100
389/390 [=====>.] - ETA: 0s - loss: 0.2982 - acc: 0.8962
Epoch 00037: saving model to /content/gdrive/My Drive/2019-09-26_37.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2983 - acc: 0.8963 -
val_loss: 0.5146 - val_acc: 0.8501
Epoch 38/100
389/390 [=====>.] - ETA: 0s - loss: 0.2884 - acc: 0.8980
Epoch 00038: saving model to /content/gdrive/My Drive/2019-09-26_38.hdf5
390/390 [=====] - 166s 426ms/step - loss: 0.2887 - acc: 0.8979 -
val_loss: 0.4418 - val_acc: 0.8674
Epoch 39/100
389/390 [=====>.] - ETA: 0s - loss: 0.2825 - acc: 0.9030
Epoch 00039: saving model to /content/gdrive/My Drive/2019-09-26_39.hdf5
390/390 [=====] - 166s 427ms/step - loss: 0.2824 - acc: 0.9030 -
val_loss: 0.6906 - val_acc: 0.8163
Epoch 40/100
389/390 [=====>.] - ETA: 0s - loss: 0.2808 - acc: 0.9021
Epoch 00040: saving model to /content/gdrive/My Drive/2019-09-26_40.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2809 - acc: 0.9020 -
val_loss: 0.3763 - val_acc: 0.8831
Epoch 41/100
389/390 [=====>.] - ETA: 0s - loss: 0.2741 - acc: 0.9046
Epoch 00041: saving model to /content/gdrive/My Drive/2019-09-26_41.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.2743 - acc: 0.9046 -
val_loss: 0.4467 - val_acc: 0.8691
Epoch 42/100
389/390 [=====>.] - ETA: 0s - loss: 0.2705 - acc: 0.9060
Epoch 00042: saving model to /content/gdrive/My Drive/2019-09-26_42.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2708 - acc: 0.9058 -
val_loss: 0.6155 - val_acc: 0.8355
Epoch 43/100
389/390 [=====>.] - ETA: 0s - loss: 0.2708 - acc: 0.9056
Epoch 00043: saving model to /content/gdrive/My Drive/2019-09-26_43.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2705 - acc: 0.9056 -
val_loss: 0.3521 - val_acc: 0.8931
Epoch 44/100
389/390 [=====>.] - ETA: 0s - loss: 0.2648 - acc: 0.9068
Epoch 00044: saving model to /content/gdrive/My Drive/2019-09-26_44.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.2649 - acc: 0.9068 -
val_loss: 0.3954 - val_acc: 0.8819
Epoch 45/100
389/390 [=====>.] - ETA: 0s - loss: 0.2613 - acc: 0.9085
Epoch 00045: saving model to /content/gdrive/My Drive/2019-09-26_45.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2615 - acc: 0.9084 -
val_loss: 0.4737 - val_acc: 0.8616
Epoch 46/100
389/390 [=====>.] - ETA: 0s - loss: 0.2603 - acc: 0.9093
Epoch 00046: saving model to /content/gdrive/My Drive/2019-09-26_46.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2601 - acc: 0.9093 -
val_loss: 0.4855 - val_acc: 0.8737
Epoch 47/100
389/390 [=====>.] - ETA: 0s - loss: 0.2558 - acc: 0.9106
Epoch 00047: saving model to /content/gdrive/My Drive/2019-09-26_47.hdf5
390/390 [=====] - 166s 427ms/step - loss: 0.2558 - acc: 0.9106 -
val_loss: 0.4534 - val_acc: 0.8781
Epoch 48/100
389/390 [=====>.] - ETA: 0s - loss: 0.2472 - acc: 0.9123
Epoch 00048: saving model to /content/gdrive/My Drive/2019-09-26_48.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.2470 - acc: 0.9123 -
val_loss: 0.6821 - val_acc: 0.8275
Epoch 49/100
389/390 [=====>.] - ETA: 0s - loss: 0.2464 - acc: 0.9150
Epoch 00049: saving model to /content/gdrive/My Drive/2019-09-26_49.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.2463 - acc: 0.9150 -
val_loss: 0.4024 - val_acc: 0.8862
Epoch 50/100
389/390 [=====>.] - ETA: 0s - loss: 0.2447 - acc: 0.9137
Epoch 00050: saving model to /content/gdrive/My Drive/2019-09-26_50.hdf5
390/390 [=====] - 168s 430ms/step - loss: 0.2448 - acc: 0.9137 -
val_loss: 0.4495 - val_acc: 0.8767
Epoch 51/100
389/390 [=====>.] - ETA: 0s - loss: 0.2394 - acc: 0.9149
Epoch 00051: saving model to /content/gdrive/My Drive/2019-09-26_51.hdf5
390/390 [=====] - 168s 430ms/step - loss: 0.2392 - acc: 0.9150 -
val_loss: 0.4856 - val_acc: 0.8684
Epoch 52/100
389/390 [=====>.] - ETA: 0s - loss: 0.2377 - acc: 0.9174

