In [1]:

```
# import keras
# from keras.datasets import cifar10
# from keras.models import Model, Sequential
# from keras.layers import Dense, Dropout, Flatten, Input, AveragePooling2D, merge, Act
ivation
# 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, Nadam

import numpy as np
from tqdm import tqdm
from matplotlib import pyplot
from prettytable import PrettyTable
from numpy import expand_dims
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
from keras.preprocessing.image import ImageDataGenerator
from keras.callbacks import ModelCheckpoint,LearningRateScheduler,CSVLogger, Callback,R
educeLROnPlateau

import matplotlib.pyplot as plt

from keras import models
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade (https://www.tensorflow.org/guide/migrate) now or ensure your notebook will continue to use TensorFlow 1.x via the `%tensorflow_version 1.x` magic: more info (https://colab.research.google.com/notebooks/tensorflow_version.ipynb).

```
Using TensorFlow backend.
```

In [13]:

```
from google.colab import drive
drive.mount('gdrive',force_remount=True)
```

```
Mounted at gdrive
```

In [0]:

```
# this part will prevent tensorflow to allocate all the avaliable GPU Memory
# backend
import tensorflow as tf
# from tensorflow import keras

# from keras import backend as k

# Don't pre-allocate memory; allocate as-needed
# import tensorflow as tf
# tf.config.gpu.set_per_process_memory_fraction(0.75)
# tf.config.gpu.set_per_process_memory_growth(True)
# config = tf.ConfigProto()
# config.gpu_options.allow_growth = True

# Create a session with the above options specified.
# k.tensorflow_backend.set_session(tf.Session(config=config))
```

In [0]:

```
final_tab = PrettyTable(['Augmentation','l','num_filters','compression','Optimizer','Te
st Accuracy'])
```

In [0]:

```
# Hyperparameters
batch_size = 128
num_classes = 10
epochs = 100
l = 9
num_filter = 24
compression = 1.041
dropout_rate = 0.2
```

In [6]:

```
# 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 encoing
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.ta
r.gz
170500096/170498071 [==============================] - 6s 0us/step
```

In [7]:

```
print('Train Shape:',X_train.shape)
print('Test Shape:',X_test.shape)
```

```
Train Shape: (50000, 32, 32, 3)
Test Shape: (10000, 32, 32, 3)
```

In [0]:

```
# Dense Block
def denseblock(input, num_filter = 12, dropout_rate = 0.2):
    global compression
    temp = input
    for _ in range(l):
        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 Blosck
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=Fals
e ,padding='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
    print('input',input.shape)
    BatchNorm = layers.BatchNormalization()(input)
    print('Batch',BatchNorm.shape)
    relu = layers.Activation('relu')(BatchNorm)
    print('relu',relu.shape)
    AvgPooling = layers.AveragePooling2D(pool_size=(2,2))(relu)
    # print('pooling',AvgPooling.shape)
    # flat = layers.Flatten()(AvgPooling)
    # print('flat',flat.shape)
    # # tf.reshape(flat,(4,246))
    # # print(flat.reshape(7,4,4,246,1))
    # output = layers.Conv1D(num_filter,kernel_size=1)(tf.reshape(flat,(1,4,246)))




    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 [0]:

```
num_filter = 12
dropout_rate = 0.2
l = 12
```

In [9]:

```
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_
core/python/ops/resource_variable_ops.py:1630: calling BaseResourceVariabl
e.__init__ (from tensorflow.python.ops.resource_variable_ops) with constra
int is deprecated and will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
input (?, 4, 4, 240)
Batch (?, 4, 4, 240)
relu (?, 4, 4, 240)
```

In [0]:

```
#https://arxiv.org/pdf/1608.06993.pdf
from IPython.display import IFrame, YouTubeVideo
YouTubeVideo(id='-W6y8xnd--U', width=600)
```

In [10]:

```
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, 24)   648         input_1[0][0]
__________________________________________________________________________________________________
batch_normalization (BatchNorma (None, 32, 32, 24)   96          conv2d[0][0]
__________________________________________________________________________________________________
activation (Activation)         (None, 32, 32, 24)   0           batch_normalization[0][0]
__________________________________________________________________________________________________
conv2d_1 (Conv2D)               (None, 32, 32, 24)   5184        activation[0][0]
__________________________________________________________________________________________________
dropout (Dropout)               (None, 32, 32, 24)   0           conv2d_1[0][0]
__________________________________________________________________________________________________
concatenate (Concatenate)       (None, 32, 32, 48)   0           conv2d[0][0]
                                                                 dropout[0][0]
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 32, 32, 48)   192         concatenate[0][0]
__________________________________________________________________________________________________
activation_1 (Activation)       (None, 32, 32, 48)   0           batch_normalization_1[0][0]
__________________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 32, 32, 24)   10368       activation_1[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 32, 32, 24)   0           conv2d_2[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 32, 32, 72)   0           concatenate[0][0]
                                                                 dropout_1[0][0]
__________________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, 32, 32, 72)   288         concatenate_1[0][0]
__________________________________________________________________________________________________
```

```
________________________________
activation_2 (Activation)       (None, 32, 32, 72)   0            batch_nor
malization_2[0][0]
__________________________________________________________________________________________________
________________________________
conv2d_3 (Conv2D)               (None, 32, 32, 24)   15552        activatio
n_2[0][0]
__________________________________________________________________________________________________
________________________________
dropout_2 (Dropout)             (None, 32, 32, 24)   0            conv2d_3
[0][0]
__________________________________________________________________________________________________
________________________________
concatenate_2 (Concatenate)     (None, 32, 32, 96)   0            concatena
te_1[0][0]
                                                                  dropout_2
[0][0]
__________________________________________________________________________________________________
________________________________
batch_normalization_3 (BatchNor (None, 32, 32, 96)   384          concatena
te_2[0][0]
__________________________________________________________________________________________________
________________________________
activation_3 (Activation)       (None, 32, 32, 96)   0            batch_nor
malization_3[0][0]
__________________________________________________________________________________________________
________________________________
conv2d_4 (Conv2D)               (None, 32, 32, 24)   20736        activatio
n_3[0][0]
__________________________________________________________________________________________________
________________________________
dropout_3 (Dropout)             (None, 32, 32, 24)   0            conv2d_4
[0][0]
__________________________________________________________________________________________________
________________________________
concatenate_3 (Concatenate)     (None, 32, 32, 120)  0            concatena
te_2[0][0]
                                                                  dropout_3
[0][0]
__________________________________________________________________________________________________
________________________________
batch_normalization_4 (BatchNor (None, 32, 32, 120)  480          concatena
te_3[0][0]
__________________________________________________________________________________________________
________________________________
activation_4 (Activation)       (None, 32, 32, 120)  0            batch_nor
malization_4[0][0]
__________________________________________________________________________________________________
________________________________
conv2d_5 (Conv2D)               (None, 32, 32, 24)   25920        activatio
n_4[0][0]
__________________________________________________________________________________________________
________________________________
dropout_4 (Dropout)             (None, 32, 32, 24)   0            conv2d_5
[0][0]
__________________________________________________________________________________________________
________________________________
concatenate_4 (Concatenate)     (None, 32, 32, 144)  0            concatena
te_3[0][0]
                                                                  dropout_4
[0][0]
```

```
________________________________________________________________________________
__________________________
batch_normalization_5 (BatchNor (None, 32, 32, 144)  576         concatena
te_4[0][0]
________________________________________________________________________________
__________________________
activation_5 (Activation)       (None, 32, 32, 144)  0           batch_nor
malization_5[0][0]
________________________________________________________________________________
__________________________
conv2d_6 (Conv2D)               (None, 32, 32, 24)   31104       activatio
n_5[0][0]
________________________________________________________________________________
__________________________
dropout_5 (Dropout)             (None, 32, 32, 24)   0           conv2d_6
[0][0]
________________________________________________________________________________
__________________________
concatenate_5 (Concatenate)     (None, 32, 32, 168)  0           concatena
te_4[0][0]
                                                                 dropout_5
[0][0]
________________________________________________________________________________
__________________________
batch_normalization_6 (BatchNor (None, 32, 32, 168)  672         concatena
te_5[0][0]
________________________________________________________________________________
__________________________
activation_6 (Activation)       (None, 32, 32, 168)  0           batch_nor
malization_6[0][0]
________________________________________________________________________________
__________________________
conv2d_7 (Conv2D)               (None, 32, 32, 24)   36288       activatio
n_6[0][0]
________________________________________________________________________________
__________________________
dropout_6 (Dropout)             (None, 32, 32, 24)   0           conv2d_7
[0][0]
________________________________________________________________________________
__________________________
concatenate_6 (Concatenate)     (None, 32, 32, 192)  0           concatena
te_5[0][0]
                                                                 dropout_6
[0][0]
________________________________________________________________________________
__________________________
batch_normalization_7 (BatchNor (None, 32, 32, 192)  768         concatena
te_6[0][0]
________________________________________________________________________________
__________________________
activation_7 (Activation)       (None, 32, 32, 192)  0           batch_nor
malization_7[0][0]
________________________________________________________________________________
__________________________
conv2d_8 (Conv2D)               (None, 32, 32, 24)   41472       activatio
n_7[0][0]
________________________________________________________________________________
__________________________
dropout_7 (Dropout)             (None, 32, 32, 24)   0           conv2d_8
[0][0]
________________________________________________________________________________
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________________________________
concatenate_7 (Concatenate)     (None, 32, 32, 216)  0           concatena
te_6[0][0]
                                                                 dropout_7
[0][0]
__________________________________________________________________________________________________
batch_normalization_8 (BatchNor (None, 32, 32, 216)  864         concatena
te_7[0][0]
__________________________________________________________________________________________________
activation_8 (Activation)       (None, 32, 32, 216)  0           batch_nor
malization_8[0][0]
__________________________________________________________________________________________________
conv2d_9 (Conv2D)               (None, 32, 32, 24)   46656       activatio
n_8[0][0]
__________________________________________________________________________________________________
dropout_8 (Dropout)             (None, 32, 32, 24)   0           conv2d_9
[0][0]
__________________________________________________________________________________________________
concatenate_8 (Concatenate)     (None, 32, 32, 240)  0           concatena
te_7[0][0]
                                                                 dropout_8
[0][0]
__________________________________________________________________________________________________
batch_normalization_9 (BatchNor (None, 32, 32, 240)  960         concatena
te_8[0][0]
__________________________________________________________________________________________________
activation_9 (Activation)       (None, 32, 32, 240)  0           batch_nor
malization_9[0][0]
__________________________________________________________________________________________________
conv2d_10 (Conv2D)              (None, 32, 32, 24)   5760        activatio
n_9[0][0]
__________________________________________________________________________________________________
dropout_9 (Dropout)             (None, 32, 32, 24)   0           conv2d_10
[0][0]
__________________________________________________________________________________________________
average_pooling2d (AveragePooli (None, 16, 16, 24)   0           dropout_9
[0][0]
__________________________________________________________________________________________________
batch_normalization_10 (BatchNo (None, 16, 16, 24)   96          average_p
ooling2d[0][0]
__________________________________________________________________________________________________
activation_10 (Activation)      (None, 16, 16, 24)   0           batch_nor
malization_10[0][0]
__________________________________________________________________________________________________
conv2d_11 (Conv2D)              (None, 16, 16, 24)   5184        activatio
n_10[0][0]
__________________________________________________________________________________________________
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```

```
dropout_10 (Dropout)            (None, 16, 16, 24)   0           conv2d_11
[0][0]
__________________________________________________________________________
________________________
concatenate_9 (Concatenate)     (None, 16, 16, 48)   0           average_p
ooling2d[0][0]
                                                                 dropout_1
0[0][0]
__________________________________________________________________________
________________________
batch_normalization_11 (BatchNo (None, 16, 16, 48)   192         concatena
te_9[0][0]
__________________________________________________________________________
________________________
activation_11 (Activation)      (None, 16, 16, 48)   0           batch_nor
malization_11[0][0]
__________________________________________________________________________
________________________
conv2d_12 (Conv2D)              (None, 16, 16, 24)   10368       activatio
n_11[0][0]
__________________________________________________________________________
________________________
dropout_11 (Dropout)            (None, 16, 16, 24)   0           conv2d_12
[0][0]
__________________________________________________________________________
________________________
concatenate_10 (Concatenate)    (None, 16, 16, 72)   0           concatena
te_9[0][0]
                                                                 dropout_1
1[0][0]
__________________________________________________________________________
________________________
batch_normalization_12 (BatchNo (None, 16, 16, 72)   288         concatena
te_10[0][0]
__________________________________________________________________________
________________________
activation_12 (Activation)      (None, 16, 16, 72)   0           batch_nor
malization_12[0][0]
__________________________________________________________________________
________________________
conv2d_13 (Conv2D)              (None, 16, 16, 24)   15552       activatio
n_12[0][0]
__________________________________________________________________________
________________________
dropout_12 (Dropout)            (None, 16, 16, 24)   0           conv2d_13
[0][0]
__________________________________________________________________________
________________________
concatenate_11 (Concatenate)    (None, 16, 16, 96)   0           concatena
te_10[0][0]
                                                                 dropout_1
2[0][0]
__________________________________________________________________________
________________________
batch_normalization_13 (BatchNo (None, 16, 16, 96)   384         concatena
te_11[0][0]
__________________________________________________________________________
________________________
activation_13 (Activation)      (None, 16, 16, 96)   0           batch_nor
malization_13[0][0]
__________________________________________________________________________
```

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______________________________
conv2d_14 (Conv2D)              (None, 16, 16, 24)   20736       activatio
n_13[0][0]
__________________________________________________________________________________________________
______________________________
dropout_13 (Dropout)            (None, 16, 16, 24)   0           conv2d_14
[0][0]
__________________________________________________________________________________________________
______________________________
concatenate_12 (Concatenate)    (None, 16, 16, 120)  0           concatena
te_11[0][0]
                                                                 dropout_1
3[0][0]
__________________________________________________________________________________________________
______________________________
batch_normalization_14 (BatchNo (None, 16, 16, 120)  480         concatena
te_12[0][0]
__________________________________________________________________________________________________
______________________________
activation_14 (Activation)      (None, 16, 16, 120)  0           batch_nor
malization_14[0][0]
__________________________________________________________________________________________________
______________________________
conv2d_15 (Conv2D)              (None, 16, 16, 24)   25920       activatio
n_14[0][0]
__________________________________________________________________________________________________
______________________________
dropout_14 (Dropout)            (None, 16, 16, 24)   0           conv2d_15
[0][0]
__________________________________________________________________________________________________
______________________________
concatenate_13 (Concatenate)    (None, 16, 16, 144)  0           concatena
te_12[0][0]
                                                                 dropout_1
4[0][0]
__________________________________________________________________________________________________
______________________________
batch_normalization_15 (BatchNo (None, 16, 16, 144)  576         concatena
te_13[0][0]
__________________________________________________________________________________________________
______________________________
activation_15 (Activation)      (None, 16, 16, 144)  0           batch_nor
malization_15[0][0]
__________________________________________________________________________________________________
______________________________
conv2d_16 (Conv2D)              (None, 16, 16, 24)   31104       activatio
n_15[0][0]
__________________________________________________________________________________________________
______________________________
dropout_15 (Dropout)            (None, 16, 16, 24)   0           conv2d_16
[0][0]
__________________________________________________________________________________________________
______________________________
concatenate_14 (Concatenate)    (None, 16, 16, 168)  0           concatena
te_13[0][0]
                                                                 dropout_1
5[0][0]
__________________________________________________________________________________________________
______________________________
batch_normalization_16 (BatchNo (None, 16, 16, 168)  672         concatena
te_14[0][0]
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________________________________________________________________________________
__________________________
activation_16 (Activation)      (None, 16, 16, 168)  0           batch_nor
malization_16[0][0]
________________________________________________________________________________
__________________________
conv2d_17 (Conv2D)              (None, 16, 16, 24)   36288       activatio
n_16[0][0]
________________________________________________________________________________
__________________________
dropout_16 (Dropout)            (None, 16, 16, 24)   0           conv2d_17
[0][0]
________________________________________________________________________________
__________________________
concatenate_15 (Concatenate)    (None, 16, 16, 192)  0           concatena
te_14[0][0]
                                                                 dropout_1
6[0][0]
________________________________________________________________________________
__________________________
batch_normalization_17 (BatchNo (None, 16, 16, 192)  768         concatena
te_15[0][0]
________________________________________________________________________________
__________________________
activation_17 (Activation)      (None, 16, 16, 192)  0           batch_nor
malization_17[0][0]
________________________________________________________________________________
__________________________
conv2d_18 (Conv2D)              (None, 16, 16, 24)   41472       activatio
n_17[0][0]
________________________________________________________________________________
__________________________
dropout_17 (Dropout)            (None, 16, 16, 24)   0           conv2d_18
[0][0]
________________________________________________________________________________
__________________________
concatenate_16 (Concatenate)    (None, 16, 16, 216)  0           concatena
te_15[0][0]
                                                                 dropout_1
7[0][0]
________________________________________________________________________________
__________________________
batch_normalization_18 (BatchNo (None, 16, 16, 216)  864         concatena
te_16[0][0]
________________________________________________________________________________
__________________________
activation_18 (Activation)      (None, 16, 16, 216)  0           batch_nor
malization_18[0][0]
________________________________________________________________________________
__________________________
conv2d_19 (Conv2D)              (None, 16, 16, 24)   46656       activatio
n_18[0][0]
________________________________________________________________________________
__________________________
dropout_18 (Dropout)            (None, 16, 16, 24)   0           conv2d_19
[0][0]
________________________________________________________________________________
__________________________
concatenate_17 (Concatenate)    (None, 16, 16, 240)  0           concatena
te_16[0][0]
                                                                 dropout_1
```

