CNN_ Cifar10

With image augmentation

codes from below source are used in this casesetudy

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https://machinelearningmastery.com/how-to-develop-a-cnn-from-scratch-for-cifar-10-photo-classification/
https://machinelearningmastery.com/how-to-configure-image-data-augmentation-when-training-deep-learning-neural-networks/
https://machinelearningmastery.com/how-to-stop-training-deep-neural-networks-at-the-right-time-using-early-stopping/
https://github.com/moritzhambach/Image-Augmentation-in-Keras-CIFAR-10-
/blob/master/CNN%20with%20Image%20Augmentation%20(CIFAR10).ipynb

Customised Dense Net with Image Augmentation

https://github.com/ludwikbukowski/mysupernet/blob/master/densenetcustom.py

In [0]:

```
%tensorflow_version 1.x
```

```
TensorFlow 1.x selected.
```

In [0]:

```
import os
import numpy as np
from keras import backend as K
from keras.datasets import cifar10
from keras.models import Model, Sequential
from keras import models, layers
from keras.layers import Dense, Dropout, Flatten, Input, AveragePooling2D, merge, Activation
from keras.layers import Conv2D, MaxPooling2D, BatchNormalization, DepthwiseConv2D
from keras.layers import Concatenate
from keras.models import load_model
from keras.optimizers import SGD, Adam, RMSprop
from keras.preprocessing.image import ImageDataGenerator
from keras.callbacks import ReduceLROnPlateau, ModelCheckpoint, EarlyStopping,
LearningRateScheduler, CSVLogger
from keras.callbacks import Callback
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
import keras
import tensorflow as tf
from keras import backend as k
```

```
Using TensorFlow backend.
```

In [0]:

```
%time
datagen = ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.125,
    height_shift_range=0.125,
    horizontal_flip=True,
    fill_mode='nearest',
    zoom_range=0.10
)
```

```
CPU times: user 3 µs, sys: 0 ns, total: 3 µs
Wall time: 5.96 µs
```

In [0]:

```
num_classes = 10
```

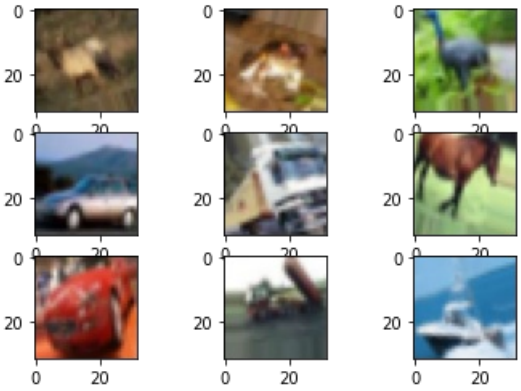
In [0]:

```
# 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.tar.gz
170500096/170498071 [==============================] - 3s 0us/step
```

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
```



In [0]:

```
# Dense Block
def denseblock(input, num_filter = 12):
    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='sam
e')(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):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    Conv2D_BottleNeck = layers.Conv2D(int(num_filter*compression), (1,1), use_bias=False ,padding='
same')(relu)
    #if dropout_rate>0:
         #Conv2D_BottleNeck = layers.Dropout(dropout_rate)(Conv2D_BottleNeck)
```

```
    avg = layers.AveragePooling2D(pool_size=(2,2))(Conv2D_BottleNeck)
    return avg

#output layer
def output_layer(input):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    AvgPooling = layers.AveragePooling2D(pool_size=(2,2))(relu)
    #flat = layers.Flatten()(AvgPooling)
    #output = layers.Dense(num_classes, activation='softmax')(flat)
    #replcaing Dense layer by conv layer
    #http://cs231n.github.io/convolutional-networks/#convert
    conv_layer = layers.Conv2D(num_classes, (1,1), use_bias=False ,padding='same')(AvgPooling)
    last = layers.GlobalMaxPooling2D()(conv_layer)
#https://www.researchgate.net/post/Differences_between_Global_Max_Pooling_and_Global_Average_poolir

    output = layers.Activation('softmax')(last)
    return output
```

In [0]:

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

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

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

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

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

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