Epoch 00052: saving model to /content/gdrive/My Drive/2019-09-26_52.hdf5
390/390 [=====] - 168s 430ms/step - loss: 0.2379 - acc: 0.9173 -
val_loss: 0.3956 - val_acc: 0.8870
Epoch 53/100
389/390 [=====>.] - ETA: 0s - loss: 0.2333 - acc: 0.9179
Epoch 00053: saving model to /content/gdrive/My Drive/2019-09-26_53.hdf5
390/390 [=====] - 168s 431ms/step - loss: 0.2333 - acc: 0.9179 -
val_loss: 0.6031 - val_acc: 0.8485
Epoch 54/100
389/390 [=====>.] - ETA: 0s - loss: 0.2337 - acc: 0.9188
Epoch 00054: saving model to /content/gdrive/My Drive/2019-09-26_54.hdf5
390/390 [=====] - 168s 431ms/step - loss: 0.2338 - acc: 0.9188 -
val_loss: 0.4622 - val_acc: 0.8684
Epoch 55/100
389/390 [=====>.] - ETA: 0s - loss: 0.2318 - acc: 0.9180
Epoch 00055: saving model to /content/gdrive/My Drive/2019-09-26_55.hdf5
390/390 [=====] - 168s 431ms/step - loss: 0.2318 - acc: 0.9179 -
val_loss: 0.4264 - val_acc: 0.8812
Epoch 56/100
389/390 [=====>.] - ETA: 0s - loss: 0.2276 - acc: 0.9203
Epoch 00056: saving model to /content/gdrive/My Drive/2019-09-26_56.hdf5
390/390 [=====] - 168s 430ms/step - loss: 0.2275 - acc: 0.9204 -
val_loss: 0.4594 - val_acc: 0.8738
Epoch 57/100
389/390 [=====>.] - ETA: 0s - loss: 0.2245 - acc: 0.9219
Epoch 00057: saving model to /content/gdrive/My Drive/2019-09-26_57.hdf5
390/390 [=====] - 168s 431ms/step - loss: 0.2248 - acc: 0.9218 -
val_loss: 0.3712 - val_acc: 0.8904
Epoch 58/100
389/390 [=====>.] - ETA: 0s - loss: 0.2200 - acc: 0.9232
Epoch 00058: saving model to /content/gdrive/My Drive/2019-09-26_58.hdf5
390/390 [=====] - 168s 430ms/step - loss: 0.2198 - acc: 0.9232 -
val_loss: 0.5191 - val_acc: 0.8631
Epoch 59/100
389/390 [=====>.] - ETA: 0s - loss: 0.2185 - acc: 0.9226
Epoch 00059: saving model to /content/gdrive/My Drive/2019-09-26_59.hdf5
390/390 [=====] - 168s 430ms/step - loss: 0.2183 - acc: 0.9226 -
val_loss: 0.4826 - val_acc: 0.8739
Epoch 60/100