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8[0][0]
__________________________________________________________________________________________________
batch_normalization_19 (BatchNo (None, 16, 16, 240)  960         concatenate_17[0][0]
__________________________________________________________________________________________________
activation_19 (Activation)      (None, 16, 16, 240)  0           batch_normalization_19[0][0]
__________________________________________________________________________________________________
conv2d_20 (Conv2D)              (None, 16, 16, 24)   5760        activation_19[0][0]
__________________________________________________________________________________________________
dropout_19 (Dropout)            (None, 16, 16, 24)   0           conv2d_20[0][0]
__________________________________________________________________________________________________
average_pooling2d_1 (AveragePoo (None, 8, 8, 24)     0           dropout_19[0][0]
__________________________________________________________________________________________________
batch_normalization_20 (BatchNo (None, 8, 8, 24)     96          average_pooling2d_1[0][0]
__________________________________________________________________________________________________
activation_20 (Activation)      (None, 8, 8, 24)     0           batch_normalization_20[0][0]
__________________________________________________________________________________________________
conv2d_21 (Conv2D)              (None, 8, 8, 24)     5184        activation_20[0][0]
__________________________________________________________________________________________________
dropout_20 (Dropout)            (None, 8, 8, 24)     0           conv2d_21[0][0]
__________________________________________________________________________________________________
concatenate_18 (Concatenate)    (None, 8, 8, 48)     0           average_pooling2d_1[0][0]
                                                                 dropout_20[0][0]
__________________________________________________________________________________________________
batch_normalization_21 (BatchNo (None, 8, 8, 48)     192         concatenate_18[0][0]
__________________________________________________________________________________________________
activation_21 (Activation)      (None, 8, 8, 48)     0           batch_normalization_21[0][0]
__________________________________________________________________________________________________
conv2d_22 (Conv2D)              (None, 8, 8, 24)     10368       activation_21[0][0]
__________________________________________________________________________________________________
dropout_21 (Dropout)            (None, 8, 8, 24)     0           conv2d_22[0][0]
__________________________________________________________________________________________________
```

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concatenate_19 (Concatenate)    (None, 8, 8, 72)     0           concatena
te_18[0][0]
                                                                 dropout_2
1[0][0]
__________________________________________________________________________
________________________
batch_normalization_22 (BatchNo (None, 8, 8, 72)     288         concatena
te_19[0][0]
__________________________________________________________________________
________________________
activation_22 (Activation)      (None, 8, 8, 72)     0           batch_nor
malization_22[0][0]
__________________________________________________________________________
________________________
conv2d_23 (Conv2D)              (None, 8, 8, 24)     15552       activatio
n_22[0][0]
__________________________________________________________________________
________________________
dropout_22 (Dropout)            (None, 8, 8, 24)     0           conv2d_23
[0][0]
__________________________________________________________________________
________________________
concatenate_20 (Concatenate)    (None, 8, 8, 96)     0           concatena
te_19[0][0]
                                                                 dropout_2
2[0][0]
__________________________________________________________________________
________________________
batch_normalization_23 (BatchNo (None, 8, 8, 96)     384         concatena
te_20[0][0]
__________________________________________________________________________
________________________
activation_23 (Activation)      (None, 8, 8, 96)     0           batch_nor
malization_23[0][0]
__________________________________________________________________________
________________________
conv2d_24 (Conv2D)              (None, 8, 8, 24)     20736       activatio
n_23[0][0]
__________________________________________________________________________
________________________
dropout_23 (Dropout)            (None, 8, 8, 24)     0           conv2d_24
[0][0]
__________________________________________________________________________
________________________
concatenate_21 (Concatenate)    (None, 8, 8, 120)    0           concatena
te_20[0][0]
                                                                 dropout_2
3[0][0]
__________________________________________________________________________
________________________
batch_normalization_24 (BatchNo (None, 8, 8, 120)    480         concatena
te_21[0][0]
__________________________________________________________________________
________________________
activation_24 (Activation)      (None, 8, 8, 120)    0           batch_nor
malization_24[0][0]
__________________________________________________________________________
________________________
conv2d_25 (Conv2D)              (None, 8, 8, 24)     25920       activatio
n_24[0][0]
__________________________________________________________________________
```

```
________________________
dropout_24 (Dropout)            (None, 8, 8, 24)     0            conv2d_25
[0][0]
__________________________________________________________________________
________________________
concatenate_22 (Concatenate)    (None, 8, 8, 144)    0            concatena
te_21[0][0]
                                                                  dropout_2
4[0][0]
__________________________________________________________________________
________________________
batch_normalization_25 (BatchNo (None, 8, 8, 144)    576          concatena
te_22[0][0]
__________________________________________________________________________
________________________
activation_25 (Activation)      (None, 8, 8, 144)    0            batch_nor
malization_25[0][0]
__________________________________________________________________________
________________________
conv2d_26 (Conv2D)              (None, 8, 8, 24)     31104        activatio
n_25[0][0]
__________________________________________________________________________
________________________
dropout_25 (Dropout)            (None, 8, 8, 24)     0            conv2d_26
[0][0]
__________________________________________________________________________
________________________
concatenate_23 (Concatenate)    (None, 8, 8, 168)    0            concatena
te_22[0][0]
                                                                  dropout_2
5[0][0]
__________________________________________________________________________
________________________
batch_normalization_26 (BatchNo (None, 8, 8, 168)    672          concatena
te_23[0][0]
__________________________________________________________________________
________________________
activation_26 (Activation)      (None, 8, 8, 168)    0            batch_nor
malization_26[0][0]
__________________________________________________________________________
________________________
conv2d_27 (Conv2D)              (None, 8, 8, 24)     36288        activatio
n_26[0][0]
__________________________________________________________________________
________________________
dropout_26 (Dropout)            (None, 8, 8, 24)     0            conv2d_27
[0][0]
__________________________________________________________________________
________________________
concatenate_24 (Concatenate)    (None, 8, 8, 192)    0            concatena
te_23[0][0]
                                                                  dropout_2
6[0][0]
__________________________________________________________________________
________________________
batch_normalization_27 (BatchNo (None, 8, 8, 192)    768          concatena
te_24[0][0]
__________________________________________________________________________
________________________
activation_27 (Activation)      (None, 8, 8, 192)    0            batch_nor
malization_27[0][0]
```

```
______________________________________________________________________________
________________________________
conv2d_28 (Conv2D)              (None, 8, 8, 24)     41472       activatio
n_27[0][0]
______________________________________________________________________________
________________________________
dropout_27 (Dropout)            (None, 8, 8, 24)     0           conv2d_28
[0][0]
______________________________________________________________________________
________________________________
concatenate_25 (Concatenate)    (None, 8, 8, 216)    0           concatena
te_24[0][0]
                                                                 dropout_2
7[0][0]
______________________________________________________________________________
________________________________
batch_normalization_28 (BatchNo (None, 8, 8, 216)    864         concatena
te_25[0][0]
______________________________________________________________________________
________________________________
activation_28 (Activation)      (None, 8, 8, 216)    0           batch_nor
malization_28[0][0]
______________________________________________________________________________
________________________________
conv2d_29 (Conv2D)              (None, 8, 8, 24)     46656       activatio
n_28[0][0]
______________________________________________________________________________
________________________________
dropout_28 (Dropout)            (None, 8, 8, 24)     0           conv2d_29
[0][0]
______________________________________________________________________________
________________________________
concatenate_26 (Concatenate)    (None, 8, 8, 240)    0           concatena
te_25[0][0]
                                                                 dropout_2
8[0][0]
______________________________________________________________________________
________________________________
batch_normalization_29 (BatchNo (None, 8, 8, 240)    960         concatena
te_26[0][0]
______________________________________________________________________________
________________________________
activation_29 (Activation)      (None, 8, 8, 240)    0           batch_nor
malization_29[0][0]
______________________________________________________________________________
________________________________
conv2d_30 (Conv2D)              (None, 8, 8, 24)     5760        activatio
n_29[0][0]
______________________________________________________________________________
________________________________
dropout_29 (Dropout)            (None, 8, 8, 24)     0           conv2d_30
[0][0]
______________________________________________________________________________
________________________________
average_pooling2d_2 (AveragePoo (None, 4, 4, 24)     0           dropout_2
9[0][0]
______________________________________________________________________________
________________________________
batch_normalization_30 (BatchNo (None, 4, 4, 24)     96          average_p
ooling2d_2[0][0]
______________________________________________________________________________
```

```
________________________
activation_30 (Activation)      (None, 4, 4, 24)     0           batch_nor
malization_30[0][0]
__________________________________________________________________________
________________________
conv2d_31 (Conv2D)              (None, 4, 4, 24)     5184        activatio
n_30[0][0]
__________________________________________________________________________
________________________
dropout_30 (Dropout)            (None, 4, 4, 24)     0           conv2d_31
[0][0]
__________________________________________________________________________
________________________
concatenate_27 (Concatenate)    (None, 4, 4, 48)     0           average_p
ooling2d_2[0][0]
                                                                 dropout_3
0[0][0]
__________________________________________________________________________
________________________
batch_normalization_31 (BatchNo (None, 4, 4, 48)     192         concatena
te_27[0][0]
__________________________________________________________________________
________________________
activation_31 (Activation)      (None, 4, 4, 48)     0           batch_nor
malization_31[0][0]
__________________________________________________________________________
________________________
conv2d_32 (Conv2D)              (None, 4, 4, 24)     10368       activatio
n_31[0][0]
__________________________________________________________________________
________________________
dropout_31 (Dropout)            (None, 4, 4, 24)     0           conv2d_32
[0][0]
__________________________________________________________________________
________________________
concatenate_28 (Concatenate)    (None, 4, 4, 72)     0           concatena
te_27[0][0]
                                                                 dropout_3
1[0][0]
__________________________________________________________________________
________________________
batch_normalization_32 (BatchNo (None, 4, 4, 72)     288         concatena
te_28[0][0]
__________________________________________________________________________
________________________
activation_32 (Activation)      (None, 4, 4, 72)     0           batch_nor
malization_32[0][0]
__________________________________________________________________________
________________________
conv2d_33 (Conv2D)              (None, 4, 4, 24)     15552       activatio
n_32[0][0]
__________________________________________________________________________
________________________
dropout_32 (Dropout)            (None, 4, 4, 24)     0           conv2d_33
[0][0]
__________________________________________________________________________
________________________
concatenate_29 (Concatenate)    (None, 4, 4, 96)     0           concatena
te_28[0][0]
                                                                 dropout_3
2[0][0]
```

```
________________________________________________________________________________
________________________
batch_normalization_33 (BatchNo (None, 4, 4, 96)     384         concatena
te_29[0][0]
________________________________________________________________________________
________________________
activation_33 (Activation)      (None, 4, 4, 96)     0           batch_nor
malization_33[0][0]
________________________________________________________________________________
________________________
conv2d_34 (Conv2D)              (None, 4, 4, 24)     20736       activatio
n_33[0][0]
________________________________________________________________________________
________________________
dropout_33 (Dropout)            (None, 4, 4, 24)     0           conv2d_34
[0][0]
________________________________________________________________________________
________________________
concatenate_30 (Concatenate)    (None, 4, 4, 120)    0           concatena
te_29[0][0]
                                                                 dropout_3
3[0][0]
________________________________________________________________________________
________________________
batch_normalization_34 (BatchNo (None, 4, 4, 120)    480         concatena
te_30[0][0]
________________________________________________________________________________
________________________
activation_34 (Activation)      (None, 4, 4, 120)    0           batch_nor
malization_34[0][0]
________________________________________________________________________________
________________________
conv2d_35 (Conv2D)              (None, 4, 4, 24)     25920       activatio
n_34[0][0]
________________________________________________________________________________
________________________
dropout_34 (Dropout)            (None, 4, 4, 24)     0           conv2d_35
[0][0]
________________________________________________________________________________
________________________
concatenate_31 (Concatenate)    (None, 4, 4, 144)    0           concatena
te_30[0][0]
                                                                 dropout_3
4[0][0]
________________________________________________________________________________
________________________
batch_normalization_35 (BatchNo (None, 4, 4, 144)    576         concatena
te_31[0][0]
________________________________________________________________________________
________________________
activation_35 (Activation)      (None, 4, 4, 144)    0           batch_nor
malization_35[0][0]
________________________________________________________________________________
________________________
conv2d_36 (Conv2D)              (None, 4, 4, 24)     31104       activatio
n_35[0][0]
________________________________________________________________________________
________________________
dropout_35 (Dropout)            (None, 4, 4, 24)     0           conv2d_36
[0][0]
________________________________________________________________________________
```

```
________________________
concatenate_32 (Concatenate)    (None, 4, 4, 168)    0           concatena
te_31[0][0]
                                                                 dropout_3
5[0][0]
__________________________________________________________________________
________________________
batch_normalization_36 (BatchNo (None, 4, 4, 168)    672         concatena
te_32[0][0]
__________________________________________________________________________
________________________
activation_36 (Activation)      (None, 4, 4, 168)    0           batch_nor
malization_36[0][0]
__________________________________________________________________________
________________________
conv2d_37 (Conv2D)              (None, 4, 4, 24)     36288       activatio
n_36[0][0]
__________________________________________________________________________
________________________
dropout_36 (Dropout)            (None, 4, 4, 24)     0           conv2d_37
[0][0]
__________________________________________________________________________
________________________
concatenate_33 (Concatenate)    (None, 4, 4, 192)    0           concatena
te_32[0][0]
                                                                 dropout_3
6[0][0]
__________________________________________________________________________
________________________
batch_normalization_37 (BatchNo (None, 4, 4, 192)    768         concatena
te_33[0][0]
__________________________________________________________________________
________________________
activation_37 (Activation)      (None, 4, 4, 192)    0           batch_nor
malization_37[0][0]
__________________________________________________________________________
________________________
conv2d_38 (Conv2D)              (None, 4, 4, 24)     41472       activatio
n_37[0][0]
__________________________________________________________________________
________________________
dropout_37 (Dropout)            (None, 4, 4, 24)     0           conv2d_38
[0][0]
__________________________________________________________________________
________________________
concatenate_34 (Concatenate)    (None, 4, 4, 216)    0           concatena
te_33[0][0]
                                                                 dropout_3
7[0][0]
__________________________________________________________________________
________________________
batch_normalization_38 (BatchNo (None, 4, 4, 216)    864         concatena
te_34[0][0]
__________________________________________________________________________
________________________
activation_38 (Activation)      (None, 4, 4, 216)    0           batch_nor
malization_38[0][0]
__________________________________________________________________________
________________________
conv2d_39 (Conv2D)              (None, 4, 4, 24)     46656       activatio
n_38[0][0]
```

```
________________________________________________________________________________
__________________________
dropout_38 (Dropout)            (None, 4, 4, 24)     0            conv2d_39
[0][0]
________________________________________________________________________________
__________________________
concatenate_35 (Concatenate)    (None, 4, 4, 240)    0            concatena
te_34[0][0]
                                                                  dropout_3
8[0][0]
________________________________________________________________________________
__________________________
batch_normalization_39 (BatchNo (None, 4, 4, 240)    960          concatena
te_35[0][0]
________________________________________________________________________________
__________________________
activation_39 (Activation)      (None, 4, 4, 240)    0            batch_nor
malization_39[0][0]
________________________________________________________________________________
__________________________
average_pooling2d_3 (AveragePoo (None, 2, 2, 240)    0            activatio
n_39[0][0]
________________________________________________________________________________
__________________________
conv2d_40 (Conv2D)              (None, 2, 2, 10)     2400         average_p
ooling2d_3[0][0]
________________________________________________________________________________
__________________________
global_max_pooling2d (GlobalMax (None, 10)           0            conv2d_40
[0][0]
________________________________________________________________________________
__________________________
activation_40 (Activation)      (None, 10)           0            global_ma
x_pooling2d[0][0]
================================================================================
========================
Total params: 974,568
Trainable params: 964,008
Non-trainable params: 10,560
________________________________________________________________________________
__________________________
```

In [0]:

```
# determine Loss function and Optimizer

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

In [0]:

```
model.fit(X_train, y_train,
                    batch_size=batch_size,
                    epochs=epochs,
                    verbose=1,
                    validation_data=(X_test, y_test))
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 112s 2ms/sample - loss: 1.7
266 - acc: 0.3533 - val_loss: 1.5696 - val_acc: 0.4313
Epoch 2/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.37
10 - acc: 0.4956 - val_loss: 1.6232 - val_acc: 0.4712
Epoch 3/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.20
11 - acc: 0.5626 - val_loss: 1.2632 - val_acc: 0.5566
Epoch 4/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.09
69 - acc: 0.6025 - val_loss: 1.2591 - val_acc: 0.5634
Epoch 5/10
50000/50000 [==============================] - 95s 2ms/sample - loss: 1.03
90 - acc: 0.6257 - val_loss: 1.2728 - val_acc: 0.5842
Epoch 6/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.98
57 - acc: 0.6452 - val_loss: 1.4487 - val_acc: 0.5634
Epoch 7/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.95
01 - acc: 0.6597 - val_loss: 1.9306 - val_acc: 0.4998
Epoch 8/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.92
04 - acc: 0.6683 - val_loss: 1.0015 - val_acc: 0.6638
Epoch 9/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.88
58 - acc: 0.6805 - val_loss: 1.3980 - val_acc: 0.5892
Epoch 10/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.86
14 - acc: 0.6891 - val_loss: 1.3597 - val_acc: 0.5937
```

Out[0]:

```
<tensorflow.python.keras.callbacks.History at 0x7f368f86a518>
```

In [0]:

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

```
10000/10000 [==============================] - 8s 848us/sample - loss: 1.3
597 - acc: 0.5937
Test loss: 1.3597363298416139
Test accuracy: 0.5937
```

In [0]:

```
# Save the trained weights in to .h5 format
model.save_weights("DNST_model.h5")
print("Saved model to disk")
```

In [0]:

```
# ['Augmentation','l','num_filters','compression','Optimizer','Test Accuracy']

final_tab.add_row([None,l, num_filter, compression,'Adam',0.59])
```

In [0]:

```
print(final_tab)
```

```
+--------------+----+-------------+-------------+-----------+-------------
--+
| Augmentation | l  | num_filters | compression | Optimizer | Test Accurac
y |
+--------------+----+-------------+-------------+-----------+-------------
--+
|     None     | 12 |      12     |     0.5     |    Adam   |     0.59
|
+--------------+----+-------------+-------------+-----------+-------------
--+
```

DenseNet Function

In [0]:

```
def dense_net(xtrain,xtest, optim = Adam(),k_size=(3,3), b_size = batch_size, epoch = e
pochs):
          print('b_size:{} epochs:{}'.format(b_size,epoch))
          input = layers.Input(shape=(img_height, img_width, channel,))
          First_Conv2D = layers.Conv2D(num_filter, (3,3), use_bias=False ,padding='sam
e')(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)


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

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

          model.fit(xtrain, y_train,
                              batch_size=batch_size,
                              epochs=epochs,
                              verbose=1,
                              validation_data=(xtest, y_test))




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

          return model
```

Image Augmentation Techniques

Some of the augmentation techniques are as follows

1. Vertical Shift Augmentation
2. Horizontal Shift Augmentation
3. Vertical Flip Augmentation
4. Horizontal Flip Augmentation

Vertical and Horizontal Shift Augmentation:

A shift to an image means moving all pixels of the image in one direction, vertically,horizontally while keeping the image dimensions the same.

In [0]:

```
# Reff https://machinelearningmastery.com/how-to-configure-image-data-augmentation-when
-training-deep-learning-neural-networks/

def vertical_horizontal_shift(arr_imgs):

      # convert to numpy array
      d = arr_imgs.copy()

      for i in tqdm(range(d.shape[0]), position=0):
          data = d[i]
          # expand dimension to one sample
          samples = expand_dims(data, 0)
          # create image data augmentation generator
          datagen = ImageDataGenerator(width_shift_range=[-15,15], height_shift_range=[
-15,15])
          # prepare iterator
          it = datagen.flow(samples, batch_size=1)
          # generate samples and plot
          # define subplot
          # pyplot.subplot(330 + 1 + i)
          # generate batch of images
          for j in range(9):
              batch = it.next()
              if j == 0:

                  # convert to unsigned integers for viewing
                  image = batch[0].astype('uint8')
                  d[i] = image
                  # plot raw pixel data
                  break
      return d
```

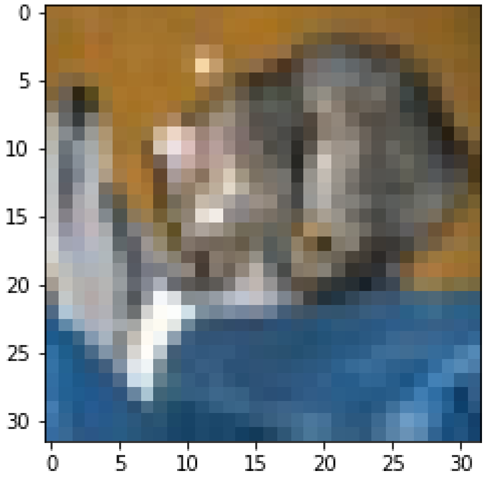
Original Image

In [0]:

```
pyplot.imshow(X_test[0])
```

Out[0]:

```
<matplotlib.image.AxesImage at 0x7fecfc932240>
```



After Vertical and Horizontal Shift

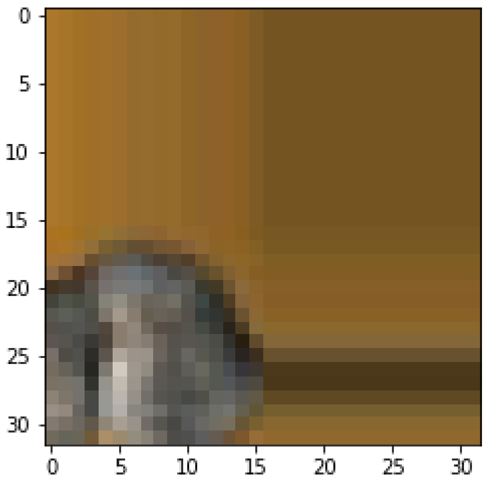
In [0]:

```
pyplot.imshow(vertical_horizontal_shift(X_test)[0])
```

```
100%|██████████| 10000/10000 [00:58<00:00, 169.87it/s]
```

Out[0]:

```
<matplotlib.image.AxesImage at 0x7fe0a7a5a278>
```



Applying vertical and horizontal shift on vertical and horizontal shift

In [0]:

```
v_h_shift_train = vertical_horizontal_shift(X_train)
v_h_shift_test  = vertical_horizontal_shift(X_test)
```

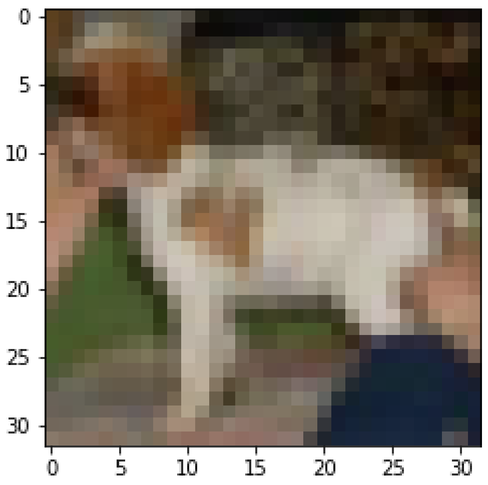
```
100%|██████████| 50000/50000 [00:42<00:00, 1170.97it/s]
100%|██████████| 10000/10000 [00:08<00:00, 1207.90it/s]
```

In [0]:

```
pyplot.imshow(X_test[12])
```

Out[0]:

<matplotlib.image.AxesImage at 0x7fe0a43b8550>

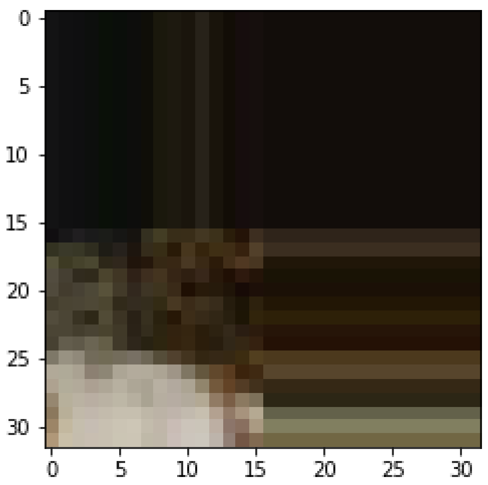


In [0]:

```
pyplot.imshow(v_h_shift_test[12])
```

Out[0]:

<matplotlib.image.AxesImage at 0x7fe0a33e3438>



DenseNet with Adam Optimizer on Vertical Horizantal Shift Data

In [0]:

```
v_h_shift_model = dense_net(v_h_shift_train, v_h_shift_test)
```

```
b_size:64 epochs:10
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 191s 4ms/sample - loss: 2.0
386 - acc: 0.2355 - val_loss: 1.9912 - val_acc: 0.2963
Epoch 2/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.8
141 - acc: 0.3226 - val_loss: 1.7621 - val_acc: 0.3535
Epoch 3/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.6
705 - acc: 0.3824 - val_loss: 1.9284 - val_acc: 0.3487
Epoch 4/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.5
842 - acc: 0.4157 - val_loss: 1.6201 - val_acc: 0.4319
Epoch 5/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.5
244 - acc: 0.4409 - val_loss: 1.7455 - val_acc: 0.4045
Epoch 6/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.4
734 - acc: 0.4619 - val_loss: 1.5040 - val_acc: 0.4666
Epoch 7/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.4
372 - acc: 0.4787 - val_loss: 1.6663 - val_acc: 0.4400
Epoch 8/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.4
007 - acc: 0.4926 - val_loss: 1.6158 - val_acc: 0.4545
Epoch 9/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.3
735 - acc: 0.5033 - val_loss: 1.4835 - val_acc: 0.4785
Epoch 10/10
50000/50000 [==============================] - 174s 3ms/sample - loss: 1.3
441 - acc: 0.5166 - val_loss: 1.5579 - val_acc: 0.4632
10000/10000 [==============================] - 11s 1ms/sample - loss: 1.55
79 - acc: 0.4632
Test loss: 1.5579216079711915
Test accuracy: 0.4632
```

In [0]:

```
final_tab.add_row(['Vertical_Horizantal_Shift',l, num_filter, compression,'Adam',0.42])
```

DenseNet with Nadam Optimizer on Vertical Horizantal Shift Data

In [0]:

```
v_h_shift_model_nadam = dense_net(v_h_shift_train, v_h_shift_test, optim=Nadam())
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 105s 2ms/sample - loss: 2.1
528 - acc: 0.1884 - val_loss: 2.3496 - val_acc: 0.1900
Epoch 2/10
50000/50000 [==============================] - 95s 2ms/sample - loss: 2.01
43 - acc: 0.2405 - val_loss: 2.0252 - val_acc: 0.2460
Epoch 3/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.88
41 - acc: 0.2924 - val_loss: 2.0804 - val_acc: 0.2567
Epoch 4/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.79
20 - acc: 0.3263 - val_loss: 1.9178 - val_acc: 0.3146
Epoch 5/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.72
42 - acc: 0.3547 - val_loss: 1.7486 - val_acc: 0.3612
Epoch 6/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.67
26 - acc: 0.3753 - val_loss: 1.7488 - val_acc: 0.3691
Epoch 7/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.62
98 - acc: 0.3925 - val_loss: 1.7267 - val_acc: 0.3831
Epoch 8/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.59
24 - acc: 0.4099 - val_loss: 1.7654 - val_acc: 0.3777
Epoch 9/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.56
21 - acc: 0.4232 - val_loss: 1.6809 - val_acc: 0.4004
Epoch 10/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.53
30 - acc: 0.4333 - val_loss: 1.5949 - val_acc: 0.4122
10000/10000 [==============================] - 8s 757us/sample - loss: 1.5
949 - acc: 0.4122
Test loss: 1.5949444211959838
Test accuracy: 0.4122
```

In [0]:

```
final_tab.add_row(['Vertical_Horizantal_Shift',1, num_filter, compression,'Nadam',0.41
])
```

Horizontal and Vertical Flip Augmentation

An image flip means reversing the rows or columns of pixels in the case of a vertical or horizontal flip respectively.

In [0]:

```
# Reff https://machinelearningmastery.com/how-to-configure-image-data-augmentation-when
-training-deep-learning-neural-networks/


def vertical_horizontal_flip(arr_imgs):

      # convert to numpy array
      d = arr_imgs.copy()

      for i in tqdm(range(d.shape[0])):
          data = d[i]
          # expand dimension to one sample
          samples = expand_dims(data, 0)
          # create image data augmentation generator
          datagen = ImageDataGenerator(vertical_flip=True, horizontal_flip=True)
          # prepare iterator
          it = datagen.flow(samples, batch_size=1)
          # generate samples and plot
          # define subplot
          # pyplot.subplot(330 + 1 + i)
          # generate batch of images
          for j in range(9):
            batch = it.next()
            if j == 2:
              # convert to unsigned integers for viewing
              image = batch[0].astype('uint8')
              d[i] = image
              break
            # plot raw pixel data
      return d
```

In [0]:

```

```

DenseNet with Optimizer on Vertical Horizantal Flip Data

In [0]:

```
v_h_flip_xtrain = vertical_horizontal_flip(X_train)
v_h_flip_xtest  = vertical_horizontal_flip(X_test)
```

```
100%|██████████| 50000/50000 [00:25<00:00, 1929.50it/s]
100%|██████████| 10000/10000 [00:05<00:00, 1898.82it/s]
```

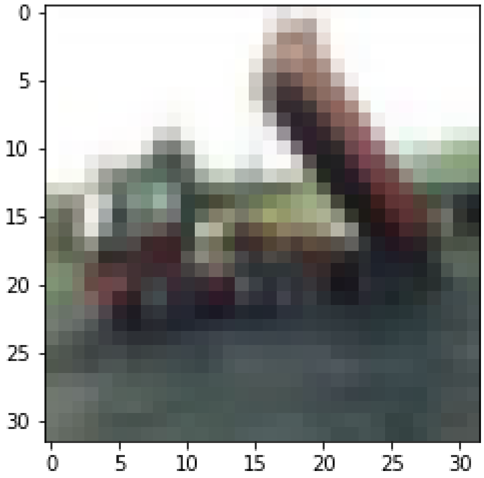
Before Flipping

In [0]:

```
pyplot.imshow(X_train[2])
```

Out[0]:

```
<matplotlib.image.AxesImage at 0x7fe0530cf400>
```



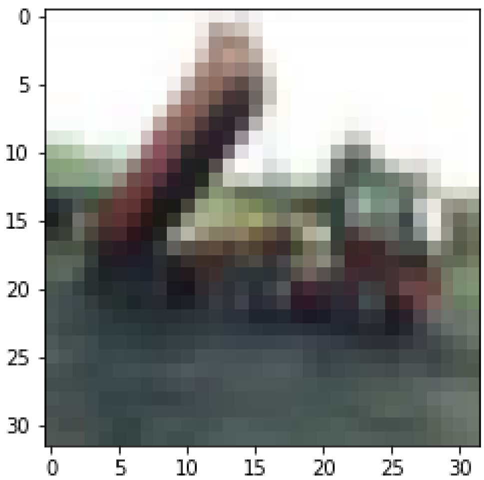
After Flipping

In [0]:

```
pyplot.imshow(v_h_flip_xtrain[2])
```

Out[0]:

```
<matplotlib.image.AxesImage at 0x7fe053061550>
```



In [0]:

```
v_h_flip_model = dense_net(v_h_flip_xtrain, v_h_flip_xtest)
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 107s 2ms/sample - loss: 1.7
911 - acc: 0.3097 - val_loss: 1.6606 - val_acc: 0.3809
Epoch 2/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.52
31 - acc: 0.4242 - val_loss: 1.6694 - val_acc: 0.4135
Epoch 3/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.38
28 - acc: 0.4865 - val_loss: 1.4306 - val_acc: 0.4768
Epoch 4/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.27
82 - acc: 0.5326 - val_loss: 1.4148 - val_acc: 0.5241
Epoch 5/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.19
89 - acc: 0.5606 - val_loss: 1.3927 - val_acc: 0.5238
Epoch 6/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.14
67 - acc: 0.5804 - val_loss: 1.4058 - val_acc: 0.5260
Epoch 7/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.10
55 - acc: 0.5982 - val_loss: 1.7325 - val_acc: 0.4948
Epoch 8/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.06
89 - acc: 0.6086 - val_loss: 1.3379 - val_acc: 0.5305
Epoch 9/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.04
25 - acc: 0.6206 - val_loss: 1.4536 - val_acc: 0.5383
Epoch 10/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.02
03 - acc: 0.6314 - val_loss: 1.3940 - val_acc: 0.5526
10000/10000 [==============================] - 8s 824us/sample - loss: 1.3
940 - acc: 0.5526
Test loss: 1.3939515771865845
Test accuracy: 0.5526
```

In [0]:

```
final_tab.add_row(['Vertical_Horizantal_Flip',l, num_filter, compression,'Adam',0.55])
```

DenseNet with Nadam Optimizer on Vertical Horizantal Flip Data

In [0]:

```
v_h_flip_model_nadam = dense_net(v_h_flip_xtrain, v_h_flip_xtest, optim = Nadam())
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 108s 2ms/sample - loss: 1.8
078 - acc: 0.3088 - val_loss: 1.7010 - val_acc: 0.3601
Epoch 2/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.52
87 - acc: 0.4237 - val_loss: 1.4924 - val_acc: 0.4579
Epoch 3/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.41
01 - acc: 0.4767 - val_loss: 1.5825 - val_acc: 0.4363
Epoch 4/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.33
54 - acc: 0.5046 - val_loss: 1.4079 - val_acc: 0.4948
Epoch 5/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.27
51 - acc: 0.5342 - val_loss: 1.5963 - val_acc: 0.4315
Epoch 6/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.22
14 - acc: 0.5540 - val_loss: 1.3639 - val_acc: 0.5135
Epoch 7/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.17
18 - acc: 0.5729 - val_loss: 1.3339 - val_acc: 0.5423
Epoch 8/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.13
02 - acc: 0.5892 - val_loss: 1.2992 - val_acc: 0.5498
Epoch 9/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.10
01 - acc: 0.6005 - val_loss: 1.2659 - val_acc: 0.5631
Epoch 10/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.07
06 - acc: 0.6119 - val_loss: 1.1701 - val_acc: 0.5946
10000/10000 [==============================] - 8s 823us/sample - loss: 1.1
701 - acc: 0.5946
Test loss: 1.1700947647094726
Test accuracy: 0.5946
```

In [0]:

```
final_tab.add_row(['Vertical_Horizantal_Flip',l, num_filter, compression,'Nadam',0.59])
```

Brightness Augmentation

The brightness of the image can be augmented by either randomly darkening images, brightening images, or both.

In [0]:

```
def brightness(arr_imgs):

      # convert to numpy array
      d = arr_imgs.copy()

      for i in tqdm(range(d.shape[0])):
          data = d[i]
          # expand dimension to one sample
          samples = expand_dims(data, 0)
          # create image data augmentation generator
          datagen = ImageDataGenerator(brightness_range=[0.5,0.6])
          # prepare iterator
          it = datagen.flow(samples, batch_size=1)
          # generate samples and plot
          # define subplot
          # pyplot.subplot(330 + 1 + i)
          # generate batch of images
          for j in range(9):
            batch = it.next()
            if j == 8:
              # convert to unsigned integers for viewing
              image = batch[0].astype('uint8')
              d[i] = image
              break
            # plot raw pixel data
      return d
```

In [0]:

```
bright_xtrain = brightness(X_train)
bright_xtest = brightness(X_test)
```

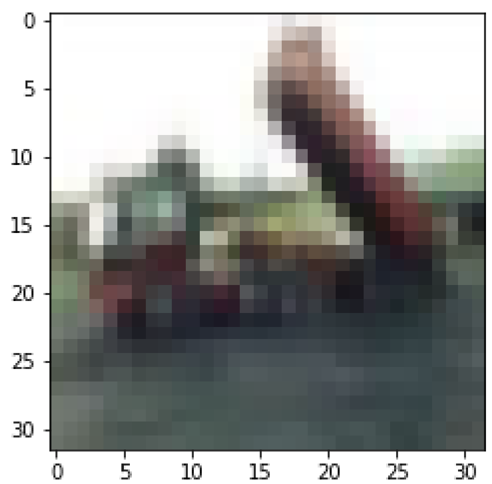
```
100%|██████████| 50000/50000 [02:29<00:00, 333.62it/s]
100%|██████████| 10000/10000 [00:30<00:00, 328.29it/s]
```

In [0]:

```
pyplot.imshow(X_train[2])
```

Out[0]:

```
<matplotlib.image.AxesImage at 0x7fe04e823518>
```

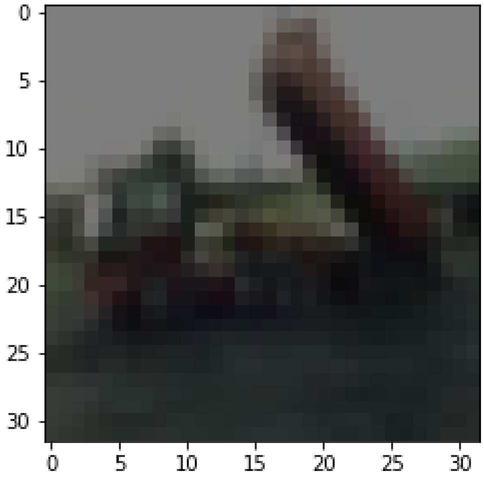


In [0]:

```
pyplot.imshow(bright_xtrain[2])
```

Out[0]:

```
<matplotlib.image.AxesImage at 0x7fe04dbf18d0>
```



DenseNet with Adam Optimizer on Brightness Augmentation Data

In [0]:

```
bright_model = dense_net(bright_xtrain, bright_xtest)
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 110s 2ms/sample - loss: 1.7
495 - acc: 0.3368 - val_loss: 2.0044 - val_acc: 0.3110
Epoch 2/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 1.39
59 - acc: 0.4854 - val_loss: 1.5577 - val_acc: 0.4708
Epoch 3/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 1.20
84 - acc: 0.5608 - val_loss: 1.2202 - val_acc: 0.5645
Epoch 4/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.09
93 - acc: 0.6017 - val_loss: 1.3322 - val_acc: 0.5412
Epoch 5/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.02
83 - acc: 0.6269 - val_loss: 1.1301 - val_acc: 0.6099
Epoch 6/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 0.98
44 - acc: 0.6458 - val_loss: 1.2942 - val_acc: 0.5640
Epoch 7/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.94
09 - acc: 0.6628 - val_loss: 1.1198 - val_acc: 0.6105
Epoch 8/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 0.90
53 - acc: 0.6769 - val_loss: 1.5355 - val_acc: 0.5591
Epoch 9/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.88
34 - acc: 0.6845 - val_loss: 1.2051 - val_acc: 0.6246
Epoch 10/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.85
41 - acc: 0.6950 - val_loss: 0.9743 - val_acc: 0.6735
10000/10000 [==============================] - 8s 782us/sample - loss: 0.9
743 - acc: 0.6735
Test loss: 0.9742989232063294
Test accuracy: 0.6735
```

In [0]:

```
final_tab.add_row(['Brightness',l, num_filter, compression,'Adam',0.67])
```

DenseNet with Nadam Optimizer on Brightness Augmentation Data

In [0]:

```
bright_model_nadam = dense_net(bright_xtrain, bright_xtest, optim=Nadam())
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 112s 2ms/sample - loss: 1.7
422 - acc: 0.3393 - val_loss: 1.6212 - val_acc: 0.4032
Epoch 2/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 1.39
62 - acc: 0.4847 - val_loss: 1.5139 - val_acc: 0.4873
Epoch 3/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 1.21
54 - acc: 0.5559 - val_loss: 1.1808 - val_acc: 0.5713
Epoch 4/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.11
44 - acc: 0.5982 - val_loss: 1.2420 - val_acc: 0.5821
Epoch 5/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 1.04
50 - acc: 0.6246 - val_loss: 1.0905 - val_acc: 0.6186
Epoch 6/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.98
83 - acc: 0.6453 - val_loss: 1.2437 - val_acc: 0.5991
Epoch 7/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.94
78 - acc: 0.6600 - val_loss: 1.3254 - val_acc: 0.5601
Epoch 8/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.90
93 - acc: 0.6746 - val_loss: 1.1406 - val_acc: 0.6206
Epoch 9/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.88
46 - acc: 0.6830 - val_loss: 0.9157 - val_acc: 0.6844
Epoch 10/10
50000/50000 [==============================] - 96s 2ms/sample - loss: 0.85
84 - acc: 0.6917 - val_loss: 0.9772 - val_acc: 0.6706
10000/10000 [==============================] - 9s 924us/sample - loss: 0.9
772 - acc: 0.6706
Test loss: 0.9772336851119995
Test accuracy: 0.6706
```

In [0]:

```
final_tab.add_row(['Brightness',l, num_filter, compression,'Nadam',0.67])
```

Feature Standardization

In [0]:

```
def standard(arr_imgs):

      # convert to numpy array
      d = arr_imgs.copy()

      for i in tqdm(range(d.shape[0])):
          data = d[i]
          # expand dimension to one sample
          samples = expand_dims(data, 0)
          # create image data augmentation generator
          datagen = ImageDataGenerator(featurewise_center=True, featurewise_std_normali
zation=True)
          # prepare iterator
          it = datagen.flow(samples, batch_size=1)
          # generate samples and plot
          # define subplot
          # pyplot.subplot(330 + 1 + i)
          # generate batch of images
          for j in range(9):
              batch = it.next()
              if j == 5:
                # convert to unsigned integers for viewing
                image = batch[0].astype('uint8')
                d[i] = image
                break
                # plot raw pixel data
      return d
```

In [0]:

```
# stand_xtrain = standard(X_train)
stand_xtest  = standard(X_test)
```

```
  0%|          | 0/10000 [00:00<?, ?it/s]/usr/local/lib/python3.6/dist-pac
kages/keras_preprocessing/image/image_data_generator.py:716: UserWarning:
This ImageDataGenerator specifies `featurewise_center`, but it hasn't been
fit on any training data. Fit it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:724: UserWarning: This ImageDataGenerator specifies `featur
ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
100%|██████████| 10000/10000 [00:08<00:00, 1211.73it/s]
```

DenseNet with Adam Optimizer on Standardized Data

In [0]:

```
stand_model = dense_net(stand_xtrain, stand_xtest)
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 116s 2ms/sample - loss: 1.7
418 - acc: 0.3469 - val_loss: 1.5594 - val_acc: 0.4418
Epoch 2/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 1.37
99 - acc: 0.4947 - val_loss: 1.6403 - val_acc: 0.4437
Epoch 3/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 1.21
29 - acc: 0.5580 - val_loss: 1.1566 - val_acc: 0.5843
Epoch 4/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 1.11
02 - acc: 0.6008 - val_loss: 1.2747 - val_acc: 0.5612
Epoch 5/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 1.04
14 - acc: 0.6250 - val_loss: 1.2837 - val_acc: 0.5759
Epoch 6/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 0.99
09 - acc: 0.6446 - val_loss: 1.2212 - val_acc: 0.5953
Epoch 7/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 0.94
81 - acc: 0.6585 - val_loss: 1.1835 - val_acc: 0.6058
Epoch 8/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 0.90
93 - acc: 0.6741 - val_loss: 1.0955 - val_acc: 0.6406
Epoch 9/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 0.88
40 - acc: 0.6811 - val_loss: 0.8493 - val_acc: 0.6984
Epoch 10/10
50000/50000 [==============================] - 97s 2ms/sample - loss: 0.86
02 - acc: 0.6903 - val_loss: 1.0805 - val_acc: 0.6348
10000/10000 [==============================] - 11s 1ms/sample - loss: 1.08
05 - acc: 0.6348
Test loss: 1.0804764985084534
Test accuracy: 0.6348
```

In [0]:

```
final_tab.add_row(['Standardized',l, num_filter, compression,'Adam',0.63])
```

DenseNet with Nadam Optimizer on Standardized Data

In [0]:

```
stand_model_nadam = dense_net(stand_xtrain,stand_xtest, optim = Nadam())
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 117s 2ms/sample - loss: 1.7
193 - acc: 0.3541 - val_loss: 2.2187 - val_acc: 0.3326
Epoch 2/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 1.36
88 - acc: 0.4973 - val_loss: 1.5857 - val_acc: 0.4589
Epoch 3/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 1.22
11 - acc: 0.5536 - val_loss: 1.5198 - val_acc: 0.5076
Epoch 4/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 1.11
58 - acc: 0.5921 - val_loss: 1.4742 - val_acc: 0.5246
Epoch 5/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 1.03
99 - acc: 0.6241 - val_loss: 1.0491 - val_acc: 0.6400
Epoch 6/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 0.99
17 - acc: 0.6427 - val_loss: 1.0171 - val_acc: 0.6433
Epoch 7/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 0.94
90 - acc: 0.6574 - val_loss: 1.4362 - val_acc: 0.5504
Epoch 8/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 0.91
09 - acc: 0.6737 - val_loss: 1.0236 - val_acc: 0.6586
Epoch 9/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 0.87
78 - acc: 0.6854 - val_loss: 1.4910 - val_acc: 0.5662
Epoch 10/10
50000/50000 [==============================] - 98s 2ms/sample - loss: 0.85
48 - acc: 0.6942 - val_loss: 0.9976 - val_acc: 0.6743
10000/10000 [==============================] - 10s 1ms/sample - loss: 0.99
76 - acc: 0.6743
Test loss: 0.9975716045379639
Test accuracy: 0.6743
```

In [0]:

```
final_tab.add_row(['Standardized',l, num_filter, compression,'Nadam',0.63])
```

Now lets try with changing some of the parameters

In [0]:

```
l = 8
num_filter = 38
compression = 1
```

DenseNet with Adam Optimizer on Vertical Horizantal Shift

In [0]:

```
v_h_shift_model2 = dense_net(v_h_shift_train,v_h_shift_test)
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 295s 6ms/sample - loss: 1.9
932 - acc: 0.2628 - val_loss: 2.8806 - val_acc: 0.2111
Epoch 2/10
50000/50000 [==============================] - 269s 5ms/sample - loss: 1.6
862 - acc: 0.3815 - val_loss: 1.8009 - val_acc: 0.3622
Epoch 3/10
50000/50000 [==============================] - 269s 5ms/sample - loss: 1.5
389 - acc: 0.4382 - val_loss: 1.7920 - val_acc: 0.4283
Epoch 4/10
50000/50000 [==============================] - 269s 5ms/sample - loss: 1.4
265 - acc: 0.4839 - val_loss: 1.6365 - val_acc: 0.4426
Epoch 5/10
50000/50000 [==============================] - 269s 5ms/sample - loss: 1.3
483 - acc: 0.5146 - val_loss: 1.5748 - val_acc: 0.4719
Epoch 6/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.2
871 - acc: 0.5360 - val_loss: 1.4691 - val_acc: 0.4993
Epoch 7/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.2
317 - acc: 0.5591 - val_loss: 1.5214 - val_acc: 0.4985
Epoch 8/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 1.1
819 - acc: 0.5803 - val_loss: 1.5452 - val_acc: 0.5099
Epoch 9/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 1.1
379 - acc: 0.5932 - val_loss: 1.6148 - val_acc: 0.4963
Epoch 10/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 1.1
026 - acc: 0.6052 - val_loss: 1.5244 - val_acc: 0.5223
10000/10000 [==============================] - 20s 2ms/sample - loss: 1.52
44 - acc: 0.5223
Test loss: 1.5243553981781006
Test accuracy: 0.5223
```

In [0]:

```
final_tab.add_row(['Vertical_Horizantal_shift',1, num_filter, compression,'Adam',0.52])
```

DenseNet with Nadam Optimizer on Vertical Horizantal Shift

In [0]:

```
v_h_shift_model2_nadam = dense_net(v_h_shift_train,v_h_shift_test,optim=Nadam())
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 288s 6ms/sample - loss: 1.9
957 - acc: 0.2672 - val_loss: 2.0370 - val_acc: 0.2677
Epoch 2/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.6
974 - acc: 0.3788 - val_loss: 5.1156 - val_acc: 0.1736
Epoch 3/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.5
542 - acc: 0.4349 - val_loss: 1.7738 - val_acc: 0.3912
Epoch 4/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.4
505 - acc: 0.4729 - val_loss: 2.0385 - val_acc: 0.3929
Epoch 5/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.3
684 - acc: 0.5075 - val_loss: 1.6887 - val_acc: 0.4409
Epoch 6/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.3
042 - acc: 0.5300 - val_loss: 1.4545 - val_acc: 0.5053
Epoch 7/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.2
509 - acc: 0.5508 - val_loss: 1.8779 - val_acc: 0.4289
Epoch 8/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.2
035 - acc: 0.5672 - val_loss: 1.8281 - val_acc: 0.4424
Epoch 9/10
50000/50000 [==============================] - 270s 5ms/sample - loss: 1.1
597 - acc: 0.5850 - val_loss: 3.2673 - val_acc: 0.3621
Epoch 10/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 1.1
192 - acc: 0.6013 - val_loss: 1.4267 - val_acc: 0.5364
10000/10000 [==============================] - 19s 2ms/sample - loss: 1.42
67 - acc: 0.5364
Test loss: 1.426656289100647
Test accuracy: 0.5364
```

In [0]:

```
final_tab.add_row(['Vertical_Horizantal_shift',l, num_filter, compression,'Nadam',0.53
])
```

DenseNet with Adam Optimizer on Vertical Horizantal Flip

In [0]:

```
v_h_flip_model2 = dense_net(v_h_flip_xtrain,v_h_flip_xtest)
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 292s 6ms/sample - loss: 1.5
497 - acc: 0.4271 - val_loss: 2.2234 - val_acc: 0.3542
Epoch 2/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 1.1
109 - acc: 0.6005 - val_loss: 1.9077 - val_acc: 0.4839
Epoch 3/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.9
230 - acc: 0.6673 - val_loss: 1.4761 - val_acc: 0.5829
Epoch 4/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.8
136 - acc: 0.7084 - val_loss: 1.4341 - val_acc: 0.5631
Epoch 5/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.7
315 - acc: 0.7382 - val_loss: 1.2017 - val_acc: 0.6418
Epoch 6/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.6
601 - acc: 0.7642 - val_loss: 1.3863 - val_acc: 0.6156
Epoch 7/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.6
100 - acc: 0.7844 - val_loss: 0.9802 - val_acc: 0.7015
Epoch 8/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.5
659 - acc: 0.7992 - val_loss: 1.0941 - val_acc: 0.6696
Epoch 9/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.5
260 - acc: 0.8134 - val_loss: 0.8848 - val_acc: 0.7286
Epoch 10/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.4
873 - acc: 0.8256 - val_loss: 1.0112 - val_acc: 0.7244
10000/10000 [==============================] - 20s 2ms/sample - loss: 1.01
12 - acc: 0.7244
Test loss: 1.0111705540180207
Test accuracy: 0.7244
```

In [0]:

```
final_tab.add_row(['Vertical_Horizantal_flip',l, num_filter, compression,'Adam',0.72])
```

DenseNet with Nadam Optimizer on Vertical Horizantal Flip

In [0]:

```
v_h_flip_model2_nadam = dense_net(v_h_flip_xtrain,v_h_flip_xtest,optim=Nadam())
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 293s 6ms/sample - loss: 1.5
328 - acc: 0.4368 - val_loss: 1.8540 - val_acc: 0.3984
Epoch 2/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 1.0
911 - acc: 0.6057 - val_loss: 1.1753 - val_acc: 0.6160
Epoch 3/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.9
227 - acc: 0.6685 - val_loss: 1.1697 - val_acc: 0.6228
Epoch 4/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.8
073 - acc: 0.7112 - val_loss: 2.4143 - val_acc: 0.4619
Epoch 5/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.7
319 - acc: 0.7377 - val_loss: 1.4257 - val_acc: 0.6086
Epoch 6/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.6
665 - acc: 0.7597 - val_loss: 1.1833 - val_acc: 0.6594
Epoch 7/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.6
127 - acc: 0.7821 - val_loss: 1.2028 - val_acc: 0.6588
Epoch 8/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.5
698 - acc: 0.7967 - val_loss: 0.8314 - val_acc: 0.7259
Epoch 9/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.5
264 - acc: 0.8124 - val_loss: 0.8623 - val_acc: 0.7422
Epoch 10/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.4
910 - acc: 0.8264 - val_loss: 1.1797 - val_acc: 0.6763
10000/10000 [==============================] - 18s 2ms/sample - loss: 1.17
97 - acc: 0.6763
Test loss: 1.1797264897346496
Test accuracy: 0.6763
```

In [0]:

```
final_tab.add_row(['Vertical_Horizantal_flip',l, num_filter, compression,'Nadam',0.67])
```

DenseNet with Adam Optimizer on Brightness

In [0]:

```
bright_model2 = dense_net(bright_xtrain, bright_xtest)
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 262s 5ms/sample - loss: 1.3
957 - acc: 0.4889 - val_loss: 2.1067 - val_acc: 0.4403
Epoch 2/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.8
968 - acc: 0.6821 - val_loss: 1.0364 - val_acc: 0.6581
Epoch 3/10
50000/50000 [==============================] - 246s 5ms/sample - loss: 0.7
104 - acc: 0.7495 - val_loss: 0.9763 - val_acc: 0.6957
Epoch 4/10
50000/50000 [==============================] - 246s 5ms/sample - loss: 0.6
112 - acc: 0.7871 - val_loss: 1.1059 - val_acc: 0.6766
Epoch 5/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.5
337 - acc: 0.8115 - val_loss: 1.3122 - val_acc: 0.6740
Epoch 6/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.4
847 - acc: 0.8298 - val_loss: 1.0951 - val_acc: 0.7134
Epoch 7/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.4
338 - acc: 0.8492 - val_loss: 0.7656 - val_acc: 0.7695
Epoch 8/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.3
972 - acc: 0.8608 - val_loss: 0.9332 - val_acc: 0.7533
Epoch 9/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.3
658 - acc: 0.8720 - val_loss: 0.8406 - val_acc: 0.7652
Epoch 10/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.3
417 - acc: 0.8804 - val_loss: 0.7648 - val_acc: 0.7923
10000/10000 [==============================] - 15s 2ms/sample - loss: 0.76
48 - acc: 0.7923
Test loss: 0.7648081164598465
Test accuracy: 0.7923
```

In [0]:

```
final_tab.add_row(['Brightness',1, num_filter, compression,'Adam',0.79])
```

DenseNet with Nadam Optimizer on Brightness

In [0]:

```
bright_model2_nadam = dense_net(bright_xtrain, bright_xtest, optim=Nadam())
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 252s 5ms/sample - loss: 1.3
535 - acc: 0.5083 - val_loss: 2.6686 - val_acc: 0.3786
Epoch 2/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.8
746 - acc: 0.6905 - val_loss: 1.4745 - val_acc: 0.5859
Epoch 3/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.7
027 - acc: 0.7521 - val_loss: 1.2347 - val_acc: 0.6524
Epoch 4/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.6
028 - acc: 0.7891 - val_loss: 0.9355 - val_acc: 0.7102
Epoch 5/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.5
348 - acc: 0.8140 - val_loss: 0.7049 - val_acc: 0.7758
Epoch 6/10
50000/50000 [==============================] - 246s 5ms/sample - loss: 0.4
797 - acc: 0.8329 - val_loss: 0.8034 - val_acc: 0.7683
Epoch 7/10
50000/50000 [==============================] - 246s 5ms/sample - loss: 0.4
343 - acc: 0.8484 - val_loss: 1.1576 - val_acc: 0.6972
Epoch 8/10
50000/50000 [==============================] - 246s 5ms/sample - loss: 0.4
059 - acc: 0.8565 - val_loss: 0.6769 - val_acc: 0.8014
Epoch 9/10
50000/50000 [==============================] - 246s 5ms/sample - loss: 0.3
660 - acc: 0.8709 - val_loss: 0.9298 - val_acc: 0.7320
Epoch 10/10
50000/50000 [==============================] - 247s 5ms/sample - loss: 0.3
360 - acc: 0.8828 - val_loss: 1.2232 - val_acc: 0.7018
10000/10000 [==============================] - 15s 1ms/sample - loss: 1.22
32 - acc: 0.7018
Test loss: 1.2232139734268188
Test accuracy: 0.7018
```

In [0]:

```
final_tab.add_row(['Brightness',l, num_filter, compression,'Nadam',0.70])
```

DenseNet with Adam Optimizer on Standardized Data

In [0]:

```
stand_model2 = dense_net(stand_xtrain,stand_xtest)
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 290s 6ms/sample - loss: 1.3
630 - acc: 0.5059 - val_loss: 1.8054 - val_acc: 0.4663
Epoch 2/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.8
947 - acc: 0.6818 - val_loss: 2.0782 - val_acc: 0.5325
Epoch 3/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.7
168 - acc: 0.7482 - val_loss: 1.2432 - val_acc: 0.6331
Epoch 4/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.6
117 - acc: 0.7844 - val_loss: 1.6101 - val_acc: 0.6382
Epoch 5/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.5
369 - acc: 0.8114 - val_loss: 1.1828 - val_acc: 0.6678
Epoch 6/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.4
824 - acc: 0.8326 - val_loss: 0.9018 - val_acc: 0.7418
Epoch 7/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.4
367 - acc: 0.8485 - val_loss: 1.2826 - val_acc: 0.6894
Epoch 8/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.3
977 - acc: 0.8611 - val_loss: 0.7730 - val_acc: 0.7711
Epoch 9/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.3
629 - acc: 0.8738 - val_loss: 1.0036 - val_acc: 0.7356
Epoch 10/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.3
349 - acc: 0.8831 - val_loss: 0.8019 - val_acc: 0.7713
10000/10000 [==============================] - 19s 2ms/sample - loss: 0.80
19 - acc: 0.7713
Test loss: 0.8018832360267639
Test accuracy: 0.7713
```

In [0]:

```
final_tab.add_row(['Standardized',l, num_filter, compression,'Adam',0.77])
```

DenseNet with Nadam Optimizer on Standardized Data

In [0]:

```
stand_model2_nadam = dense_net(stand_xtrain,stand_xtest, optim = Nadam())
```

```
Train on 50000 samples, validate on 10000 samples
Epoch 1/10
50000/50000 [==============================] - 291s 6ms/sample - loss: 1.3
426 - acc: 0.5116 - val_loss: 1.8898 - val_acc: 0.4669
Epoch 2/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.8
734 - acc: 0.6906 - val_loss: 2.5935 - val_acc: 0.4521
Epoch 3/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.7
015 - acc: 0.7531 - val_loss: 1.2029 - val_acc: 0.6608
Epoch 4/10
50000/50000 [==============================] - 273s 5ms/sample - loss: 0.5
990 - acc: 0.7908 - val_loss: 1.4715 - val_acc: 0.6416
Epoch 5/10
50000/50000 [==============================] - 273s 5ms/sample - loss: 0.5
287 - acc: 0.8131 - val_loss: 0.6723 - val_acc: 0.7890
Epoch 6/10
50000/50000 [==============================] - 273s 5ms/sample - loss: 0.4
771 - acc: 0.8332 - val_loss: 2.1752 - val_acc: 0.5709
Epoch 7/10
50000/50000 [==============================] - 272s 5ms/sample - loss: 0.4
321 - acc: 0.8491 - val_loss: 0.9137 - val_acc: 0.7556
Epoch 8/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.3
960 - acc: 0.8619 - val_loss: 0.5650 - val_acc: 0.8256
Epoch 9/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.3
607 - acc: 0.8754 - val_loss: 0.7361 - val_acc: 0.7944
Epoch 10/10
50000/50000 [==============================] - 271s 5ms/sample - loss: 0.3
387 - acc: 0.8808 - val_loss: 0.6667 - val_acc: 0.8088
10000/10000 [==============================] - 20s 2ms/sample - loss: 0.66
67 - acc: 0.8088
Test loss: 0.6666583400726318
Test accuracy: 0.8088
```

In [0]:

```
final_tab.add_row(['Standardized',l, num_filter, compression,'Nadam',0.80])
```

In [0]:

```
print(final_tab)
```

```
+---------------------------+----+-------------+-------------+-----------+
---------------+
|        Augmentation       | l  | num_filters | compression | Optimizer |
Test Accuracy |
+---------------------------+----+-------------+-------------+-----------+
---------------+
|            None           | 12 |      12     |     0.5     |    Adam   |
0.59        |
| Vertical_Horizantal_Shift | 12 |      12     |     0.5     |    Adam   |
0.41        |
| Vertical_Horizantal_Shift | 12 |      12     |     0.5     |   Nadam   |
0.409       |
|  Vertical_Horizantal_Flip | 12 |      12     |     0.5     |    Adam   |
0.604       |
|  Vertical_Horizantal_Flip | 12 |      12     |     0.5     |   Nadam   |
0.61        |
|         Brightness        | 12 |      12     |     0.5     |    Adam   |
0.66        |
|         Brightness        | 12 |      12     |     0.5     |   Nadam   |
0.67        |
|        Standardized       | 12 |      12     |     0.5     |    Adam   |
0.63        |
|        Standardized       | 12 |      12     |     0.5     |   Nadam   |
0.63        |
| Vertical_Horizantal_shift | 8  |      38     |      1      |    Adam   |
0.52        |
| Vertical_Horizantal_shift | 8  |      38     |      1      |   Nadam   |
0.53        |
|  Vertical_Horizantal_flip | 8  |      38     |      1      |    Adam   |
0.72        |
|  Vertical_Horizantal_flip | 8  |      38     |      1      |   Nadam   |
0.67        |
|         Brightness        | 8  |      38     |      1      |    Adam   |
0.79        |
|         Brightness        | 8  |      38     |      1      |   Nadam   |
0.7         |
|        Standardized       | 8  |      38     |      1      |    Adam   |
0.77        |
|        Standardized       | 8  |      38     |      1      |   Nadam   |
0.8         |
+---------------------------+----+-------------+-------------+-----------+
---------------+
```

Observations:

If we observe the test accuracy when l =8, no_filters = 38, compression = 1 is higher so we shall use these changed parameters

We shall add the image augmentation which influenced the test accuracy lot i.e brightness,standardization, flipping

In [0]:

```

```

In [11]:

```
%%time

datagen = ImageDataGenerator(

    brightness_range=[0.5,1.9],
    featurewise_center=True, featurewise_std_normalization=True,
    width_shift_range = 0.125,
    horizontal_flip=True,vertical_flip=True,rotation_range=15,
    fill_mode='nearest'
)
```

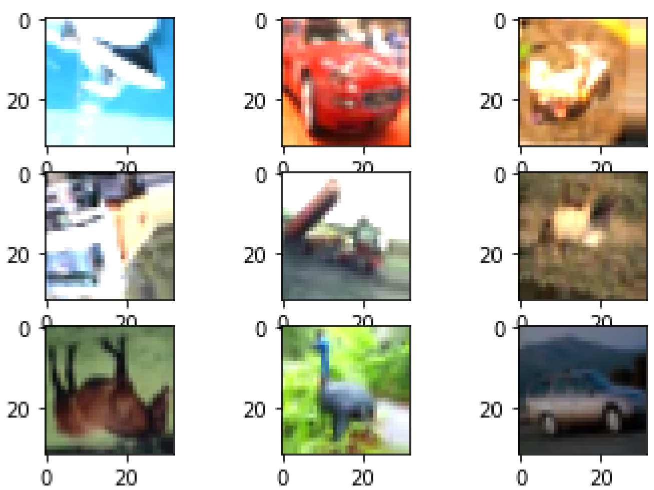
```
CPU times: user 178 µs, sys: 35 µs, total: 213 µs
Wall time: 218 µs
```

In [0]:

```
for X_batch, y_batch in datagen.flow(X_train[:9], y_train[:9], batch_size=9):
    for i in range(0, 9):
        plt.subplot(330 + 1 + i)

        plt.imshow(X_batch[i].astype('uint8'), cmap=plt.get_cmap('prism'))
    plt.show()
    break
```

```
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:716: UserWarning: This ImageDataGenerator specifies `featur
ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:724: UserWarning: This ImageDataGenerator specifies `featur
ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
```



In [0]:

```
1
```

In [0]:

```
def dense_net2(xtrain,xtest, optim = Adam(),k_size=(3,3), b_size = batch_size, epoch =
epochs):
          print('b_size:{} epochs:{} '.format(b_size,epoch))
          input = layers.Input(shape=(img_height, img_width, channel,))
          First_Conv2D = layers.Conv2D(num_filter, (3,3), use_bias=False ,padding='sam
e')(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)


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

          reduce_lr = ReduceLROnPlateau(monitor = 'val_loss', factor = 0.1, patience =
5, min_lr = 0.000001)

          # early_stop = EarlyStopping(monitor = "val_loss", patience = 10)

          def decay_fn(epoch, lr):
              if epoch < 50:
                  return 0.001
              elif epoch >= 50 and epoch < 75:
                  return 0.0001
              else:
                  return 0.00001

          lr_scheduler = LearningRateScheduler(decay_fn)

          csv_logger = CSVLogger('training.log')




          checkpoint = ModelCheckpoint('gdrive/My Drive/cnnoncifar/models/model-{epoch:
03d}-{acc:03f}-{val_acc:03f}.h5',
                                       verbose=1, monitor='val_acc',save_best_only=True
, mode='auto')