```
WARNING:tensorflow:From /tensorflow-
1.15.2/python3.6/tensorflow_core/python/ops/resource_variable_ops.py:1630: calling
BaseResourceVariable.__init__ (from tensorflow.python.ops.resource_variable_ops) with constraint i
s deprecated and will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:4074: The name tf.nn.avg_pool is deprecated. Please u
se tf.nn.avg_pool2d instead.
```

In [0]:

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

```
Model: "model_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 32, 32, 3)         0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 32, 32, 24)        648
_________________________________________________________________
batch_normalization_1 (BatchNor (None, 32, 32, 24)        96
_________________________________________________________________
activation_1 (Activation)    (None, 32, 32, 24)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 32, 32, 24)        5184
```

concatenate_1 (Concatenate)	(None, 32, 32, 48)	0	conv2d_1[0][0] conv2d_2[0][0]
batch_normalization_2 (BatchNor	(None, 32, 32, 48)	192	concatenate_1[0][0]
activation_2 (Activation)	(None, 32, 32, 48)	0	batch_normalization_2[0][0]
conv2d_3 (Conv2D)	(None, 32, 32, 24)	10368	activation_2[0][0]
concatenate_2 (Concatenate)	(None, 32, 32, 72)	0	concatenate_1[0][0] conv2d_3[0][0]
batch_normalization_3 (BatchNor	(None, 32, 32, 72)	288	concatenate_2[0][0]
activation_3 (Activation)	(None, 32, 32, 72)	0	batch_normalization_3[0][0]
conv2d_4 (Conv2D)	(None, 32, 32, 24)	15552	activation_3[0][0]
concatenate_3 (Concatenate)	(None, 32, 32, 96)	0	concatenate_2[0][0] conv2d_4[0][0]
batch_normalization_4 (BatchNor	(None, 32, 32, 96)	384	concatenate_3[0][0]
activation_4 (Activation)	(None, 32, 32, 96)	0	batch_normalization_4[0][0]
conv2d_5 (Conv2D)	(None, 32, 32, 24)	20736	activation_4[0][0]
concatenate_4 (Concatenate)	(None, 32, 32, 120)	0	concatenate_3[0][0] conv2d_5[0][0]
batch_normalization_5 (BatchNor	(None, 32, 32, 120)	480	concatenate_4[0][0]
activation_5 (Activation)	(None, 32, 32, 120)	0	batch_normalization_5[0][0]
conv2d_6 (Conv2D)	(None, 32, 32, 24)	25920	activation_5[0][0]
concatenate_5 (Concatenate)	(None, 32, 32, 144)	0	concatenate_4[0][0] conv2d_6[0][0]
batch_normalization_6 (BatchNor	(None, 32, 32, 144)	576	concatenate_5[0][0]
activation_6 (Activation)	(None, 32, 32, 144)	0	batch_normalization_6[0][0]
conv2d_7 (Conv2D)	(None, 32, 32, 24)	31104	activation_6[0][0]
concatenate_6 (Concatenate)	(None, 32, 32, 168)	0	concatenate_5[0][0] conv2d_7[0][0]
batch_normalization_7 (BatchNor	(None, 32, 32, 168)	672	concatenate_6[0][0]
activation_7 (Activation)	(None, 32, 32, 168)	0	batch_normalization_7[0][0]
conv2d_8 (Conv2D)	(None, 32, 32, 24)	36288	activation_7[0][0]
concatenate_7 (Concatenate)	(None, 32, 32, 192)	0	concatenate_6[0][0] conv2d_8[0][0]