389/390 [=====>.] - ETA: 0s - loss: 0.2146 - acc: 0.9243
Epoch 00060: saving model to /content/gdrive/My Drive/2019-09-26_60.hdf5
390/390 [=====] - 167s 429ms/step - loss: 0.2146 - acc: 0.9243 -
val_loss: 0.4809 - val_acc: 0.8701
Epoch 61/100
389/390 [=====>.] - ETA: 0s - loss: 0.2225 - acc: 0.9225
Epoch 00061: saving model to /content/gdrive/My Drive/2019-09-26_61.hdf5
390/390 [=====] - 168s 430ms/step - loss: 0.2226 - acc: 0.9224 -
val_loss: 0.4067 - val_acc: 0.8824
Epoch 62/100
389/390 [=====>.] - ETA: 0s - loss: 0.2114 - acc: 0.9259
Epoch 00062: saving model to /content/gdrive/My Drive/2019-09-26_62.hdf5
390/390 [=====] - 168s 431ms/step - loss: 0.2112 - acc: 0.9260 -
val_loss: 0.4288 - val_acc: 0.8815
Epoch 63/100
389/390 [=====>.] - ETA: 0s - loss: 0.2135 - acc: 0.9250
Epoch 00063: saving model to /content/gdrive/My Drive/2019-09-26_63.hdf5
390/390 [=====] - 168s 431ms/step - loss: 0.2133 - acc: 0.9251 -
val_loss: 0.3692 - val_acc: 0.8910
Epoch 64/100
389/390 [=====>.] - ETA: 0s - loss: 0.2082 - acc: 0.9271
Epoch 00064: saving model to /content/gdrive/My Drive/2019-09-26_64.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2081 - acc: 0.9272 -
val_loss: 0.4434 - val_acc: 0.8828
Epoch 65/100
389/390 [=====>.] - ETA: 0s - loss: 0.2113 - acc: 0.9255
Epoch 00065: saving model to /content/gdrive/My Drive/2019-09-26_65.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2113 - acc: 0.9255 -
val_loss: 0.3337 - val_acc: 0.9060
Epoch 66/100
389/390 [=====>.] - ETA: 0s - loss: 0.2043 - acc: 0.9277
Epoch 00066: saving model to /content/gdrive/My Drive/2019-09-26_66.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.2042 - acc: 0.9278 -
val_loss: 0.4608 - val_acc: 0.8747
Epoch 67/100
389/390 [=====>.] - ETA: 0s - loss: 0.2018 - acc: 0.9287
Epoch 00067: saving model to /content/gdrive/My Drive/2019-09-26_67.hdf5
390/390 [=====] - 166s 427ms/step - loss: 0.2017 - acc: 0.9287 -