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

          # model.fit(xtrain, y_train,
          #                     batch_size=batch_size,
          #                     epochs=epochs,
          #                     verbose=1,
          #                     validation_data=(xtest, y_test))
```

```
        print(model.summary())
        model.fit_generator(
          datagen.flow(xtrain, y_train, batch_size=b_size),
          steps_per_epoch=(len(xtrain)/batch_size)*5,
          epochs=epoch,
          verbose = 1,
          validation_data=(xtest, y_test),callbacks=[checkpoint])



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

        return model
```

In [0]:

```
# l = 8
# num_filter = 27
compression = 1.041
#
#


# no of layers in dense block
l = 9
# growth rate k
num_filter = 24
```

In [0]:

```
model = dense_net2(X_train,X_test,epoch=150)
```

```
b_size:128 epochs:150
input (?, 4, 4, 240)
Batch (?, 4, 4, 240)
relu (?, 4, 4, 240)
Model: "model_2"
__________________________________________________________________________
________________________
Layer (type)                    Output Shape         Param #     Connected
to
==========================================================================
========================
input_3 (InputLayer)            [(None, 32, 32, 3)]  0
__________________________________________________________________________
________________________
conv2d_82 (Conv2D)              (None, 32, 32, 24)   648         input_3
[0][0]
__________________________________________________________________________
________________________
batch_normalization_80 (BatchNo (None, 32, 32, 24)   96          conv2d_82
[0][0]
__________________________________________________________________________
________________________
activation_82 (Activation)      (None, 32, 32, 24)   0           batch_nor
malization_80[0][0]
__________________________________________________________________________
________________________
conv2d_83 (Conv2D)              (None, 32, 32, 24)   5184        activatio
n_82[0][0]
__________________________________________________________________________
________________________
dropout_78 (Dropout)            (None, 32, 32, 24)   0           conv2d_83
[0][0]
__________________________________________________________________________
________________________
concatenate_72 (Concatenate)    (None, 32, 32, 48)   0           conv2d_82
[0][0]
                                                                 dropout_7
8[0][0]
__________________________________________________________________________
________________________
batch_normalization_81 (BatchNo (None, 32, 32, 48)   192         concatena
te_72[0][0]
__________________________________________________________________________
________________________
activation_83 (Activation)      (None, 32, 32, 48)   0           batch_nor
malization_81[0][0]
__________________________________________________________________________
________________________
conv2d_84 (Conv2D)              (None, 32, 32, 24)   10368       activatio
n_83[0][0]
__________________________________________________________________________
________________________
dropout_79 (Dropout)            (None, 32, 32, 24)   0           conv2d_84
[0][0]
__________________________________________________________________________
________________________
concatenate_73 (Concatenate)    (None, 32, 32, 72)   0           concatena
te_72[0][0]
                                                                 dropout_7
9[0][0]
__________________________________________________________________________
```

```
________________________
batch_normalization_82 (BatchNo (None, 32, 32, 72)   288         concatena
te_73[0][0]
__________________________________________________________________________
________________________
activation_84 (Activation)      (None, 32, 32, 72)   0           batch_nor
malization_82[0][0]
__________________________________________________________________________
________________________
conv2d_85 (Conv2D)              (None, 32, 32, 24)   15552       activatio
n_84[0][0]
__________________________________________________________________________
________________________
dropout_80 (Dropout)            (None, 32, 32, 24)   0           conv2d_85
[0][0]
__________________________________________________________________________
________________________
concatenate_74 (Concatenate)    (None, 32, 32, 96)   0           concatena
te_73[0][0]
                                                                 dropout_8
0[0][0]
__________________________________________________________________________
________________________
batch_normalization_83 (BatchNo (None, 32, 32, 96)   384         concatena
te_74[0][0]
__________________________________________________________________________
________________________
activation_85 (Activation)      (None, 32, 32, 96)   0           batch_nor
malization_83[0][0]
__________________________________________________________________________
________________________
conv2d_86 (Conv2D)              (None, 32, 32, 24)   20736       activatio
n_85[0][0]
__________________________________________________________________________
________________________
dropout_81 (Dropout)            (None, 32, 32, 24)   0           conv2d_86
[0][0]
__________________________________________________________________________
________________________
concatenate_75 (Concatenate)    (None, 32, 32, 120)  0           concatena
te_74[0][0]
                                                                 dropout_8
1[0][0]
__________________________________________________________________________
________________________
batch_normalization_84 (BatchNo (None, 32, 32, 120)  480         concatena
te_75[0][0]
__________________________________________________________________________
________________________
activation_86 (Activation)      (None, 32, 32, 120)  0           batch_nor
malization_84[0][0]
__________________________________________________________________________
________________________
conv2d_87 (Conv2D)              (None, 32, 32, 24)   25920       activatio
n_86[0][0]
__________________________________________________________________________
________________________
dropout_82 (Dropout)            (None, 32, 32, 24)   0           conv2d_87
[0][0]
__________________________________________________________________________
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concatenate_76 (Concatenate)    (None, 32, 32, 144)  0           concatena
te_75[0][0]
                                                                 dropout_8
2[0][0]
__________________________________________________________________________
________________________
batch_normalization_85 (BatchNo (None, 32, 32, 144)  576         concatena
te_76[0][0]
__________________________________________________________________________
________________________
activation_87 (Activation)      (None, 32, 32, 144)  0           batch_nor
malization_85[0][0]
__________________________________________________________________________
________________________
conv2d_88 (Conv2D)              (None, 32, 32, 24)   31104       activatio
n_87[0][0]
__________________________________________________________________________
________________________
dropout_83 (Dropout)            (None, 32, 32, 24)   0           conv2d_88
[0][0]
__________________________________________________________________________
________________________
concatenate_77 (Concatenate)    (None, 32, 32, 168)  0           concatena
te_76[0][0]
                                                                 dropout_8
3[0][0]
__________________________________________________________________________
________________________
batch_normalization_86 (BatchNo (None, 32, 32, 168)  672         concatena
te_77[0][0]
__________________________________________________________________________
________________________
activation_88 (Activation)      (None, 32, 32, 168)  0           batch_nor
malization_86[0][0]
__________________________________________________________________________
________________________
conv2d_89 (Conv2D)              (None, 32, 32, 24)   36288       activatio
n_88[0][0]
__________________________________________________________________________
________________________
dropout_84 (Dropout)            (None, 32, 32, 24)   0           conv2d_89
[0][0]
__________________________________________________________________________
________________________
concatenate_78 (Concatenate)    (None, 32, 32, 192)  0           concatena
te_77[0][0]
                                                                 dropout_8
4[0][0]
__________________________________________________________________________
________________________
batch_normalization_87 (BatchNo (None, 32, 32, 192)  768         concatena
te_78[0][0]
__________________________________________________________________________
________________________
activation_89 (Activation)      (None, 32, 32, 192)  0           batch_nor
malization_87[0][0]
__________________________________________________________________________
________________________
conv2d_90 (Conv2D)              (None, 32, 32, 24)   41472       activatio
n_89[0][0]
__________________________________________________________________________
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______________________________
dropout_85 (Dropout)           (None, 32, 32, 24)   0           conv2d_90
[0][0]
__________________________________________________________________________________________
______________________________
concatenate_79 (Concatenate)   (None, 32, 32, 216)  0           concatena
te_78[0][0]
                                                                dropout_8
5[0][0]
__________________________________________________________________________________________
______________________________
batch_normalization_88 (BatchNo (None, 32, 32, 216)  864         concatena
te_79[0][0]
__________________________________________________________________________________________
______________________________
activation_90 (Activation)     (None, 32, 32, 216)  0           batch_nor
malization_88[0][0]
__________________________________________________________________________________________
______________________________
conv2d_91 (Conv2D)             (None, 32, 32, 24)   46656       activatio
n_90[0][0]
__________________________________________________________________________________________
______________________________
dropout_86 (Dropout)           (None, 32, 32, 24)   0           conv2d_91
[0][0]
__________________________________________________________________________________________
______________________________
concatenate_80 (Concatenate)   (None, 32, 32, 240)  0           concatena
te_79[0][0]
                                                                dropout_8
6[0][0]
__________________________________________________________________________________________
______________________________
batch_normalization_89 (BatchNo (None, 32, 32, 240)  960         concatena
te_80[0][0]
__________________________________________________________________________________________
______________________________
activation_91 (Activation)     (None, 32, 32, 240)  0           batch_nor
malization_89[0][0]
__________________________________________________________________________________________
______________________________
conv2d_92 (Conv2D)             (None, 32, 32, 24)   5760        activatio
n_91[0][0]
__________________________________________________________________________________________
______________________________
dropout_87 (Dropout)           (None, 32, 32, 24)   0           conv2d_92
[0][0]
__________________________________________________________________________________________
______________________________
average_pooling2d_8 (AveragePoo (None, 16, 16, 24)   0           dropout_8
7[0][0]
__________________________________________________________________________________________
______________________________
batch_normalization_90 (BatchNo (None, 16, 16, 24)   96          average_p
ooling2d_8[0][0]
__________________________________________________________________________________________
______________________________
activation_92 (Activation)     (None, 16, 16, 24)   0           batch_nor
malization_90[0][0]
__________________________________________________________________________________________
______________________________
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conv2d_93 (Conv2D)              (None, 16, 16, 24)   5184        activatio
n_92[0][0]
__________________________________________________________________________
________________________
dropout_88 (Dropout)            (None, 16, 16, 24)   0           conv2d_93
[0][0]
__________________________________________________________________________
________________________
concatenate_81 (Concatenate)    (None, 16, 16, 48)   0           average_p
ooling2d_8[0][0]
                                                                 dropout_8
8[0][0]
__________________________________________________________________________
________________________
batch_normalization_91 (BatchNo (None, 16, 16, 48)   192         concatena
te_81[0][0]
__________________________________________________________________________
________________________
activation_93 (Activation)      (None, 16, 16, 48)   0           batch_nor
malization_91[0][0]
__________________________________________________________________________
________________________
conv2d_94 (Conv2D)              (None, 16, 16, 24)   10368       activatio
n_93[0][0]
__________________________________________________________________________
________________________
dropout_89 (Dropout)            (None, 16, 16, 24)   0           conv2d_94
[0][0]
__________________________________________________________________________
________________________
concatenate_82 (Concatenate)    (None, 16, 16, 72)   0           concatena
te_81[0][0]
                                                                 dropout_8
9[0][0]
__________________________________________________________________________
________________________
batch_normalization_92 (BatchNo (None, 16, 16, 72)   288         concatena
te_82[0][0]
__________________________________________________________________________
________________________
activation_94 (Activation)      (None, 16, 16, 72)   0           batch_nor
malization_92[0][0]
__________________________________________________________________________
________________________
conv2d_95 (Conv2D)              (None, 16, 16, 24)   15552       activatio
n_94[0][0]
__________________________________________________________________________
________________________
dropout_90 (Dropout)            (None, 16, 16, 24)   0           conv2d_95
[0][0]
__________________________________________________________________________
________________________
concatenate_83 (Concatenate)    (None, 16, 16, 96)   0           concatena
te_82[0][0]
                                                                 dropout_9
0[0][0]
__________________________________________________________________________
________________________
batch_normalization_93 (BatchNo (None, 16, 16, 96)   384         concatena
te_83[0][0]
__________________________________________________________________________
```

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________________________________
activation_95 (Activation)      (None, 16, 16, 96)   0           batch_nor
malization_93[0][0]
__________________________________________________________________________
________________________________
conv2d_96 (Conv2D)              (None, 16, 16, 24)   20736       activatio
n_95[0][0]
__________________________________________________________________________
________________________________
dropout_91 (Dropout)            (None, 16, 16, 24)   0           conv2d_96
[0][0]
__________________________________________________________________________
________________________________
concatenate_84 (Concatenate)    (None, 16, 16, 120)  0           concatena
te_83[0][0]
                                                                 dropout_9
1[0][0]
__________________________________________________________________________
________________________________
batch_normalization_94 (BatchNo (None, 16, 16, 120)  480         concatena
te_84[0][0]
__________________________________________________________________________
________________________________
activation_96 (Activation)      (None, 16, 16, 120)  0           batch_nor
malization_94[0][0]
__________________________________________________________________________
________________________________
conv2d_97 (Conv2D)              (None, 16, 16, 24)   25920       activatio
n_96[0][0]
__________________________________________________________________________
________________________________
dropout_92 (Dropout)            (None, 16, 16, 24)   0           conv2d_97
[0][0]
__________________________________________________________________________
________________________________
concatenate_85 (Concatenate)    (None, 16, 16, 144)  0           concatena
te_84[0][0]
                                                                 dropout_9
2[0][0]
__________________________________________________________________________
________________________________
batch_normalization_95 (BatchNo (None, 16, 16, 144)  576         concatena
te_85[0][0]
__________________________________________________________________________
________________________________
activation_97 (Activation)      (None, 16, 16, 144)  0           batch_nor
malization_95[0][0]
__________________________________________________________________________
________________________________
conv2d_98 (Conv2D)              (None, 16, 16, 24)   31104       activatio
n_97[0][0]
__________________________________________________________________________
________________________________
dropout_93 (Dropout)            (None, 16, 16, 24)   0           conv2d_98
[0][0]
__________________________________________________________________________
________________________________
concatenate_86 (Concatenate)    (None, 16, 16, 168)  0           concatena
te_85[0][0]
                                                                 dropout_9
3[0][0]
```

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__________________________________________________________________________________________________
batch_normalization_96 (BatchNo (None, 16, 16, 168)  672         concatena
te_86[0][0]
__________________________________________________________________________________________________
activation_98 (Activation)      (None, 16, 16, 168)  0           batch_nor
malization_96[0][0]
__________________________________________________________________________________________________
conv2d_99 (Conv2D)              (None, 16, 16, 24)   36288       activatio
n_98[0][0]
__________________________________________________________________________________________________
dropout_94 (Dropout)            (None, 16, 16, 24)   0           conv2d_99
[0][0]
__________________________________________________________________________________________________
concatenate_87 (Concatenate)    (None, 16, 16, 192)  0           concatena
te_86[0][0]
                                                                 dropout_9
4[0][0]
__________________________________________________________________________________________________
batch_normalization_97 (BatchNo (None, 16, 16, 192)  768         concatena
te_87[0][0]
__________________________________________________________________________________________________
activation_99 (Activation)      (None, 16, 16, 192)  0           batch_nor
malization_97[0][0]
__________________________________________________________________________________________________
conv2d_100 (Conv2D)             (None, 16, 16, 24)   41472       activatio
n_99[0][0]
__________________________________________________________________________________________________
dropout_95 (Dropout)            (None, 16, 16, 24)   0           conv2d_10
0[0][0]
__________________________________________________________________________________________________
concatenate_88 (Concatenate)    (None, 16, 16, 216)  0           concatena
te_87[0][0]
                                                                 dropout_9
5[0][0]
__________________________________________________________________________________________________
batch_normalization_98 (BatchNo (None, 16, 16, 216)  864         concatena
te_88[0][0]
__________________________________________________________________________________________________
activation_100 (Activation)     (None, 16, 16, 216)  0           batch_nor
malization_98[0][0]
__________________________________________________________________________________________________
conv2d_101 (Conv2D)             (None, 16, 16, 24)   46656       activatio
n_100[0][0]
__________________________________________________________________________________________________
dropout_96 (Dropout)            (None, 16, 16, 24)   0           conv2d_10
1[0][0]
__________________________________________________________________________________________________
```

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________________________________
concatenate_89 (Concatenate)    (None, 16, 16, 240)  0           concatena
te_88[0][0]
                                                                 dropout_9
6[0][0]
__________________________________________________________________________
________________________________
batch_normalization_99 (BatchNo (None, 16, 16, 240)  960         concatena
te_89[0][0]
__________________________________________________________________________
________________________________
activation_101 (Activation)     (None, 16, 16, 240)  0           batch_nor
malization_99[0][0]
__________________________________________________________________________
________________________________
conv2d_102 (Conv2D)             (None, 16, 16, 24)   5760        activatio
n_101[0][0]
__________________________________________________________________________
________________________________
dropout_97 (Dropout)            (None, 16, 16, 24)   0           conv2d_10
2[0][0]
__________________________________________________________________________
________________________________
average_pooling2d_9 (AveragePoo (None, 8, 8, 24)     0           dropout_9
7[0][0]
__________________________________________________________________________
________________________________
batch_normalization_100 (BatchN (None, 8, 8, 24)     96          average_p
ooling2d_9[0][0]
__________________________________________________________________________
________________________________
activation_102 (Activation)     (None, 8, 8, 24)     0           batch_nor
malization_100[0][0]
__________________________________________________________________________
________________________________
conv2d_103 (Conv2D)             (None, 8, 8, 24)     5184        activatio
n_102[0][0]
__________________________________________________________________________
________________________________
dropout_98 (Dropout)            (None, 8, 8, 24)     0           conv2d_10
3[0][0]
__________________________________________________________________________
________________________________
concatenate_90 (Concatenate)    (None, 8, 8, 48)     0           average_p
ooling2d_9[0][0]
                                                                 dropout_9
8[0][0]
__________________________________________________________________________
________________________________
batch_normalization_101 (BatchN (None, 8, 8, 48)     192         concatena
te_90[0][0]
__________________________________________________________________________
________________________________
activation_103 (Activation)     (None, 8, 8, 48)     0           batch_nor
malization_101[0][0]
__________________________________________________________________________
________________________________
conv2d_104 (Conv2D)             (None, 8, 8, 24)     10368       activatio
n_103[0][0]
__________________________________________________________________________
________________________________
```

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dropout_99 (Dropout)            (None, 8, 8, 24)     0           conv2d_10
4[0][0]
__________________________________________________________________________________________________
concatenate_91 (Concatenate)    (None, 8, 8, 72)     0           concatena
te_90[0][0]
                                                                 dropout_9
9[0][0]
__________________________________________________________________________________________________
batch_normalization_102 (BatchN (None, 8, 8, 72)     288         concatena
te_91[0][0]
__________________________________________________________________________________________________
activation_104 (Activation)     (None, 8, 8, 72)     0           batch_nor
malization_102[0][0]
__________________________________________________________________________________________________
conv2d_105 (Conv2D)             (None, 8, 8, 24)     15552       activatio
n_104[0][0]
__________________________________________________________________________________________________
dropout_100 (Dropout)           (None, 8, 8, 24)     0           conv2d_10
5[0][0]
__________________________________________________________________________________________________
concatenate_92 (Concatenate)    (None, 8, 8, 96)     0           concatena
te_91[0][0]
                                                                 dropout_1
00[0][0]
__________________________________________________________________________________________________
batch_normalization_103 (BatchN (None, 8, 8, 96)     384         concatena
te_92[0][0]
__________________________________________________________________________________________________
activation_105 (Activation)     (None, 8, 8, 96)     0           batch_nor
malization_103[0][0]
__________________________________________________________________________________________________
conv2d_106 (Conv2D)             (None, 8, 8, 24)     20736       activatio
n_105[0][0]
__________________________________________________________________________________________________
dropout_101 (Dropout)           (None, 8, 8, 24)     0           conv2d_10
6[0][0]
__________________________________________________________________________________________________
concatenate_93 (Concatenate)    (None, 8, 8, 120)    0           concatena
te_92[0][0]
                                                                 dropout_1
01[0][0]
__________________________________________________________________________________________________
batch_normalization_104 (BatchN (None, 8, 8, 120)    480         concatena
te_93[0][0]
__________________________________________________________________________________________________
activation_106 (Activation)     (None, 8, 8, 120)    0           batch_nor
malization_104[0][0]
__________________________________________________________________________________________________
```

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________________________________
conv2d_107 (Conv2D)             (None, 8, 8, 24)     25920       activatio
n_106[0][0]
__________________________________________________________________________________________________
dropout_102 (Dropout)           (None, 8, 8, 24)     0           conv2d_10
7[0][0]
__________________________________________________________________________________________________
concatenate_94 (Concatenate)    (None, 8, 8, 144)    0           concatena
te_93[0][0]
                                                                 dropout_1
02[0][0]
__________________________________________________________________________________________________
batch_normalization_105 (BatchN (None, 8, 8, 144)    576         concatena
te_94[0][0]
__________________________________________________________________________________________________
activation_107 (Activation)     (None, 8, 8, 144)    0           batch_nor
malization_105[0][0]
__________________________________________________________________________________________________
conv2d_108 (Conv2D)             (None, 8, 8, 24)     31104       activatio
n_107[0][0]
__________________________________________________________________________________________________
dropout_103 (Dropout)           (None, 8, 8, 24)     0           conv2d_10
8[0][0]
__________________________________________________________________________________________________
concatenate_95 (Concatenate)    (None, 8, 8, 168)    0           concatena
te_94[0][0]
                                                                 dropout_1
03[0][0]
__________________________________________________________________________________________________
batch_normalization_106 (BatchN (None, 8, 8, 168)    672         concatena
te_95[0][0]
__________________________________________________________________________________________________
activation_108 (Activation)     (None, 8, 8, 168)    0           batch_nor
malization_106[0][0]
__________________________________________________________________________________________________
conv2d_109 (Conv2D)             (None, 8, 8, 24)     36288       activatio
n_108[0][0]
__________________________________________________________________________________________________
dropout_104 (Dropout)           (None, 8, 8, 24)     0           conv2d_10
9[0][0]
__________________________________________________________________________________________________
concatenate_96 (Concatenate)    (None, 8, 8, 192)    0           concatena
te_95[0][0]
                                                                 dropout_1
04[0][0]
__________________________________________________________________________________________________
batch_normalization_107 (BatchN (None, 8, 8, 192)    768         concatena
te_96[0][0]
```