batch_normalization_8 (BatchNor	(None, 32, 32, 192)	768	concatenate_7[0][0]
activation_8 (Activation)	(None, 32, 32, 192)	0	batch_normalization_8[0][0]
conv2d_9 (Conv2D)	(None, 32, 32, 24)	41472	activation_8[0][0]
concatenate_8 (Concatenate)	(None, 32, 32, 216)	0	concatenate_7[0][0] conv2d_9[0][0]
batch_normalization_9 (BatchNor	(None, 32, 32, 216)	864	concatenate_8[0][0]
activation_9 (Activation)	(None, 32, 32, 216)	0	batch_normalization_9[0][0]
conv2d_10 (Conv2D)	(None, 32, 32, 24)	46656	activation_9[0][0]
concatenate_9 (Concatenate)	(None, 32, 32, 240)	0	concatenate_8[0][0] conv2d_10[0][0]
batch_normalization_10 (BatchNo	(None, 32, 32, 240)	960	concatenate_9[0][0]

activation_10 (Activation)	(None, 32, 32, 240)	0	batch_normalization_10[0][0]
conv2d_11 (Conv2D)	(None, 32, 32, 24)	5760	activation_10[0][0]
average_pooling2d_1 (AveragePoo	(None, 16, 16, 24)	0	conv2d_11[0][0]
batch_normalization_11 (BatchNo	(None, 16, 16, 24)	96	average_pooling2d_1[0][0]
activation_11 (Activation)	(None, 16, 16, 24)	0	batch_normalization_11[0][0]
conv2d_12 (Conv2D)	(None, 16, 16, 24)	5184	activation_11[0][0]
concatenate_10 (Concatenate)	(None, 16, 16, 48)	0	average_pooling2d_1[0][0] conv2d_12[0][0]
batch_normalization_12 (BatchNo	(None, 16, 16, 48)	192	concatenate_10[0][0]
activation_12 (Activation)	(None, 16, 16, 48)	0	batch_normalization_12[0][0]
conv2d_13 (Conv2D)	(None, 16, 16, 24)	10368	activation_12[0][0]
concatenate_11 (Concatenate)	(None, 16, 16, 72)	0	concatenate_10[0][0] conv2d_13[0][0]
batch_normalization_13 (BatchNo	(None, 16, 16, 72)	288	concatenate_11[0][0]
activation_13 (Activation)	(None, 16, 16, 72)	0	batch_normalization_13[0][0]
conv2d_14 (Conv2D)	(None, 16, 16, 24)	15552	activation_13[0][0]
concatenate_12 (Concatenate)	(None, 16, 16, 96)	0	concatenate_11[0][0] conv2d_14[0][0]
batch_normalization_14 (BatchNo	(None, 16, 16, 96)	384	concatenate_12[0][0]
activation_14 (Activation)	(None, 16, 16, 96)	0	batch_normalization_14[0][0]
conv2d_15 (Conv2D)	(None, 16, 16, 24)	20736	activation_14[0][0]
concatenate_13 (Concatenate)	(None, 16, 16, 120)	0	concatenate_12[0][0] conv2d_15[0][0]
batch_normalization_15 (BatchNo	(None, 16, 16, 120)	480	concatenate_13[0][0]
activation_15 (Activation)	(None, 16, 16, 120)	0	batch_normalization_15[0][0]
conv2d_16 (Conv2D)	(None, 16, 16, 24)	25920	activation_15[0][0]
concatenate_14 (Concatenate)	(None, 16, 16, 144)	0	concatenate_13[0][0] conv2d_16[0][0]
batch_normalization_16 (BatchNo	(None, 16, 16, 144)	576	concatenate_14[0][0]
activation_16 (Activation)	(None, 16, 16, 144)	0	batch_normalization_16[0][0]
conv2d_17 (Conv2D)	(None, 16, 16, 24)	31104	activation_16[0][0]
concatenate_15 (Concatenate)	(None, 16, 16, 168)	0	concatenate_14[0][0] conv2d_17[0][0]
batch_normalization_17 (BatchNo	(None, 16, 16, 168)	672	concatenate_15[0][0]