val_loss: 0.3984 - val_acc: 0.8885
Epoch 68/100
389/390 [=====>.] - ETA: 0s - loss: 0.2035 - acc: 0.9284
Epoch 00068: saving model to /content/gdrive/My Drive/2019-09-26_68.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.2033 - acc: 0.9285 -
val_loss: 0.4096 - val_acc: 0.8847
Epoch 69/100
389/390 [=====>.] - ETA: 0s - loss: 0.1966 - acc: 0.9297
Epoch 00069: saving model to /content/gdrive/My Drive/2019-09-26_69.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.1968 - acc: 0.9296 -
val_loss: 0.5329 - val_acc: 0.8592
Epoch 70/100
389/390 [=====>.] - ETA: 0s - loss: 0.2011 - acc: 0.9285
Epoch 00070: saving model to /content/gdrive/My Drive/2019-09-26_70.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.2010 - acc: 0.9286 -
val_loss: 0.4147 - val_acc: 0.8873
Epoch 71/100
389/390 [=====>.] - ETA: 0s - loss: 0.1959 - acc: 0.9306
Epoch 00071: saving model to /content/gdrive/My Drive/2019-09-26_71.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.1959 - acc: 0.9306 -
val_loss: 0.3789 - val_acc: 0.8966
Epoch 72/100
389/390 [=====>.] - ETA: 0s - loss: 0.1965 - acc: 0.9302
Epoch 00072: saving model to /content/gdrive/My Drive/2019-09-26_72.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.1965 - acc: 0.9302 -
val_loss: 0.4081 - val_acc: 0.8938
Epoch 73/100
389/390 [=====>.] - ETA: 0s - loss: 0.1912 - acc: 0.9323
Epoch 00073: saving model to /content/gdrive/My Drive/2019-09-26_73.hdf5
390/390 [=====] - 166s 427ms/step - loss: 0.1913 - acc: 0.9322 -
val_loss: 0.3741 - val_acc: 0.8983
Epoch 74/100
389/390 [=====>.] - ETA: 0s - loss: 0.1918 - acc: 0.9320
Epoch 00074: saving model to /content/gdrive/My Drive/2019-09-26_74.hdf5
390/390 [=====] - 166s 427ms/step - loss: 0.1918 - acc: 0.9320 -
val_loss: 0.4686 - val_acc: 0.8795
Epoch 75/100
389/390 [=====>.] - ETA: 0s - loss: 0.1889 - acc: 0.9332
Epoch 00075: saving model to /content/gdrive/My Drive/2019-09-26_75.hdf5
390/390 [=====] - 167s 428ms/step - loss: 0.1889 - acc: 0.9332 -
val_loss: 0.5079 - val_acc: 0.8750
Epoch 76/100
389/390 [=====>.] - ETA: 0s - loss: 0.1858 - acc: 0.9345
Epoch 00076: saving model to /content/gdrive/My Drive/2019-09-26_76.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.1858 - acc: 0.9345 -
val_loss: 0.5852 - val_acc: 0.8669
Epoch 77/100
389/390 [=====>.] - ETA: 0s - loss: 0.1895 - acc: 0.9332
Epoch 00077: saving model to /content/gdrive/My Drive/2019-09-26_77.hdf5
390/390 [=====] - 166s 426ms/step - loss: 0.1896 - acc: 0.9332 -
val_loss: 0.3905 - val_acc: 0.8969
Epoch 78/100
389/390 [=====>.] - ETA: 0s - loss: 0.1832 - acc: 0.9347
Epoch 00078: saving model to /content/gdrive/My Drive/2019-09-26_78.hdf5
390/390 [=====] - 166s 427ms/step - loss: 0.1832 - acc: 0.9348 -
val_loss: 0.4259 - val_acc: 0.8862
Epoch 79/100
389/390 [=====>.] - ETA: 0s - loss: 0.1851 - acc: 0.9347
Epoch 00079: saving model to /content/gdrive/My Drive/2019-09-26_79.hdf5
390/390 [=====] - 166s 427ms/step - loss: 0.1850 - acc: 0.9348 -
val_loss: 0.4110 - val_acc: 0.8839
Epoch 80/100
389/390 [=====>.] - ETA: 0s - loss: 0.1820 - acc: 0.9360
Epoch 00080: saving model to /content/gdrive/My Drive/2019-09-26_80.hdf5
390/390 [=====] - 166s 426ms/step - loss: 0.1822 - acc: 0.9360 -
val_loss: 0.4048 - val_acc: 0.8883
Epoch 81/100
389/390 [=====>.] - ETA: 0s - loss: 0.1806 - acc: 0.9360
Epoch 00081: saving model to /content/gdrive/My Drive/2019-09-26_81.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.1804 - acc: 0.9361 -
val_loss: 0.5514 - val_acc: 0.8687
Epoch 82/100
389/390 [=====>.] - ETA: 0s - loss: 0.1774 - acc: 0.9379
Epoch 00082: saving model to /content/gdrive/My Drive/2019-09-26_82.hdf5
390/390 [=====] - 167s 427ms/step - loss: 0.1775 - acc: 0.9379 -
val_loss: 0.3637 - val_acc: 0.9007
Epoch 83/100