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________________________________________________________________________________
__________________________________
activation_109 (Activation)     (None, 8, 8, 192)    0           batch_nor
malization_107[0][0]
________________________________________________________________________________
__________________________________
conv2d_110 (Conv2D)             (None, 8, 8, 24)     41472       activatio
n_109[0][0]
________________________________________________________________________________
__________________________________
dropout_105 (Dropout)           (None, 8, 8, 24)     0           conv2d_11
0[0][0]
________________________________________________________________________________
__________________________________
concatenate_97 (Concatenate)    (None, 8, 8, 216)    0           concatena
te_96[0][0]
                                                                 dropout_1
05[0][0]
________________________________________________________________________________
__________________________________
batch_normalization_108 (BatchN (None, 8, 8, 216)    864         concatena
te_97[0][0]
________________________________________________________________________________
__________________________________
activation_110 (Activation)     (None, 8, 8, 216)    0           batch_nor
malization_108[0][0]
________________________________________________________________________________
__________________________________
conv2d_111 (Conv2D)             (None, 8, 8, 24)     46656       activatio
n_110[0][0]
________________________________________________________________________________
__________________________________
dropout_106 (Dropout)           (None, 8, 8, 24)     0           conv2d_11
1[0][0]
________________________________________________________________________________
__________________________________
concatenate_98 (Concatenate)    (None, 8, 8, 240)    0           concatena
te_97[0][0]
                                                                 dropout_1
06[0][0]
________________________________________________________________________________
__________________________________
batch_normalization_109 (BatchN (None, 8, 8, 240)    960         concatena
te_98[0][0]
________________________________________________________________________________
__________________________________
activation_111 (Activation)     (None, 8, 8, 240)    0           batch_nor
malization_109[0][0]
________________________________________________________________________________
__________________________________
conv2d_112 (Conv2D)             (None, 8, 8, 24)     5760        activatio
n_111[0][0]
________________________________________________________________________________
__________________________________
dropout_107 (Dropout)           (None, 8, 8, 24)     0           conv2d_11
2[0][0]
________________________________________________________________________________
__________________________________
average_pooling2d_10 (AveragePo (None, 4, 4, 24)     0           dropout_1
07[0][0]
________________________________________________________________________________
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________________________________
batch_normalization_110 (BatchN (None, 4, 4, 24)     96          average_p
ooling2d_10[0][0]
__________________________________________________________________________
________________________________
activation_112 (Activation)     (None, 4, 4, 24)     0           batch_nor
malization_110[0][0]
__________________________________________________________________________
________________________________
conv2d_113 (Conv2D)             (None, 4, 4, 24)     5184        activatio
n_112[0][0]
__________________________________________________________________________
________________________________
dropout_108 (Dropout)           (None, 4, 4, 24)     0           conv2d_11
3[0][0]
__________________________________________________________________________
________________________________
concatenate_99 (Concatenate)    (None, 4, 4, 48)     0           average_p
ooling2d_10[0][0]
                                                                 dropout_1
08[0][0]
__________________________________________________________________________
________________________________
batch_normalization_111 (BatchN (None, 4, 4, 48)     192         concatena
te_99[0][0]
__________________________________________________________________________
________________________________
activation_113 (Activation)     (None, 4, 4, 48)     0           batch_nor
malization_111[0][0]
__________________________________________________________________________
________________________________
conv2d_114 (Conv2D)             (None, 4, 4, 24)     10368       activatio
n_113[0][0]
__________________________________________________________________________
________________________________
dropout_109 (Dropout)           (None, 4, 4, 24)     0           conv2d_11
4[0][0]
__________________________________________________________________________
________________________________
concatenate_100 (Concatenate)   (None, 4, 4, 72)     0           concatena
te_99[0][0]
                                                                 dropout_1
09[0][0]
__________________________________________________________________________
________________________________
batch_normalization_112 (BatchN (None, 4, 4, 72)     288         concatena
te_100[0][0]
__________________________________________________________________________
________________________________
activation_114 (Activation)     (None, 4, 4, 72)     0           batch_nor
malization_112[0][0]
__________________________________________________________________________
________________________________
conv2d_115 (Conv2D)             (None, 4, 4, 24)     15552       activatio
n_114[0][0]
__________________________________________________________________________
________________________________
dropout_110 (Dropout)           (None, 4, 4, 24)     0           conv2d_11
5[0][0]
__________________________________________________________________________
________________________________
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concatenate_101 (Concatenate)   (None, 4, 4, 96)     0           concatena
te_100[0][0]
                                                                 dropout_1
10[0][0]
__________________________________________________________________________
________________________
batch_normalization_113 (BatchN (None, 4, 4, 96)     384         concatena
te_101[0][0]
__________________________________________________________________________
________________________
activation_115 (Activation)     (None, 4, 4, 96)     0           batch_nor
malization_113[0][0]
__________________________________________________________________________
________________________
conv2d_116 (Conv2D)             (None, 4, 4, 24)     20736       activatio
n_115[0][0]
__________________________________________________________________________
________________________
dropout_111 (Dropout)           (None, 4, 4, 24)     0           conv2d_11
6[0][0]
__________________________________________________________________________
________________________
concatenate_102 (Concatenate)   (None, 4, 4, 120)    0           concatena
te_101[0][0]
                                                                 dropout_1
11[0][0]
__________________________________________________________________________
________________________
batch_normalization_114 (BatchN (None, 4, 4, 120)    480         concatena
te_102[0][0]
__________________________________________________________________________
________________________
activation_116 (Activation)     (None, 4, 4, 120)    0           batch_nor
malization_114[0][0]
__________________________________________________________________________
________________________
conv2d_117 (Conv2D)             (None, 4, 4, 24)     25920       activatio
n_116[0][0]
__________________________________________________________________________
________________________
dropout_112 (Dropout)           (None, 4, 4, 24)     0           conv2d_11
7[0][0]
__________________________________________________________________________
________________________
concatenate_103 (Concatenate)   (None, 4, 4, 144)    0           concatena
te_102[0][0]
                                                                 dropout_1
12[0][0]
__________________________________________________________________________
________________________
batch_normalization_115 (BatchN (None, 4, 4, 144)    576         concatena
te_103[0][0]
__________________________________________________________________________
________________________
activation_117 (Activation)     (None, 4, 4, 144)    0           batch_nor
malization_115[0][0]
__________________________________________________________________________
________________________
conv2d_118 (Conv2D)             (None, 4, 4, 24)     31104       activatio
n_117[0][0]
__________________________________________________________________________
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________________________________
dropout_113 (Dropout)           (None, 4, 4, 24)     0           conv2d_11
8[0][0]
__________________________________________________________________________
________________________________
concatenate_104 (Concatenate)   (None, 4, 4, 168)    0           concatena
te_103[0][0]
                                                                 dropout_1
13[0][0]
__________________________________________________________________________
________________________________
batch_normalization_116 (BatchN (None, 4, 4, 168)    672         concatena
te_104[0][0]
__________________________________________________________________________
________________________________
activation_118 (Activation)     (None, 4, 4, 168)    0           batch_nor
malization_116[0][0]
__________________________________________________________________________
________________________________
conv2d_119 (Conv2D)             (None, 4, 4, 24)     36288       activatio
n_118[0][0]
__________________________________________________________________________
________________________________
dropout_114 (Dropout)           (None, 4, 4, 24)     0           conv2d_11
9[0][0]
__________________________________________________________________________
________________________________
concatenate_105 (Concatenate)   (None, 4, 4, 192)    0           concatena
te_104[0][0]
                                                                 dropout_1
14[0][0]
__________________________________________________________________________
________________________________
batch_normalization_117 (BatchN (None, 4, 4, 192)    768         concatena
te_105[0][0]
__________________________________________________________________________
________________________________
activation_119 (Activation)     (None, 4, 4, 192)    0           batch_nor
malization_117[0][0]
__________________________________________________________________________
________________________________
conv2d_120 (Conv2D)             (None, 4, 4, 24)     41472       activatio
n_119[0][0]
__________________________________________________________________________
________________________________
dropout_115 (Dropout)           (None, 4, 4, 24)     0           conv2d_12
0[0][0]
__________________________________________________________________________
________________________________
concatenate_106 (Concatenate)   (None, 4, 4, 216)    0           concatena
te_105[0][0]
                                                                 dropout_1
15[0][0]
__________________________________________________________________________
________________________________
batch_normalization_118 (BatchN (None, 4, 4, 216)    864         concatena
te_106[0][0]
__________________________________________________________________________
________________________________
activation_120 (Activation)     (None, 4, 4, 216)    0           batch_nor
malization_118[0][0]
```

```
________________________________________________________________________________
________________________
conv2d_121 (Conv2D)             (None, 4, 4, 24)     46656       activatio
n_120[0][0]
________________________________________________________________________________
________________________
dropout_116 (Dropout)           (None, 4, 4, 24)     0           conv2d_12
1[0][0]
________________________________________________________________________________
________________________
concatenate_107 (Concatenate)   (None, 4, 4, 240)    0           concatena
te_106[0][0]
                                                                 dropout_1
16[0][0]
________________________________________________________________________________
________________________
batch_normalization_119 (BatchN (None, 4, 4, 240)    960         concatena
te_107[0][0]
________________________________________________________________________________
________________________
activation_121 (Activation)     (None, 4, 4, 240)    0           batch_nor
malization_119[0][0]
________________________________________________________________________________
________________________
average_pooling2d_11 (AveragePo (None, 2, 2, 240)    0           activatio
n_121[0][0]
________________________________________________________________________________
________________________
conv2d_122 (Conv2D)             (None, 2, 2, 10)     2400        average_p
ooling2d_11[0][0]
________________________________________________________________________________
________________________
global_max_pooling2d_2 (GlobalM (None, 10)           0           conv2d_12
2[0][0]
________________________________________________________________________________
________________________
activation_122 (Activation)     (None, 10)           0           global_ma
x_pooling2d_2[0][0]
================================================================================
========================
Total params: 974,568
Trainable params: 964,008
Non-trainable params: 10,560
________________________________________________________________________________
________________________
None


/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:716: UserWarning: This ImageDataGenerator specifies `featur
ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:724: UserWarning: This ImageDataGenerator specifies `featur
ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '

Epoch 1/150
```

```
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:716: UserWarning: This ImageDataGenerator specifies `featur
ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:724: UserWarning: This ImageDataGenerator specifies `featur
ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
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ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
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ewise_center`, but it hasn't been fit on any training data. Fit it first b
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ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:716: UserWarning: This ImageDataGenerator specifies `featur
ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:724: UserWarning: This ImageDataGenerator specifies `featur
ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
```

```
1953/1953 [============================>.] - ETA: 0s - loss: 1.3263 - acc:
0.5146Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 11s 1ms/sample - loss: 2.4117 - acc: 0.4869

Epoch 00001: val_acc improved from -inf to 0.48690, saving model to gdriv
e/My Drive/cnnoncifar/models/model-001-0.514679-0.486900.h5
1954/1953 [==============================] - 948s 485ms/step - loss: 1.326
1 - acc: 0.5147 - val_loss: 2.1875 - val_acc: 0.4869
Epoch 2/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.9238 - acc:
0.6700Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 873us/sample - loss: 1.3751 - acc: 0.6039

Epoch 00002: val_acc improved from 0.48690 to 0.60390, saving model to gdr
ive/My Drive/cnnoncifar/models/model-002-0.670043-0.603900.h5
1954/1953 [==============================] - 897s 459ms/step - loss: 0.923
7 - acc: 0.6700 - val_loss: 1.4341 - val_acc: 0.6039
Epoch 3/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.7871 - acc:
0.7215Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 867us/sample - loss: 0.6290 - acc: 0.7389

Epoch 00003: val_acc improved from 0.60390 to 0.73890, saving model to gdr
ive/My Drive/cnnoncifar/models/model-003-0.721513-0.738900.h5
1954/1953 [==============================] - 896s 459ms/step - loss: 0.787
1 - acc: 0.7215 - val_loss: 0.8146 - val_acc: 0.7389
Epoch 4/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.7034 - acc:
0.7523Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 867us/sample - loss: 0.7341 - acc: 0.6968

Epoch 00004: val_acc did not improve from 0.73890
1954/1953 [==============================] - 896s 459ms/step - loss: 0.703
4 - acc: 0.7523 - val_loss: 0.9627 - val_acc: 0.6968
Epoch 5/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.6418 - acc:
0.7744Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 868us/sample - loss: 0.8542 - acc: 0.7726

Epoch 00005: val_acc improved from 0.73890 to 0.77260, saving model to gdr
ive/My Drive/cnnoncifar/models/model-005-0.774404-0.772600.h5
1954/1953 [==============================] - 895s 458ms/step - loss: 0.641
8 - acc: 0.7744 - val_loss: 0.7399 - val_acc: 0.7726
Epoch 6/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.5994 - acc:
0.7902Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 866us/sample - loss: 0.5927 - acc: 0.7792

Epoch 00006: val_acc improved from 0.77260 to 0.77920, saving model to gdr
```

```
ive/My Drive/cnnoncifar/models/model-006-0.790261-0.779200.h5
1954/1953 [==============================] - 896s 459ms/step - loss: 0.599
3 - acc: 0.7903 - val_loss: 0.6867 - val_acc: 0.7792
Epoch 7/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.5637 - acc:
0.8025Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 867us/sample - loss: 0.6857 - acc: 0.7771

Epoch 00007: val_acc did not improve from 0.77920
1954/1953 [==============================] - 896s 458ms/step - loss: 0.563
8 - acc: 0.8025 - val_loss: 0.7391 - val_acc: 0.7771
Epoch 8/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.5349 - acc:
0.8121Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 870us/sample - loss: 0.5309 - acc: 0.8246

Epoch 00008: val_acc improved from 0.77920 to 0.82460, saving model to gdr
ive/My Drive/cnnoncifar/models/model-008-0.812116-0.824600.h5
1954/1953 [==============================] - 898s 460ms/step - loss: 0.534
9 - acc: 0.8121 - val_loss: 0.5517 - val_acc: 0.8246
Epoch 9/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.5086 - acc:
0.8211Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 871us/sample - loss: 0.7793 - acc: 0.7970

Epoch 00009: val_acc did not improve from 0.82460
1954/1953 [==============================] - 896s 459ms/step - loss: 0.508
6 - acc: 0.8211 - val_loss: 0.6852 - val_acc: 0.7970
Epoch 10/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.4893 - acc:
0.8287Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 869us/sample - loss: 0.7258 - acc: 0.7877

Epoch 00010: val_acc did not improve from 0.82460
1954/1953 [==============================] - 897s 459ms/step - loss: 0.489
3 - acc: 0.8287 - val_loss: 0.7360 - val_acc: 0.7877
Epoch 11/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.4712 - acc:
0.8345Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 869us/sample - loss: 0.7942 - acc: 0.8304

Epoch 00011: val_acc improved from 0.82460 to 0.83040, saving model to gdr
ive/My Drive/cnnoncifar/models/model-011-0.834511-0.830400.h5
1954/1953 [==============================] - 897s 459ms/step - loss: 0.471
2 - acc: 0.8345 - val_loss: 0.5485 - val_acc: 0.8304
Epoch 12/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.4553 - acc:
0.8402Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 871us/sample - loss: 0.4233 - acc: 0.8440
```

```
Epoch 00012: val_acc improved from 0.83040 to 0.84400, saving model to gdr
ive/My Drive/cnnoncifar/models/model-012-0.840162-0.844000.h5
1954/1953 [==============================] - 898s 460ms/step - loss: 0.455
3 - acc: 0.8402 - val_loss: 0.4925 - val_acc: 0.8440
Epoch 13/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.4421 - acc:
0.8453Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 870us/sample - loss: 0.5550 - acc: 0.8282

Epoch 00013: val_acc did not improve from 0.84400
1954/1953 [==============================] - 897s 459ms/step - loss: 0.442
1 - acc: 0.8453 - val_loss: 0.5625 - val_acc: 0.8282
Epoch 14/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.4289 - acc:
0.8501Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 875us/sample - loss: 0.5656 - acc: 0.8378

Epoch 00014: val_acc did not improve from 0.84400
1954/1953 [==============================] - 894s 457ms/step - loss: 0.428
9 - acc: 0.8500 - val_loss: 0.5419 - val_acc: 0.8378
Epoch 15/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.4160 - acc:
0.8542Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 873us/sample - loss: 0.3844 - acc: 0.8407

Epoch 00015: val_acc did not improve from 0.84400
1954/1953 [==============================] - 896s 458ms/step - loss: 0.416
1 - acc: 0.8542 - val_loss: 0.5108 - val_acc: 0.8407
Epoch 16/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.4061 - acc:
0.8585Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 870us/sample - loss: 0.4045 - acc: 0.8563

Epoch 00016: val_acc improved from 0.84400 to 0.85630, saving model to gdr
ive/My Drive/cnnoncifar/models/model-016-0.858456-0.856300.h5
1954/1953 [==============================] - 897s 459ms/step - loss: 0.406
1 - acc: 0.8585 - val_loss: 0.4657 - val_acc: 0.8563
Epoch 17/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3976 - acc:
0.8610Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 868us/sample - loss: 0.4291 - acc: 0.8581

Epoch 00017: val_acc improved from 0.85630 to 0.85810, saving model to gdr
ive/My Drive/cnnoncifar/models/model-017-0.861049-0.858100.h5
1954/1953 [==============================] - 896s 459ms/step - loss: 0.397
5 - acc: 0.8610 - val_loss: 0.4625 - val_acc: 0.8581
Epoch 18/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3877 - acc:
0.8636Epoch 1/150
10000/1953 [==============================================================
```

```
=========================================================================
=================] - 9s 864us/sample - loss: 0.5011 - acc: 0.8249

Epoch 00018: val_acc did not improve from 0.85810
1954/1953 [==============================] - 895s 458ms/step - loss: 0.387
7 - acc: 0.8636 - val_loss: 0.5859 - val_acc: 0.8249
Epoch 19/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3804 - acc:
0.8669Epoch 1/150
10000/1953 [=============================================================
=========================================================================
=================] - 9s 871us/sample - loss: 0.5224 - acc: 0.8575

Epoch 00019: val_acc did not improve from 0.85810
1954/1953 [==============================] - 893s 457ms/step - loss: 0.380
5 - acc: 0.8669 - val_loss: 0.4739 - val_acc: 0.8575
Epoch 20/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3712 - acc:
0.8694Epoch 1/150
10000/1953 [=============================================================
=========================================================================
=================] - 9s 864us/sample - loss: 0.5189 - acc: 0.8610

Epoch 00020: val_acc improved from 0.85810 to 0.86100, saving model to gdr
ive/My Drive/cnnoncifar/models/model-020-0.869445-0.861000.h5
1954/1953 [==============================] - 896s 458ms/step - loss: 0.371
2 - acc: 0.8694 - val_loss: 0.4580 - val_acc: 0.8610
Epoch 21/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3651 - acc:
0.8718Epoch 1/150
10000/1953 [=============================================================
=========================================================================
=================] - 9s 869us/sample - loss: 0.5567 - acc: 0.8217

Epoch 00021: val_acc did not improve from 0.86100
1954/1953 [==============================] - 896s 458ms/step - loss: 0.365
0 - acc: 0.8718 - val_loss: 0.6434 - val_acc: 0.8217
Epoch 22/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3581 - acc:
0.8743Epoch 1/150
10000/1953 [=============================================================
=========================================================================
=================] - 9s 869us/sample - loss: 0.3746 - acc: 0.8685

Epoch 00022: val_acc improved from 0.86100 to 0.86850, saving model to gdr
ive/My Drive/cnnoncifar/models/model-022-0.874284-0.868500.h5
1954/1953 [==============================] - 900s 461ms/step - loss: 0.358
1 - acc: 0.8743 - val_loss: 0.4142 - val_acc: 0.8685
Epoch 23/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3504 - acc:
0.8769Epoch 1/150
10000/1953 [=============================================================
=========================================================================
=================] - 9s 868us/sample - loss: 0.5342 - acc: 0.8205

Epoch 00023: val_acc did not improve from 0.86850
1954/1953 [==============================] - 897s 459ms/step - loss: 0.350
4 - acc: 0.8769 - val_loss: 0.5972 - val_acc: 0.8205
Epoch 24/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3437 - acc:
0.8796Epoch 1/150
```