activation_17 (Activation)	(None, 16, 16, 168)	0	batch_normalization_17[0][0]
conv2d_18 (Conv2D)	(None, 16, 16, 24)	36288	activation_17[0][0]
concatenate_16 (Concatenate)	(None, 16, 16, 192)	0	concatenate_15[0][0] conv2d_18[0][0]
batch_normalization_18 (BatchNo	(None, 16, 16, 192)	768	concatenate_16[0][0]
activation_18 (Activation)	(None, 16, 16, 192)	0	batch_normalization_18[0][0]
conv2d_19 (Conv2D)	(None, 16, 16, 24)	41472	activation_18[0][0]
concatenate_17 (Concatenate)	(None, 16, 16, 216)	0	concatenate_16[0][0]

			conv2d_19[0][0]
batch_normalization_19 (BatchNo	(None, 16, 16, 216)	864	concatenate_17[0][0]
activation_19 (Activation)	(None, 16, 16, 216)	0	batch_normalization_19[0][0]
conv2d_20 (Conv2D)	(None, 16, 16, 24)	46656	activation_19[0][0]
concatenate_18 (Concatenate)	(None, 16, 16, 240)	0	concatenate_17[0][0] conv2d_20[0][0]
batch_normalization_20 (BatchNo	(None, 16, 16, 240)	960	concatenate_18[0][0]
activation_20 (Activation)	(None, 16, 16, 240)	0	batch_normalization_20[0][0]
conv2d_21 (Conv2D)	(None, 16, 16, 24)	5760	activation_20[0][0]
average_pooling2d_2 (AveragePoo	(None, 8, 8, 24)	0	conv2d_21[0][0]
batch_normalization_21 (BatchNo	(None, 8, 8, 24)	96	average_pooling2d_2[0][0]
activation_21 (Activation)	(None, 8, 8, 24)	0	batch_normalization_21[0][0]
conv2d_22 (Conv2D)	(None, 8, 8, 24)	5184	activation_21[0][0]
concatenate_19 (Concatenate)	(None, 8, 8, 48)	0	average_pooling2d_2[0][0] conv2d_22[0][0]
batch_normalization_22 (BatchNo	(None, 8, 8, 48)	192	concatenate_19[0][0]
activation_22 (Activation)	(None, 8, 8, 48)	0	batch_normalization_22[0][0]
conv2d_23 (Conv2D)	(None, 8, 8, 24)	10368	activation_22[0][0]
concatenate_20 (Concatenate)	(None, 8, 8, 72)	0	concatenate_19[0][0] conv2d_23[0][0]
batch_normalization_23 (BatchNo	(None, 8, 8, 72)	288	concatenate_20[0][0]
activation_23 (Activation)	(None, 8, 8, 72)	0	batch_normalization_23[0][0]
conv2d_24 (Conv2D)	(None, 8, 8, 24)	15552	activation_23[0][0]
concatenate_21 (Concatenate)	(None, 8, 8, 96)	0	concatenate_20[0][0] conv2d_24[0][0]
batch_normalization_24 (BatchNo	(None, 8, 8, 96)	384	concatenate_21[0][0]
activation_24 (Activation)	(None, 8, 8, 96)	0	batch_normalization_24[0][0]
conv2d_25 (Conv2D)	(None, 8, 8, 24)	20736	activation_24[0][0]
concatenate_22 (Concatenate)	(None, 8, 8, 120)	0	concatenate_21[0][0] conv2d_25[0][0]
batch_normalization_25 (BatchNo	(None, 8, 8, 120)	480	concatenate_22[0][0]
activation_25 (Activation)	(None, 8, 8, 120)	0	batch_normalization_25[0][0]
conv2d_26 (Conv2D)	(None, 8, 8, 24)	25920	activation_25[0][0]
concatenate_23 (Concatenate)	(None, 8, 8, 144)	0	concatenate_22[0][0] conv2d_26[0][0]
batch_normalization_26 (BatchNo	(None, 8, 8, 144)	576	concatenate_23[0][0]
activation_26 (Activation)	(None, 8, 8, 144)	0	batch_normalization_26[0][0]
conv2d_27 (Conv2D)	(None, 8, 8, 24)	31104	activation_26[0][0]