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389/390 [=====>.] - ETA: 0s - loss: 0.1772 - acc: 0.9367
Epoch 00083: saving model to /content/gdrive/My Drive/2019-09-26_83.hdf5
390/390 [=====>.] - 167s 428ms/step - loss: 0.1772 - acc: 0.9367 -
val_loss: 0.6886 - val_acc: 0.8442
Epoch 84/100
389/390 [=====>.] - ETA: 0s - loss: 0.1777 - acc: 0.9370
Epoch 00084: saving model to /content/gdrive/My Drive/2019-09-26_84.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1774 - acc: 0.9372 -
val_loss: 0.4635 - val_acc: 0.8818
Epoch 85/100
389/390 [=====>.] - ETA: 0s - loss: 0.1749 - acc: 0.9374
Epoch 00085: saving model to /content/gdrive/My Drive/2019-09-26_85.hdf5
390/390 [=====>.] - 166s 427ms/step - loss: 0.1750 - acc: 0.9374 -
val_loss: 0.4858 - val_acc: 0.8780
Epoch 86/100
389/390 [=====>.] - ETA: 0s - loss: 0.1707 - acc: 0.9395
Epoch 00086: saving model to /content/gdrive/My Drive/2019-09-26_86.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1709 - acc: 0.9393 -
val_loss: 0.4529 - val_acc: 0.8850
Epoch 87/100
389/390 [=====>.] - ETA: 0s - loss: 0.1726 - acc: 0.9388
Epoch 00087: saving model to /content/gdrive/My Drive/2019-09-26_87.hdf5
390/390 [=====>.] - 167s 428ms/step - loss: 0.1727 - acc: 0.9388 -
val_loss: 0.3611 - val_acc: 0.9024
Epoch 88/100
389/390 [=====>.] - ETA: 0s - loss: 0.1699 - acc: 0.9397
Epoch 00088: saving model to /content/gdrive/My Drive/2019-09-26_88.hdf5
390/390 [=====>.] - 167s 428ms/step - loss: 0.1700 - acc: 0.9397 -
val_loss: 0.3430 - val_acc: 0.9089
Epoch 89/100
389/390 [=====>.] - ETA: 0s - loss: 0.1696 - acc: 0.9390
Epoch 00089: saving model to /content/gdrive/My Drive/2019-09-26_89.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1695 - acc: 0.9390 -
val_loss: 0.3605 - val_acc: 0.9037
Epoch 90/100
389/390 [=====>.] - ETA: 0s - loss: 0.1696 - acc: 0.9396
Epoch 00090: saving model to /content/gdrive/My Drive/2019-09-26_90.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1694 - acc: 0.9397 -
val_loss: 0.4783 - val_acc: 0.8731
Epoch 91/100
389/390 [=====>.] - ETA: 0s - loss: 0.1640 - acc: 0.9415
Epoch 00091: saving model to /content/gdrive/My Drive/2019-09-26_91.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1638 - acc: 0.9415 -
val_loss: 0.6223 - val_acc: 0.8575
Epoch 92/100
389/390 [=====>.] - ETA: 0s - loss: 0.1665 - acc: 0.9419
Epoch 00092: saving model to /content/gdrive/My Drive/2019-09-26_92.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1665 - acc: 0.9419 -
val_loss: 0.3458 - val_acc: 0.9090
Epoch 93/100
389/390 [=====>.] - ETA: 0s - loss: 0.1655 - acc: 0.9412
Epoch 00093: saving model to /content/gdrive/My Drive/2019-09-26_93.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1655 - acc: 0.9411 -
val_loss: 0.4977 - val_acc: 0.8756
Epoch 94/100
389/390 [=====>.] - ETA: 0s - loss: 0.1618 - acc: 0.9416
Epoch 00094: saving model to /content/gdrive/My Drive/2019-09-26_94.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1620 - acc: 0.9416 -
val_loss: 0.5011 - val_acc: 0.8795
Epoch 95/100
389/390 [=====>.] - ETA: 0s - loss: 0.1623 - acc: 0.9422
Epoch 00095: saving model to /content/gdrive/My Drive/2019-09-26_95.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1624 - acc: 0.9422 -
val_loss: 0.3774 - val_acc: 0.9049
Epoch 96/100
389/390 [=====>.] - ETA: 0s - loss: 0.1576 - acc: 0.9431
Epoch 00096: saving model to /content/gdrive/My Drive/2019-09-26_96.hdf5
390/390 [=====>.] - 167s 427ms/step - loss: 0.1576 - acc: 0.9431 -
val_loss: 0.4331 - val_acc: 0.8940
Epoch 97/100
389/390 [=====>.] - ETA: 0s - loss: 0.1631 - acc: 0.9420
Epoch 00097: saving model to /content/gdrive/My Drive/2019-09-26_97.hdf5
390/390 [=====>.] - 168s 432ms/step - loss: 0.1630 - acc: 0.9420 -
val_loss: 0.4029 - val_acc: 0.8995
Epoch 98/100
389/390 [=====>.] - ETA: 0s - loss: 0.1554 - acc: 0.9452
Epoch 00098: saving model to /content/gdrive/My Drive/2019-09-26_98.hdf5
```