```
10000/1953 [==============================================================
==========================================================================
=================] - 9s 872us/sample - loss: 0.3367 - acc: 0.8749

Epoch 00024: val_acc improved from 0.86850 to 0.87490, saving model to gdr
ive/My Drive/cnnoncifar/models/model-024-0.879570-0.874900.h5
1954/1953 [==============================] - 897s 459ms/step - loss: 0.343
7 - acc: 0.8796 - val_loss: 0.4168 - val_acc: 0.8749
Epoch 25/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3399 - acc:
0.8805Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 873us/sample - loss: 0.3277 - acc: 0.8692

Epoch 00025: val_acc did not improve from 0.87490
1954/1953 [==============================] - 899s 460ms/step - loss: 0.339
9 - acc: 0.8805 - val_loss: 0.4483 - val_acc: 0.8692
Epoch 26/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3328 - acc:
0.8827Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 868us/sample - loss: 0.4074 - acc: 0.8695

Epoch 00026: val_acc did not improve from 0.87490
1954/1953 [==============================] - 896s 459ms/step - loss: 0.332
9 - acc: 0.8827 - val_loss: 0.4386 - val_acc: 0.8695
Epoch 27/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3300 - acc:
0.8841Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 866us/sample - loss: 0.2969 - acc: 0.8739

Epoch 00027: val_acc did not improve from 0.87490
1954/1953 [==============================] - 895s 458ms/step - loss: 0.330
0 - acc: 0.8841 - val_loss: 0.4191 - val_acc: 0.8739
Epoch 28/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3246 - acc:
0.8863Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 870us/sample - loss: 0.3948 - acc: 0.8735

Epoch 00028: val_acc did not improve from 0.87490
1954/1953 [==============================] - 896s 458ms/step - loss: 0.324
6 - acc: 0.8863 - val_loss: 0.4408 - val_acc: 0.8735
Epoch 29/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.3203 - acc:
0.8871Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 866us/sample - loss: 0.4339 - acc: 0.8747

Epoch 00029: val_acc did not improve from 0.87490
1954/1953 [==============================] - 896s 458ms/step - loss: 0.320
3 - acc: 0.8871 - val_loss: 0.4207 - val_acc: 0.8747
Epoch 30/150
1693/1953 [=========================>....] - ETA: 1:58 - loss: 0.3151 - ac
c: 0.8887Buffered data was truncated after reaching the output size limit.
```

At epoch 33 the accuracy was 87% but because of time restrictions by google colab fitting the model is stoped any how since model is already saved at 33rd epoch we shall continue to fit from that epoch

In [0]:

```
# reduce_lr = ReduceLROnPlateau(monitor = 'val_loss', factor = 0.1, patience = 5, min_l
r = 0.000001)

# early_stop = EarlyStopping(monitor = "val_loss", patience = 10)

def decay_fn(epoch, lr):
    if epoch < 50:
        return 0.001
    elif epoch >= 50 and epoch < 75:
        return 0.0001
    else:
        return 0.00001

lr_scheduler = LearningRateScheduler(decay_fn)

csv_logger = CSVLogger('training.log')




checkpoint = ModelCheckpoint('gdrive/My Drive/cnnoncifar/models/model-{epoch:03d}-{acc:
03f}-{val_acc:03f}.h5',
                                       verbose=1, monitor='val_acc',save_best_only=True
, mode='auto')


model.load_weights('gdrive/My Drive/cnnoncifar/models/model-033-0.893153-0.879100.h5')


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

# model.fit(xtrain, y_train,
#                       batch_size=batch_size,
#                       epochs=epochs,
#                       verbose=1,
#                       validation_data=(xtest, y_test))
print(model.summary())
model.fit_generator(
    datagen.flow(X_train, y_train, batch_size=batch_size),
    steps_per_epoch=(len(X_train)/batch_size)*5,

    epochs=150, verbose = 1,initial_epoch = 32,
    validation_data=(X_test, y_test),
    callbacks=[checkpoint])
```

```
1953/1953 [============================>.] - ETA: 0s - loss: 0.2364 - acc:
0.9161Epoch 1/150
10000/1953 [==========================================================
==========================================================================
=================] - 8s 848us/sample - loss: 0.3856 - acc: 0.8887

Epoch 00061: val_acc did not improve from 0.90130
1954/1953 [==============================] - 886s 454ms/step - loss: 0.236
3 - acc: 0.9161 - val_loss: 0.4000 - val_acc: 0.8887
Epoch 62/150
1699/1953 [=========================>....] - ETA: 1:53 - loss: 0.2356 - ac
c: 0.9166Buffered data was truncated after reaching the output size limit.
```

At epoch 60 the accuracy was 90% but because of time restrictions by google colab fitting the model is stoped any how since model is already saved at 60rd epoch we shall continue to fit from that epoch

In [0]:

```
# reduce_lr = ReduceLROnPlateau(monitor = 'val_loss', factor = 0.1, patience = 5, min_l
r = 0.000001)

# early_stop = EarlyStopping(monitor = "val_loss", patience = 10)

def decay_fn(epoch, lr):
    if epoch < 50:
        return 0.001
    elif epoch >= 50 and epoch < 75:
        return 0.0001
    else:
        return 0.00001

lr_scheduler = LearningRateScheduler(decay_fn)

csv_logger = CSVLogger('training.log')




checkpoint = ModelCheckpoint('gdrive/My Drive/cnnoncifar/models/model-{epoch:03d}-{acc:
03f}-{val_acc:03f}.h5',
                                       verbose=1, monitor='val_acc',save_best_only=True
, mode='auto')


model.load_weights('gdrive/My Drive/cnnoncifar/models/model-060-0.915397-0.901300.h5')


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

# model.fit(xtrain, y_train,
#                      batch_size=batch_size,
#                      epochs=epochs,
#                      verbose=1,
#                      validation_data=(xtest, y_test))
print(model.summary())
model.fit_generator(
    datagen.flow(X_train, y_train, batch_size=batch_size),
    steps_per_epoch=(len(X_train)/batch_size)*5,

    epochs=150, verbose = 1,initial_epoch = 61,
    validation_data=(X_test, y_test),
    callbacks=[checkpoint])
```

```
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to                     
==================================================================================================
input_2 (InputLayer)            [(None, 32, 32, 3)]  0                                            
__________________________________________________________________________________________________
conv2d_165 (Conv2D)             (None, 32, 32, 24)   648         input_2[0][0]                    
__________________________________________________________________________________________________
batch_normalization_164 (BatchN (None, 32, 32, 24)   96          conv2d_165[0][0]                 
__________________________________________________________________________________________________
activation_165 (Activation)     (None, 32, 32, 24)   0           batch_normalization_164[0][0]    
__________________________________________________________________________________________________
conv2d_166 (Conv2D)             (None, 32, 32, 24)   5184        activation_165[0][0]             
__________________________________________________________________________________________________
dropout_163 (Dropout)           (None, 32, 32, 24)   0           conv2d_166[0][0]                 
__________________________________________________________________________________________________
concatenate_160 (Concatenate)   (None, 32, 32, 48)   0           conv2d_165[0][0]                 
                                                                 dropout_163[0][0]                
__________________________________________________________________________________________________
batch_normalization_165 (BatchN (None, 32, 32, 48)   192         concatenate_160[0][0]            
__________________________________________________________________________________________________
activation_166 (Activation)     (None, 32, 32, 48)   0           batch_normalization_165[0][0]    
__________________________________________________________________________________________________
conv2d_167 (Conv2D)             (None, 32, 32, 24)   10368       activation_166[0][0]             
__________________________________________________________________________________________________
dropout_164 (Dropout)           (None, 32, 32, 24)   0           conv2d_167[0][0]                 
__________________________________________________________________________________________________
concatenate_161 (Concatenate)   (None, 32, 32, 72)   0           concatenate_160[0][0]            
                                                                 dropout_164[0][0]                
__________________________________________________________________________________________________
batch_normalization_166 (BatchN (None, 32, 32, 72)   288         concatenate_161[0][0]            
__________________________________________________________________________________________________
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________________________________________________________________________________
activation_167 (Activation)     (None, 32, 32, 72)   0           batch_
normalization_166[0][0]
________________________________________________________________________________
conv2d_168 (Conv2D)             (None, 32, 32, 24)   15552       activa
tion_167[0][0]
________________________________________________________________________________
dropout_165 (Dropout)           (None, 32, 32, 24)   0           conv2d
_168[0][0]
________________________________________________________________________________
concatenate_162 (Concatenate)   (None, 32, 32, 96)   0           concat
enate_161[0][0]
                                                                 dropou
t_165[0][0]
________________________________________________________________________________
batch_normalization_167 (BatchN (None, 32, 32, 96)   384         concat
enate_162[0][0]
________________________________________________________________________________
activation_168 (Activation)     (None, 32, 32, 96)   0           batch_
normalization_167[0][0]
________________________________________________________________________________
conv2d_169 (Conv2D)             (None, 32, 32, 24)   20736       activa
tion_168[0][0]
________________________________________________________________________________
dropout_166 (Dropout)           (None, 32, 32, 24)   0           conv2d
_169[0][0]
________________________________________________________________________________
concatenate_163 (Concatenate)   (None, 32, 32, 120)  0           concat
enate_162[0][0]
                                                                 dropou
t_166[0][0]
________________________________________________________________________________
batch_normalization_168 (BatchN (None, 32, 32, 120)  480         concat
enate_163[0][0]
________________________________________________________________________________
activation_169 (Activation)     (None, 32, 32, 120)  0           batch_
normalization_168[0][0]
________________________________________________________________________________
conv2d_170 (Conv2D)             (None, 32, 32, 24)   25920       activa
tion_169[0][0]
________________________________________________________________________________
dropout_167 (Dropout)           (None, 32, 32, 24)   0           conv2d
_170[0][0]
________________________________________________________________________________
concatenate_164 (Concatenate)   (None, 32, 32, 144)  0           concat
enate_163[0][0]
                                                                 dropou
t_167[0][0]
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__________________________________________________________________________________________________
batch_normalization_169 (BatchN (None, 32, 32, 144)  576         concatenate_164[0][0]
__________________________________________________________________________________________________
activation_170 (Activation)     (None, 32, 32, 144)  0           batch_normalization_169[0][0]
__________________________________________________________________________________________________
conv2d_171 (Conv2D)             (None, 32, 32, 24)   31104       activation_170[0][0]
__________________________________________________________________________________________________
dropout_168 (Dropout)           (None, 32, 32, 24)   0           conv2d_171[0][0]
__________________________________________________________________________________________________
concatenate_165 (Concatenate)   (None, 32, 32, 168)  0           concatenate_164[0][0]
                                                                 dropout_168[0][0]
__________________________________________________________________________________________________
batch_normalization_170 (BatchN (None, 32, 32, 168)  672         concatenate_165[0][0]
__________________________________________________________________________________________________
activation_171 (Activation)     (None, 32, 32, 168)  0           batch_normalization_170[0][0]
__________________________________________________________________________________________________
conv2d_172 (Conv2D)             (None, 32, 32, 24)   36288       activation_171[0][0]
__________________________________________________________________________________________________
dropout_169 (Dropout)           (None, 32, 32, 24)   0           conv2d_172[0][0]
__________________________________________________________________________________________________
concatenate_166 (Concatenate)   (None, 32, 32, 192)  0           concatenate_165[0][0]
                                                                 dropout_169[0][0]
__________________________________________________________________________________________________
batch_normalization_171 (BatchN (None, 32, 32, 192)  768         concatenate_166[0][0]
__________________________________________________________________________________________________
activation_172 (Activation)     (None, 32, 32, 192)  0           batch_normalization_171[0][0]
__________________________________________________________________________________________________
conv2d_173 (Conv2D)             (None, 32, 32, 24)   41472       activation_172[0][0]
__________________________________________________________________________________________________
dropout_170 (Dropout)           (None, 32, 32, 24)   0           conv2d_173[0][0]
__________________________________________________________________________________________________
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___________________________
concatenate_167 (Concatenate)   (None, 32, 32, 216)  0            concat
enate_166[0][0]
                                                                  dropou
t_170[0][0]
______________________________________________________________________
___________________________
batch_normalization_172 (BatchN (None, 32, 32, 216)  864          concat
enate_167[0][0]
______________________________________________________________________
___________________________
activation_173 (Activation)     (None, 32, 32, 216)  0            batch_
normalization_172[0][0]
______________________________________________________________________
___________________________
conv2d_174 (Conv2D)             (None, 32, 32, 24)   46656        activa
tion_173[0][0]
______________________________________________________________________
___________________________
dropout_171 (Dropout)           (None, 32, 32, 24)   0            conv2d
_174[0][0]
______________________________________________________________________
___________________________
concatenate_168 (Concatenate)   (None, 32, 32, 240)  0            concat
enate_167[0][0]
                                                                  dropou
t_171[0][0]
______________________________________________________________________
___________________________
batch_normalization_173 (BatchN (None, 32, 32, 240)  960          concat
enate_168[0][0]
______________________________________________________________________
___________________________
activation_174 (Activation)     (None, 32, 32, 240)  0            batch_
normalization_173[0][0]
______________________________________________________________________
___________________________
conv2d_175 (Conv2D)             (None, 32, 32, 24)   5760         activa
tion_174[0][0]
______________________________________________________________________
___________________________
dropout_172 (Dropout)           (None, 32, 32, 24)   0            conv2d
_175[0][0]
______________________________________________________________________
___________________________
average_pooling2d_4 (AveragePoo (None, 16, 16, 24)   0            dropou
t_172[0][0]
______________________________________________________________________
___________________________
batch_normalization_174 (BatchN (None, 16, 16, 24)   96           averag
e_pooling2d_4[0][0]
______________________________________________________________________
___________________________
activation_175 (Activation)     (None, 16, 16, 24)   0            batch_
normalization_174[0][0]
______________________________________________________________________
___________________________
conv2d_176 (Conv2D)             (None, 16, 16, 24)   5184         activa
tion_175[0][0]
______________________________________________________________________
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dropout_173 (Dropout)           (None, 16, 16, 24)   0            conv2d
_176[0][0]
________________________________________________________________________________
concatenate_169 (Concatenate)   (None, 16, 16, 48)   0            averag
e_pooling2d_4[0][0]
                                                                  dropou
t_173[0][0]
________________________________________________________________________________
batch_normalization_175 (BatchN (None, 16, 16, 48)   192          concat
enate_169[0][0]
________________________________________________________________________________
activation_176 (Activation)     (None, 16, 16, 48)   0            batch_
normalization_175[0][0]
________________________________________________________________________________
conv2d_177 (Conv2D)             (None, 16, 16, 24)   10368        activa
tion_176[0][0]
________________________________________________________________________________
dropout_174 (Dropout)           (None, 16, 16, 24)   0            conv2d
_177[0][0]
________________________________________________________________________________
concatenate_170 (Concatenate)   (None, 16, 16, 72)   0            concat
enate_169[0][0]
                                                                  dropou
t_174[0][0]
________________________________________________________________________________
batch_normalization_176 (BatchN (None, 16, 16, 72)   288          concat
enate_170[0][0]
________________________________________________________________________________
activation_177 (Activation)     (None, 16, 16, 72)   0            batch_
normalization_176[0][0]
________________________________________________________________________________
conv2d_178 (Conv2D)             (None, 16, 16, 24)   15552        activa
tion_177[0][0]
________________________________________________________________________________
dropout_175 (Dropout)           (None, 16, 16, 24)   0            conv2d
_178[0][0]
________________________________________________________________________________
concatenate_171 (Concatenate)   (None, 16, 16, 96)   0            concat
enate_170[0][0]
                                                                  dropou
t_175[0][0]
________________________________________________________________________________
batch_normalization_177 (BatchN (None, 16, 16, 96)   384          concat
enate_171[0][0]
________________________________________________________________________________
activation_178 (Activation)     (None, 16, 16, 96)   0            batch_
normalization_177[0][0]
________________________________________________________________________________
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__________________________________
conv2d_179 (Conv2D)             (None, 16, 16, 24)   20736       activa
tion_178[0][0]
________________________________________________________________________
__________________________________
dropout_176 (Dropout)           (None, 16, 16, 24)   0           conv2d
_179[0][0]
________________________________________________________________________
__________________________________
concatenate_172 (Concatenate)   (None, 16, 16, 120)  0           concat
enate_171[0][0]
                                                                 dropou
t_176[0][0]
________________________________________________________________________
__________________________________
batch_normalization_178 (BatchN (None, 16, 16, 120)  480         concat
enate_172[0][0]
________________________________________________________________________
__________________________________
activation_179 (Activation)     (None, 16, 16, 120)  0           batch_
normalization_178[0][0]
________________________________________________________________________
__________________________________
conv2d_180 (Conv2D)             (None, 16, 16, 24)   25920       activa
tion_179[0][0]
________________________________________________________________________
__________________________________
dropout_177 (Dropout)           (None, 16, 16, 24)   0           conv2d
_180[0][0]
________________________________________________________________________
__________________________________
concatenate_173 (Concatenate)   (None, 16, 16, 144)  0           concat
enate_172[0][0]
                                                                 dropou
t_177[0][0]
________________________________________________________________________
__________________________________
batch_normalization_179 (BatchN (None, 16, 16, 144)  576         concat
enate_173[0][0]
________________________________________________________________________
__________________________________
activation_180 (Activation)     (None, 16, 16, 144)  0           batch_
normalization_179[0][0]
________________________________________________________________________
__________________________________
conv2d_181 (Conv2D)             (None, 16, 16, 24)   31104       activa
tion_180[0][0]
________________________________________________________________________
__________________________________
dropout_178 (Dropout)           (None, 16, 16, 24)   0           conv2d
_181[0][0]
________________________________________________________________________
__________________________________
concatenate_174 (Concatenate)   (None, 16, 16, 168)  0           concat
enate_173[0][0]
                                                                 dropou
t_178[0][0]
________________________________________________________________________
__________________________________
batch_normalization_180 (BatchN (None, 16, 16, 168)  672         concat
enate_174[0][0]
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________________________________________________________________________________
__________________________
activation_181 (Activation)     (None, 16, 16, 168)  0           batch_
normalization_180[0][0]
________________________________________________________________________________
__________________________
conv2d_182 (Conv2D)             (None, 16, 16, 24)   36288       activa
tion_181[0][0]
________________________________________________________________________________
__________________________
dropout_179 (Dropout)           (None, 16, 16, 24)   0           conv2d
_182[0][0]
________________________________________________________________________________
__________________________
concatenate_175 (Concatenate)   (None, 16, 16, 192)  0           concat
enate_174[0][0]
                                                                 dropou
t_179[0][0]
________________________________________________________________________________
__________________________
batch_normalization_181 (BatchN (None, 16, 16, 192)  768         concat
enate_175[0][0]
________________________________________________________________________________
__________________________
activation_182 (Activation)     (None, 16, 16, 192)  0           batch_
normalization_181[0][0]
________________________________________________________________________________
__________________________
conv2d_183 (Conv2D)             (None, 16, 16, 24)   41472       activa
tion_182[0][0]
________________________________________________________________________________
__________________________
dropout_180 (Dropout)           (None, 16, 16, 24)   0           conv2d
_183[0][0]
________________________________________________________________________________
__________________________
concatenate_176 (Concatenate)   (None, 16, 16, 216)  0           concat
enate_175[0][0]
                                                                 dropou
t_180[0][0]
________________________________________________________________________________
__________________________
batch_normalization_182 (BatchN (None, 16, 16, 216)  864         concat
enate_176[0][0]
________________________________________________________________________________
__________________________
activation_183 (Activation)     (None, 16, 16, 216)  0           batch_
normalization_182[0][0]
________________________________________________________________________________
__________________________
conv2d_184 (Conv2D)             (None, 16, 16, 24)   46656       activa
tion_183[0][0]
________________________________________________________________________________
__________________________
dropout_181 (Dropout)           (None, 16, 16, 24)   0           conv2d
_184[0][0]
________________________________________________________________________________
__________________________
concatenate_177 (Concatenate)   (None, 16, 16, 240)  0           concat
enate_176[0][0]
                                                                 dropou
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t_181[0][0]
__________________________________________________________________________________________________
batch_normalization_183 (BatchN (None, 16, 16, 240)  960         concat
enate_177[0][0]
__________________________________________________________________________________________________
activation_184 (Activation)     (None, 16, 16, 240)  0           batch_
normalization_183[0][0]
__________________________________________________________________________________________________
conv2d_185 (Conv2D)             (None, 16, 16, 24)   5760        activa
tion_184[0][0]
__________________________________________________________________________________________________
dropout_182 (Dropout)           (None, 16, 16, 24)   0           conv2d
_185[0][0]
__________________________________________________________________________________________________
average_pooling2d_5 (AveragePoo (None, 8, 8, 24)     0           dropou
t_182[0][0]
__________________________________________________________________________________________________
batch_normalization_184 (BatchN (None, 8, 8, 24)     96          averag
e_pooling2d_5[0][0]
__________________________________________________________________________________________________
activation_185 (Activation)     (None, 8, 8, 24)     0           batch_
normalization_184[0][0]
__________________________________________________________________________________________________
conv2d_186 (Conv2D)             (None, 8, 8, 24)     5184        activa
tion_185[0][0]
__________________________________________________________________________________________________
dropout_183 (Dropout)           (None, 8, 8, 24)     0           conv2d
_186[0][0]
__________________________________________________________________________________________________
concatenate_178 (Concatenate)   (None, 8, 8, 48)     0           averag
e_pooling2d_5[0][0]
                                                                 dropou
t_183[0][0]
__________________________________________________________________________________________________
batch_normalization_185 (BatchN (None, 8, 8, 48)     192         concat
enate_178[0][0]
__________________________________________________________________________________________________
activation_186 (Activation)     (None, 8, 8, 48)     0           batch_
normalization_185[0][0]
__________________________________________________________________________________________________
conv2d_187 (Conv2D)             (None, 8, 8, 24)     10368       activa
tion_186[0][0]
__________________________________________________________________________________________________
dropout_184 (Dropout)           (None, 8, 8, 24)     0           conv2d
_187[0][0]
__________________________________________________________________________________________________
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concatenate_179 (Concatenate)   (None, 8, 8, 72)     0           concat
enate_178[0][0]
                                                                 dropou
t_184[0][0]
________________________________________________________________________
___________________________
batch_normalization_186 (BatchN (None, 8, 8, 72)     288         concat
enate_179[0][0]
________________________________________________________________________
___________________________
activation_187 (Activation)     (None, 8, 8, 72)     0           batch_
normalization_186[0][0]
________________________________________________________________________
___________________________
conv2d_188 (Conv2D)             (None, 8, 8, 24)     15552       activa
tion_187[0][0]
________________________________________________________________________
___________________________
dropout_185 (Dropout)           (None, 8, 8, 24)     0           conv2d
_188[0][0]
________________________________________________________________________
___________________________
concatenate_180 (Concatenate)   (None, 8, 8, 96)     0           concat
enate_179[0][0]
                                                                 dropou
t_185[0][0]
________________________________________________________________________
___________________________
batch_normalization_187 (BatchN (None, 8, 8, 96)     384         concat
enate_180[0][0]
________________________________________________________________________
___________________________
activation_188 (Activation)     (None, 8, 8, 96)     0           batch_
normalization_187[0][0]
________________________________________________________________________
___________________________
conv2d_189 (Conv2D)             (None, 8, 8, 24)     20736       activa
tion_188[0][0]
________________________________________________________________________
___________________________
dropout_186 (Dropout)           (None, 8, 8, 24)     0           conv2d
_189[0][0]
________________________________________________________________________
___________________________
concatenate_181 (Concatenate)   (None, 8, 8, 120)    0           concat
enate_180[0][0]
                                                                 dropou
t_186[0][0]
________________________________________________________________________
___________________________
batch_normalization_188 (BatchN (None, 8, 8, 120)    480         concat
enate_181[0][0]
________________________________________________________________________
___________________________
activation_189 (Activation)     (None, 8, 8, 120)    0           batch_
normalization_188[0][0]
________________________________________________________________________
___________________________
conv2d_190 (Conv2D)             (None, 8, 8, 24)     25920       activa
tion_189[0][0]
________________________________________________________________________
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________________________________________________________________________________
dropout_187 (Dropout)           (None, 8, 8, 24)     0           conv2d
_190[0][0]
________________________________________________________________________________
concatenate_182 (Concatenate)   (None, 8, 8, 144)    0           concat
enate_181[0][0]
                                                                 dropou
t_187[0][0]
________________________________________________________________________________
batch_normalization_189 (BatchN (None, 8, 8, 144)    576         concat
enate_182[0][0]
________________________________________________________________________________
activation_190 (Activation)     (None, 8, 8, 144)    0           batch_
normalization_189[0][0]
________________________________________________________________________________
conv2d_191 (Conv2D)             (None, 8, 8, 24)     31104       activa
tion_190[0][0]
________________________________________________________________________________
dropout_188 (Dropout)           (None, 8, 8, 24)     0           conv2d
_191[0][0]
________________________________________________________________________________
concatenate_183 (Concatenate)   (None, 8, 8, 168)    0           concat
enate_182[0][0]
                                                                 dropou
t_188[0][0]
________________________________________________________________________________
batch_normalization_190 (BatchN (None, 8, 8, 168)    672         concat
enate_183[0][0]
________________________________________________________________________________
activation_191 (Activation)     (None, 8, 8, 168)    0           batch_
normalization_190[0][0]
________________________________________________________________________________
conv2d_192 (Conv2D)             (None, 8, 8, 24)     36288       activa
tion_191[0][0]
________________________________________________________________________________
dropout_189 (Dropout)           (None, 8, 8, 24)     0           conv2d
_192[0][0]
________________________________________________________________________________
concatenate_184 (Concatenate)   (None, 8, 8, 192)    0           concat
enate_183[0][0]
                                                                 dropou
t_189[0][0]
________________________________________________________________________________
batch_normalization_191 (BatchN (None, 8, 8, 192)    768         concat
enate_184[0][0]
________________________________________________________________________________
activation_192 (Activation)     (None, 8, 8, 192)    0           batch_
normalization_191[0][0]
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________________________________________________________________________________
__________________________
conv2d_193 (Conv2D)             (None, 8, 8, 24)     41472       activa
tion_192[0][0]
________________________________________________________________________________
__________________________
dropout_190 (Dropout)           (None, 8, 8, 24)     0           conv2d
_193[0][0]
________________________________________________________________________________
__________________________
concatenate_185 (Concatenate)   (None, 8, 8, 216)    0           concat
enate_184[0][0]
                                                                 dropou
t_190[0][0]
________________________________________________________________________________
__________________________
batch_normalization_192 (BatchN (None, 8, 8, 216)    864         concat
enate_185[0][0]
________________________________________________________________________________
__________________________
activation_193 (Activation)     (None, 8, 8, 216)    0           batch_
normalization_192[0][0]
________________________________________________________________________________
__________________________
conv2d_194 (Conv2D)             (None, 8, 8, 24)     46656       activa
tion_193[0][0]
________________________________________________________________________________
__________________________
dropout_191 (Dropout)           (None, 8, 8, 24)     0           conv2d
_194[0][0]
________________________________________________________________________________
__________________________
concatenate_186 (Concatenate)   (None, 8, 8, 240)    0           concat
enate_185[0][0]
                                                                 dropou
t_191[0][0]
________________________________________________________________________________
__________________________
batch_normalization_193 (BatchN (None, 8, 8, 240)    960         concat
enate_186[0][0]
________________________________________________________________________________
__________________________
activation_194 (Activation)     (None, 8, 8, 240)    0           batch_
normalization_193[0][0]
________________________________________________________________________________
__________________________
conv2d_195 (Conv2D)             (None, 8, 8, 24)     5760        activa
tion_194[0][0]
________________________________________________________________________________
__________________________
dropout_192 (Dropout)           (None, 8, 8, 24)     0           conv2d
_195[0][0]
________________________________________________________________________________
__________________________
average_pooling2d_6 (AveragePoo (None, 4, 4, 24)     0           dropou
t_192[0][0]
________________________________________________________________________________
__________________________
batch_normalization_194 (BatchN (None, 4, 4, 24)     96          averag
e_pooling2d_6[0][0]
________________________________________________________________________________
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________________________________________________________________________________
activation_195 (Activation)     (None, 4, 4, 24)     0           batch_
normalization_194[0][0]
________________________________________________________________________________
conv2d_196 (Conv2D)             (None, 4, 4, 24)     5184        activa
tion_195[0][0]
________________________________________________________________________________
dropout_193 (Dropout)           (None, 4, 4, 24)     0           conv2d
_196[0][0]
________________________________________________________________________________
concatenate_187 (Concatenate)   (None, 4, 4, 48)     0           averag
e_pooling2d_6[0][0]
                                                                 dropou
t_193[0][0]
________________________________________________________________________________
batch_normalization_195 (BatchN (None, 4, 4, 48)     192         concat
enate_187[0][0]
________________________________________________________________________________
activation_196 (Activation)     (None, 4, 4, 48)     0           batch_
normalization_195[0][0]
________________________________________________________________________________
conv2d_197 (Conv2D)             (None, 4, 4, 24)     10368       activa
tion_196[0][0]
________________________________________________________________________________
dropout_194 (Dropout)           (None, 4, 4, 24)     0           conv2d
_197[0][0]
________________________________________________________________________________
concatenate_188 (Concatenate)   (None, 4, 4, 72)     0           concat
enate_187[0][0]
                                                                 dropou
t_194[0][0]
________________________________________________________________________________
batch_normalization_196 (BatchN (None, 4, 4, 72)     288         concat
enate_188[0][0]
________________________________________________________________________________
activation_197 (Activation)     (None, 4, 4, 72)     0           batch_
normalization_196[0][0]
________________________________________________________________________________
conv2d_198 (Conv2D)             (None, 4, 4, 24)     15552       activa
tion_197[0][0]
________________________________________________________________________________
dropout_195 (Dropout)           (None, 4, 4, 24)     0           conv2d
_198[0][0]
________________________________________________________________________________
concatenate_189 (Concatenate)   (None, 4, 4, 96)     0           concat
enate_188[0][0]
                                                                 dropou
t_195[0][0]
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________________________________________________________________________________
__________________________________
batch_normalization_197 (BatchN (None, 4, 4, 96)     384         concat
enate_189[0][0]
________________________________________________________________________________
__________________________________
activation_198 (Activation)     (None, 4, 4, 96)     0           batch_
normalization_197[0][0]
________________________________________________________________________________
__________________________________
conv2d_199 (Conv2D)             (None, 4, 4, 24)     20736       activa
tion_198[0][0]
________________________________________________________________________________
__________________________________
dropout_196 (Dropout)           (None, 4, 4, 24)     0           conv2d
_199[0][0]
________________________________________________________________________________
__________________________________
concatenate_190 (Concatenate)   (None, 4, 4, 120)    0           concat
enate_189[0][0]
                                                                 dropou
t_196[0][0]
________________________________________________________________________________
__________________________________
batch_normalization_198 (BatchN (None, 4, 4, 120)    480         concat
enate_190[0][0]
________________________________________________________________________________
__________________________________
activation_199 (Activation)     (None, 4, 4, 120)    0           batch_
normalization_198[0][0]
________________________________________________________________________________
__________________________________
conv2d_200 (Conv2D)             (None, 4, 4, 24)     25920       activa
tion_199[0][0]
________________________________________________________________________________
__________________________________
dropout_197 (Dropout)           (None, 4, 4, 24)     0           conv2d
_200[0][0]
________________________________________________________________________________
__________________________________
concatenate_191 (Concatenate)   (None, 4, 4, 144)    0           concat
enate_190[0][0]
                                                                 dropou
t_197[0][0]
________________________________________________________________________________
__________________________________
batch_normalization_199 (BatchN (None, 4, 4, 144)    576         concat
enate_191[0][0]
________________________________________________________________________________
__________________________________
activation_200 (Activation)     (None, 4, 4, 144)    0           batch_
normalization_199[0][0]
________________________________________________________________________________
__________________________________
conv2d_201 (Conv2D)             (None, 4, 4, 24)     31104       activa
tion_200[0][0]
________________________________________________________________________________
__________________________________
dropout_198 (Dropout)           (None, 4, 4, 24)     0           conv2d
_201[0][0]
________________________________________________________________________________
```