concatenate_24 (Concatenate)	(None, 8, 8, 168)	0	concatenate_23[0][0] conv2d_27[0][0]
batch_normalization_27 (BatchNo	(None, 8, 8, 168)	672	concatenate_24[0][0]
activation_27 (Activation)	(None, 8, 8, 168)	0	batch_normalization_27[0][0]

conv2d_28 (Conv2D)	(None, 8, 8, 24)	36288	activation_27[0][0]
concatenate_25 (Concatenate)	(None, 8, 8, 192)	0	concatenate_24[0][0] conv2d_28[0][0]
batch_normalization_28 (BatchNo	(None, 8, 8, 192)	768	concatenate_25[0][0]
activation_28 (Activation)	(None, 8, 8, 192)	0	batch_normalization_28[0][0]
conv2d_29 (Conv2D)	(None, 8, 8, 24)	41472	activation_28[0][0]
concatenate_26 (Concatenate)	(None, 8, 8, 216)	0	concatenate_25[0][0] conv2d_29[0][0]
batch_normalization_29 (BatchNo	(None, 8, 8, 216)	864	concatenate_26[0][0]
activation_29 (Activation)	(None, 8, 8, 216)	0	batch_normalization_29[0][0]
conv2d_30 (Conv2D)	(None, 8, 8, 24)	46656	activation_29[0][0]
concatenate_27 (Concatenate)	(None, 8, 8, 240)	0	concatenate_26[0][0] conv2d_30[0][0]
batch_normalization_30 (BatchNo	(None, 8, 8, 240)	960	concatenate_27[0][0]
activation_30 (Activation)	(None, 8, 8, 240)	0	batch_normalization_30[0][0]
conv2d_31 (Conv2D)	(None, 8, 8, 24)	5760	activation_30[0][0]
average_pooling2d_3 (AveragePoo	(None, 4, 4, 24)	0	conv2d_31[0][0]
batch_normalization_31 (BatchNo	(None, 4, 4, 24)	96	average_pooling2d_3[0][0]
activation_31 (Activation)	(None, 4, 4, 24)	0	batch_normalization_31[0][0]
conv2d_32 (Conv2D)	(None, 4, 4, 24)	5184	activation_31[0][0]
concatenate_28 (Concatenate)	(None, 4, 4, 48)	0	average_pooling2d_3[0][0] conv2d_32[0][0]
batch_normalization_32 (BatchNo	(None, 4, 4, 48)	192	concatenate_28[0][0]
activation_32 (Activation)	(None, 4, 4, 48)	0	batch_normalization_32[0][0]
conv2d_33 (Conv2D)	(None, 4, 4, 24)	10368	activation_32[0][0]
concatenate_29 (Concatenate)	(None, 4, 4, 72)	0	concatenate_28[0][0] conv2d_33[0][0]
batch_normalization_33 (BatchNo	(None, 4, 4, 72)	288	concatenate_29[0][0]
activation_33 (Activation)	(None, 4, 4, 72)	0	batch_normalization_33[0][0]
conv2d_34 (Conv2D)	(None, 4, 4, 24)	15552	activation_33[0][0]
concatenate_30 (Concatenate)	(None, 4, 4, 96)	0	concatenate_29[0][0] conv2d_34[0][0]
batch_normalization_34 (BatchNo	(None, 4, 4, 96)	384	concatenate_30[0][0]
activation_34 (Activation)	(None, 4, 4, 96)	0	batch_normalization_34[0][0]
conv2d_35 (Conv2D)	(None, 4, 4, 24)	20736	activation_34[0][0]
concatenate_31 (Concatenate)	(None, 4, 4, 120)	0	concatenate_30[0][0] conv2d_35[0][0]
batch_normalization_35 (BatchNo	(None, 4, 4, 120)	480	concatenate_31[0][0]
activation_35 (Activation)	(None, 4, 4, 120)	0	batch_normalization_35[0][0]
conv2d_36 (Conv2D)	(None, 4, 4, 24)	25920	activation_35[0][0]
concatenate_32 (Concatenate)	(None, 4, 4, 144)	0	concatenate_31[0][0] conv2d_36[0][0]
batch_normalization_36 (BatchNo	(None, 4, 4, 144)	576	concatenate_32[0][0]