```

390/390 [=====] - 168s 432ms/step - loss: 0.1554 - acc: 0.9452 -
val_loss: 0.4104 - val_acc: 0.8995
Epoch 99/100
389/390 [=====>.] - ETA: 0s - loss: 0.1579 - acc: 0.9437
Epoch 00099: saving model to /content/gdrive/My Drive/2019-09-26_99.hdf5
390/390 [=====] - 168s 431ms/step - loss: 0.1578 - acc: 0.9438 -
val_loss: 0.3663 - val_acc: 0.9047
Epoch 100/100
389/390 [=====>.] - ETA: 0s - loss: 0.1560 - acc: 0.9445
Epoch 00100: saving model to /content/gdrive/My Drive/2019-09-26_100.hdf5
390/390 [=====] - 168s 430ms/step - loss: 0.1559 - acc: 0.9446 -
val_loss: 0.3419 - val_acc: 0.9051

```

In [16]:

```

score = model.evaluate(X_test, y_test, verbose=1)
print('Test loss:', score[0])
print('Test accuracy:', score[1])

```

```

10000/10000 [=====] - 10s 1ms/sample - loss: 0.3422 - acc: 0.9051
Test loss: 0.3422499177105725
Test accuracy: 0.9051

```

In [17]:

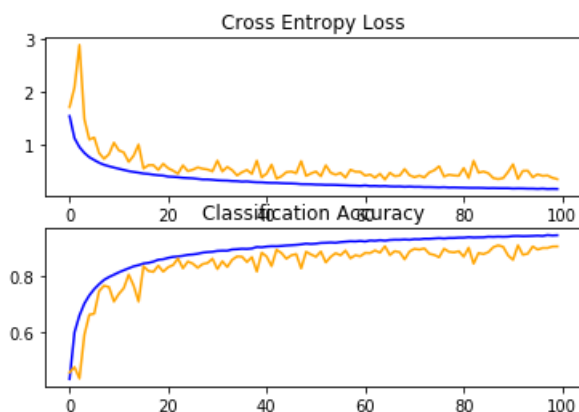
```

%matplotlib inline
import matplotlib.pyplot as plt

plt.subplot(211)
plt.title('Cross Entropy Loss')
plt.plot(history.history['loss'], color='blue', label='train')
plt.plot(history.history['val_loss'], color='orange', label='test')

# plot accuracy
plt.subplot(212)
plt.title('Classification Accuracy')
plt.plot(history.history['acc'], color='blue', label='train')
plt.plot(history.history['val_acc'], color='orange', label='test')
filename = 'cnn_cifar10'
plt.savefig(filename + '_plot.png')
plt.show()
plt.close()

```



Summary:

- We found that the accuracy of the DenseNet model was low, so in order to improve the performance we performed data augmentation on the existing baseline DenseNet model.
- Also Changed the number of filters and compression value which seemed to work well.
- So from the accuracy and cross entropy loss values, it is evident that the model's performance has significantly improved when data augmentation was used along with the existing baseline model.
- We got a test accuracy value to be more than 0.9051 at the end of 100 epochs.