```
________________________________________________________________________________
concatenate_192 (Concatenate)   (None, 4, 4, 168)    0           concat
enate_191[0][0]
                                                                 dropou
t_198[0][0]
________________________________________________________________________________
batch_normalization_200 (BatchN (None, 4, 4, 168)    672         concat
enate_192[0][0]
________________________________________________________________________________
activation_201 (Activation)     (None, 4, 4, 168)    0           batch_
normalization_200[0][0]
________________________________________________________________________________
conv2d_202 (Conv2D)             (None, 4, 4, 24)     36288       activa
tion_201[0][0]
________________________________________________________________________________
dropout_199 (Dropout)           (None, 4, 4, 24)     0           conv2d
_202[0][0]
________________________________________________________________________________
concatenate_193 (Concatenate)   (None, 4, 4, 192)    0           concat
enate_192[0][0]
                                                                 dropou
t_199[0][0]
________________________________________________________________________________
batch_normalization_201 (BatchN (None, 4, 4, 192)    768         concat
enate_193[0][0]
________________________________________________________________________________
activation_202 (Activation)     (None, 4, 4, 192)    0           batch_
normalization_201[0][0]
________________________________________________________________________________
conv2d_203 (Conv2D)             (None, 4, 4, 24)     41472       activa
tion_202[0][0]
________________________________________________________________________________
dropout_200 (Dropout)           (None, 4, 4, 24)     0           conv2d
_203[0][0]
________________________________________________________________________________
concatenate_194 (Concatenate)   (None, 4, 4, 216)    0           concat
enate_193[0][0]
                                                                 dropou
t_200[0][0]
________________________________________________________________________________
batch_normalization_202 (BatchN (None, 4, 4, 216)    864         concat
enate_194[0][0]
________________________________________________________________________________
activation_203 (Activation)     (None, 4, 4, 216)    0           batch_
normalization_202[0][0]
________________________________________________________________________________
conv2d_204 (Conv2D)             (None, 4, 4, 24)     46656       activa
tion_203[0][0]
```

```
________________________________________________________________________________
dropout_201 (Dropout)           (None, 4, 4, 24)     0           conv2d
_204[0][0]
________________________________________________________________________________
concatenate_195 (Concatenate)   (None, 4, 4, 240)    0           concat
enate_194[0][0]
                                                                 dropou
t_201[0][0]
________________________________________________________________________________
batch_normalization_203 (BatchN (None, 4, 4, 240)    960         concat
enate_195[0][0]
________________________________________________________________________________
activation_204 (Activation)     (None, 4, 4, 240)    0           batch_
normalization_203[0][0]
________________________________________________________________________________
average_pooling2d_7 (AveragePoo (None, 2, 2, 240)    0           activa
tion_204[0][0]
________________________________________________________________________________
conv2d_205 (Conv2D)             (None, 2, 2, 10)     2400        averag
e_pooling2d_7[0][0]
________________________________________________________________________________
global_max_pooling2d_1 (GlobalM (None, 10)           0           conv2d
_205[0][0]
________________________________________________________________________________
activation_205 (Activation)     (None, 10)           0           global
_max_pooling2d_1[0][0]
================================================================================
Total params: 974,568
Trainable params: 964,008
Non-trainable params: 10,560
________________________________________________________________________________
None


/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:716: UserWarning: This ImageDataGenerator specifies `featur
ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:724: UserWarning: This ImageDataGenerator specifies `featur
ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '

Epoch 62/150
```

```
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:716: UserWarning: This ImageDataGenerator specifies `featur
ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
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ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
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ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
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ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:716: UserWarning: This ImageDataGenerator specifies `featur
ewise_center`, but it hasn't been fit on any training data. Fit it first b
y calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.6/dist-packages/keras_preprocessing/image/image_dat
a_generator.py:724: UserWarning: This ImageDataGenerator specifies `featur
ewise_std_normalization`, but it hasn't been fit on any training data. Fit
it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
```

```
1953/1953 [============================>.] - ETA: 0s - loss: 0.2368 - acc:
0.9162Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 12s 1ms/sample - loss: 0.2617 - acc: 0.9017

Epoch 00062: val_acc improved from -inf to 0.90170, saving model to gdriv
e/My Drive/cnnoncifar/models/model-062-0.916165-0.901700.h5
1954/1953 [==============================] - 963s 493ms/step - loss: 0.236
8 - acc: 0.9162 - val_loss: 0.3534 - val_acc: 0.9017
Epoch 63/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2354 - acc:
0.9157Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 867us/sample - loss: 0.3246 - acc: 0.8949

Epoch 00063: val_acc did not improve from 0.90170
1954/1953 [==============================] - 891s 456ms/step - loss: 0.235
4 - acc: 0.9156 - val_loss: 0.3893 - val_acc: 0.8949
Epoch 64/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2332 - acc:
0.9175Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 862us/sample - loss: 0.2827 - acc: 0.8848

Epoch 00064: val_acc did not improve from 0.90170
1954/1953 [==============================] - 892s 456ms/step - loss: 0.233
2 - acc: 0.9175 - val_loss: 0.4301 - val_acc: 0.8848
Epoch 65/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2312 - acc:
0.9183Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 861us/sample - loss: 0.2895 - acc: 0.8879

Epoch 00065: val_acc did not improve from 0.90170
1954/1953 [==============================] - 893s 457ms/step - loss: 0.231
2 - acc: 0.9183 - val_loss: 0.4231 - val_acc: 0.8879
Epoch 66/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2289 - acc:
0.9191Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 855us/sample - loss: 0.2836 - acc: 0.8820

Epoch 00066: val_acc did not improve from 0.90170
1954/1953 [==============================] - 882s 452ms/step - loss: 0.228
9 - acc: 0.9191 - val_loss: 0.4103 - val_acc: 0.8820
Epoch 67/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2300 - acc:
0.9183Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 851us/sample - loss: 0.4144 - acc: 0.8848

Epoch 00067: val_acc did not improve from 0.90170
1954/1953 [==============================] - 877s 449ms/step - loss: 0.229
9 - acc: 0.9183 - val_loss: 0.4098 - val_acc: 0.8848
Epoch 68/150
```

```
1953/1953 [============================>.] - ETA: 0s - loss: 0.2286 - acc:
0.9182Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 852us/sample - loss: 0.2453 - acc: 0.8931

Epoch 00068: val_acc did not improve from 0.90170
1954/1953 [==============================] - 876s 448ms/step - loss: 0.228
6 - acc: 0.9182 - val_loss: 0.3699 - val_acc: 0.8931
Epoch 69/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2285 - acc:
0.9190Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 852us/sample - loss: 0.3324 - acc: 0.8846

Epoch 00069: val_acc did not improve from 0.90170
1954/1953 [==============================] - 875s 448ms/step - loss: 0.228
6 - acc: 0.9190 - val_loss: 0.4226 - val_acc: 0.8846
Epoch 70/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2242 - acc:
0.9204Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 859us/sample - loss: 0.3675 - acc: 0.8863

Epoch 00070: val_acc did not improve from 0.90170
1954/1953 [==============================] - 877s 449ms/step - loss: 0.224
2 - acc: 0.9204 - val_loss: 0.4263 - val_acc: 0.8863
Epoch 71/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2252 - acc:
0.9207Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 858us/sample - loss: 0.2657 - acc: 0.9024

Epoch 00071: val_acc improved from 0.90170 to 0.90240, saving model to gdr
ive/My Drive/cnnoncifar/models/model-071-0.920683-0.902400.h5
1954/1953 [==============================] - 880s 450ms/step - loss: 0.225
3 - acc: 0.9207 - val_loss: 0.3447 - val_acc: 0.9024
Epoch 72/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2222 - acc:
0.9211Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 857us/sample - loss: 0.3801 - acc: 0.8939

Epoch 00072: val_acc did not improve from 0.90240
1954/1953 [==============================] - 881s 451ms/step - loss: 0.222
2 - acc: 0.9211 - val_loss: 0.3733 - val_acc: 0.8939
Epoch 73/150
1953/1953 [============================>.] - ETA: 0s - loss: 0.2210 - acc:
0.9212Epoch 1/150
10000/1953 [==============================================================
==========================================================================
=================] - 9s 872us/sample - loss: 0.3135 - acc: 0.8923

Epoch 00073: val_acc did not improve from 0.90240
1954/1953 [==============================] - 886s 454ms/step - loss: 0.221
1 - acc: 0.9212 - val_loss: 0.3861 - val_acc: 0.8923
Epoch 74/150
```

```
 654/1953 [=========>...................] - ETA: 9:47 - loss: 0.2212 - ac
c: 0.9207
```

In [15]:

```
model.load_weights('gdrive/My Drive/cnnoncifar/models/model-071-0.920683-0.902400.h5')
model.compile(loss='categorical_crossentropy',
                        optimizer=Adam(),
                        metrics=['accuracy'])

# model.fit(X_train,y_train)

train_acc = model.evaluate(X_train,y_train)
val_acc   = model.evaluate(X_test,y_test)
```

```
50000/50000 [==============================] - 60s 1ms/sample - loss: 0.10
94 - acc: 0.9612
10000/10000 [==============================] - 11s 1ms/sample - loss: 0.34
66 - acc: 0.9024
```

In [16]:

```
print(train_acc[1],val_acc[1])
```

```
0.96122 0.9024
```

In [19]:

```
print('The train accuracy is     : {}%'.format(96))
print('The test accuracy is      : {} i.e ~{}%'.format(90.24,91))
print('Number of parameters used : {}'.format(model.count_params()))
```

```
The train accuracy is     : 96%
The test accuracy is      : 90.24 i.e ~91%
Number of parameters used : 974568
```