```
activation_36 (Activation)       (None, 4, 4, 144)     0           batch_normalization_36[0][0]
conv2d_37 (Conv2D)               (None, 4, 4, 24)      31104       activation_36[0][0]
concatenate_33 (Concatenate)     (None, 4, 4, 168)     0           concatenate_32[0][0]
                                                                   conv2d_37[0][0]
batch_normalization_37 (BatchNo (None, 4, 4, 168)     672         concatenate_33[0][0]
activation_37 (Activation)       (None, 4, 4, 168)     0           batch_normalization_37[0][0]
conv2d_38 (Conv2D)               (None, 4, 4, 24)      36288       activation_37[0][0]
concatenate_34 (Concatenate)     (None, 4, 4, 192)     0           concatenate_33[0][0]
                                                                   conv2d_38[0][0]
batch_normalization_38 (BatchNo (None, 4, 4, 192)     768         concatenate_34[0][0]
activation_38 (Activation)       (None, 4, 4, 192)     0           batch_normalization_38[0][0]
conv2d_39 (Conv2D)               (None, 4, 4, 24)      41472       activation_38[0][0]
concatenate_35 (Concatenate)     (None, 4, 4, 216)     0           concatenate_34[0][0]
                                                                   conv2d_39[0][0]
batch_normalization_39 (BatchNo (None, 4, 4, 216)     864         concatenate_35[0][0]
activation_39 (Activation)       (None, 4, 4, 216)     0           batch_normalization_39[0][0]
conv2d_40 (Conv2D)               (None, 4, 4, 24)      46656       activation_39[0][0]
concatenate_36 (Concatenate)     (None, 4, 4, 240)     0           concatenate_35[0][0]
                                                                   conv2d_40[0][0]
batch_normalization_40 (BatchNo (None, 4, 4, 240)     960         concatenate_36[0][0]
activation_40 (Activation)       (None, 4, 4, 240)     0           batch_normalization_40[0][0]
average_pooling2d_4 (AveragePoo (None, 2, 2, 240)     0           activation_40[0][0]
conv2d_41 (Conv2D)               (None, 2, 2, 10)      2400        average_pooling2d_4[0][0]
global_max_pooling2d_1 (GlobalM (None, 10)            0           conv2d_41[0][0]
activation_41 (Activation)       (None, 10)            0           global_max_pooling2d_1[0][0]
==================================================================================================
Total params: 974,568
Trainable params: 964,008
Non-trainable params: 10,560
__________________________________________________________________________________________________
```

In [0]:

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

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

In [0]:

```
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')
```

In [0]:

In [0]:

```
filepath = "{epoch:03d}-{val_accuracy:.3f}.hdf5"
model_chkpt = ModelCheckpoint(filepath, monitor = 'val_accuracy', save_best_only=True, verbose = 1)
```

In [0]:

```
model.compile(loss='categorical_crossentropy',
              optimizer=Adam(),#SGD(lr=0.1, momentum=0.9, decay=0.0001, nesterov=True),
              metrics=['accuracy'])
model.summary()
```

Model: "model_1"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	(None, 32, 32, 3)	0	
conv2d_1 (Conv2D)	(None, 32, 32, 24)	648	input_1[0][0]
batch_normalization_1 (BatchNor	(None, 32, 32, 24)	96	conv2d_1[0][0]
activation_1 (Activation)	(None, 32, 32, 24)	0	batch_normalization_1[0][0]
conv2d_2 (Conv2D)	(None, 32, 32, 24)	5184	activation_1[0][0]
concatenate_1 (Concatenate)	(None, 32, 32, 48)	0	conv2d_1[0][0] conv2d_2[0][0]
batch_normalization_2 (BatchNor	(None, 32, 32, 48)	192	concatenate_1[0][0]
activation_2 (Activation)	(None, 32, 32, 48)	0	batch_normalization_2[0][0]
conv2d_3 (Conv2D)	(None, 32, 32, 24)	10368	activation_2[0][0]
concatenate_2 (Concatenate)	(None, 32, 32, 72)	0	concatenate_1[0][0] conv2d_3[0][0]
batch_normalization_3 (BatchNor	(None, 32, 32, 72)	288	concatenate_2[0][0]
activation_3 (Activation)	(None, 32, 32, 72)	0	batch_normalization_3[0][0]
conv2d_4 (Conv2D)	(None, 32, 32, 24)	15552	activation_3[0][0]
concatenate_3 (Concatenate)	(None, 32, 32, 96)	0	concatenate_2[0][0] conv2d_4[0][0]
batch_normalization_4 (BatchNor	(None, 32, 32, 96)	384	concatenate_3[0][0]
activation_4 (Activation)	(None, 32, 32, 96)	0	batch_normalization_4[0][0]
conv2d_5 (Conv2D)	(None, 32, 32, 24)	20736	activation_4[0][0]
concatenate_4 (Concatenate)	(None, 32, 32, 120)	0	concatenate_3[0][0] conv2d_5[0][0]
batch_normalization_5 (BatchNor	(None, 32, 32, 120)	480	concatenate_4[0][0]
activation_5 (Activation)	(None, 32, 32, 120)	0	batch_normalization_5[0][0]
conv2d_6 (Conv2D)	(None, 32, 32, 24)	25920	activation_5[0][0]
concatenate_5 (Concatenate)	(None, 32, 32, 144)	0	concatenate_4[0][0] conv2d_6[0][0]
batch_normalization_6 (BatchNor	(None, 32, 32, 144)	576	concatenate_5[0][0]
activation_6 (Activation)	(None, 32, 32, 144)	0	batch_normalization_6[0][0]
conv2d_7 (Conv2D)	(None, 32, 32, 24)	31104	activation_6[0][0]
concatenate_6 (Concatenate)	(None, 32, 32, 168)	0	concatenate_5[0][0] conv2d_7[0][0]
batch_normalization_7 (BatchNor	(None, 32, 32, 168)	672	concatenate_6[0][0]

activation_7 (Activation)	(None, 32, 32, 168)	0	batch_normalization_7[0][0]
conv2d_8 (Conv2D)	(None, 32, 32, 24)	36288	activation_7[0][0]
concatenate_7 (Concatenate)	(None, 32, 32, 192)	0	concatenate_6[0][0] conv2d_8[0][0]
batch_normalization_8 (BatchNor	(None, 32, 32, 192)	768	concatenate_7[0][0]
activation_8 (Activation)	(None, 32, 32, 192)	0	batch_normalization_8[0][0]
conv2d_9 (Conv2D)	(None, 32, 32, 24)	41472	activation_8[0][0]
concatenate_8 (Concatenate)	(None, 32, 32, 216)	0	concatenate_7[0][0] conv2d_9[0][0]
batch_normalization_9 (BatchNor	(None, 32, 32, 216)	864	concatenate_8[0][0]
activation_9 (Activation)	(None, 32, 32, 216)	0	batch_normalization_9[0][0]
conv2d_10 (Conv2D)	(None, 32, 32, 24)	46656	activation_9[0][0]
concatenate_9 (Concatenate)	(None, 32, 32, 240)	0	concatenate_8[0][0] conv2d_10[0][0]
batch_normalization_10 (BatchNo	(None, 32, 32, 240)	960	concatenate_9[0][0]
activation_10 (Activation)	(None, 32, 32, 240)	0	batch_normalization_10[0][0]
conv2d_11 (Conv2D)	(None, 32, 32, 24)	5760	activation_10[0][0]
average_pooling2d_1 (AveragePoo	(None, 16, 16, 24)	0	conv2d_11[0][0]
batch_normalization_11 (BatchNo	(None, 16, 16, 24)	96	average_pooling2d_1[0][0]
activation_11 (Activation)	(None, 16, 16, 24)	0	batch_normalization_11[0][0]
conv2d_12 (Conv2D)	(None, 16, 16, 24)	5184	activation_11[0][0]
concatenate_10 (Concatenate)	(None, 16, 16, 48)	0	average_pooling2d_1[0][0] conv2d_12[0][0]
batch_normalization_12 (BatchNo	(None, 16, 16, 48)	192	concatenate_10[0][0]
activation_12 (Activation)	(None, 16, 16, 48)	0	batch_normalization_12[0][0]
conv2d_13 (Conv2D)	(None, 16, 16, 24)	10368	activation_12[0][0]
concatenate_11 (Concatenate)	(None, 16, 16, 72)	0	concatenate_10[0][0] conv2d_13[0][0]
batch_normalization_13 (BatchNo	(None, 16, 16, 72)	288	concatenate_11[0][0]
activation_13 (Activation)	(None, 16, 16, 72)	0	batch_normalization_13[0][0]
conv2d_14 (Conv2D)	(None, 16, 16, 24)	15552	activation_13[0][0]
concatenate_12 (Concatenate)	(None, 16, 16, 96)	0	concatenate_11[0][0] conv2d_14[0][0]
batch_normalization_14 (BatchNo	(None, 16, 16, 96)	384	concatenate_12[0][0]
activation_14 (Activation)	(None, 16, 16, 96)	0	batch_normalization_14[0][0]
conv2d_15 (Conv2D)	(None, 16, 16, 24)	20736	activation_14[0][0]
concatenate_13 (Concatenate)	(None, 16, 16, 120)	0	concatenate_12[0][0] conv2d_15[0][0]
batch_normalization_15 (BatchNo	(None, 16, 16, 120)	480	concatenate_13[0][0]
activation_15 (Activation)	(None, 16, 16, 120)	0	batch_normalization_15[0][0]
conv2d_16 (Conv2D)	(None, 16, 16, 24)	25920	activation_15[0][0]
concatenate_14 (Concatenate)	(None, 16, 16, 144)	0	concatenate_13[0][0] conv2d_16[0][0]

batch_normalization_16 (BatchNo	(None, 16, 16, 144)	576	concatenate_14[0][0]
activation_16 (Activation)	(None, 16, 16, 144)	0	batch_normalization_16[0][0]
conv2d_17 (Conv2D)	(None, 16, 16, 24)	31104	activation_16[0][0]
concatenate_15 (Concatenate)	(None, 16, 16, 168)	0	concatenate_14[0][0] conv2d_17[0][0]
batch_normalization_17 (BatchNo	(None, 16, 16, 168)	672	concatenate_15[0][0]
activation_17 (Activation)	(None, 16, 16, 168)	0	batch_normalization_17[0][0]
conv2d_18 (Conv2D)	(None, 16, 16, 24)	36288	activation_17[0][0]
concatenate_16 (Concatenate)	(None, 16, 16, 192)	0	concatenate_15[0][0] conv2d_18[0][0]
batch_normalization_18 (BatchNo	(None, 16, 16, 192)	768	concatenate_16[0][0]
activation_18 (Activation)	(None, 16, 16, 192)	0	batch_normalization_18[0][0]
conv2d_19 (Conv2D)	(None, 16, 16, 24)	41472	activation_18[0][0]
concatenate_17 (Concatenate)	(None, 16, 16, 216)	0	concatenate_16[0][0] conv2d_19[0][0]
batch_normalization_19 (BatchNo	(None, 16, 16, 216)	864	concatenate_17[0][0]
activation_19 (Activation)	(None, 16, 16, 216)	0	batch_normalization_19[0][0]
conv2d_20 (Conv2D)	(None, 16, 16, 24)	46656	activation_19[0][0]
concatenate_18 (Concatenate)	(None, 16, 16, 240)	0	concatenate_17[0][0] conv2d_20[0][0]
batch_normalization_20 (BatchNo	(None, 16, 16, 240)	960	concatenate_18[0][0]
activation_20 (Activation)	(None, 16, 16, 240)	0	batch_normalization_20[0][0]
conv2d_21 (Conv2D)	(None, 16, 16, 24)	5760	activation_20[0][0]
average_pooling2d_2 (AveragePoo	(None, 8, 8, 24)	0	conv2d_21[0][0]
batch_normalization_21 (BatchNo	(None, 8, 8, 24)	96	average_pooling2d_2[0][0]
activation_21 (Activation)	(None, 8, 8, 24)	0	batch_normalization_21[0][0]
conv2d_22 (Conv2D)	(None, 8, 8, 24)	5184	activation_21[0][0]
concatenate_19 (Concatenate)	(None, 8, 8, 48)	0	average_pooling2d_2[0][0] conv2d_22[0][0]
batch_normalization_22 (BatchNo	(None, 8, 8, 48)	192	concatenate_19[0][0]
activation_22 (Activation)	(None, 8, 8, 48)	0	batch_normalization_22[0][0]
conv2d_23 (Conv2D)	(None, 8, 8, 24)	10368	activation_22[0][0]
concatenate_20 (Concatenate)	(None, 8, 8, 72)	0	concatenate_19[0][0] conv2d_23[0][0]
batch_normalization_23 (BatchNo	(None, 8, 8, 72)	288	concatenate_20[0][0]
activation_23 (Activation)	(None, 8, 8, 72)	0	batch_normalization_23[0][0]
conv2d_24 (Conv2D)	(None, 8, 8, 24)	15552	activation_23[0][0]
concatenate_21 (Concatenate)	(None, 8, 8, 96)	0	concatenate_20[0][0] conv2d_24[0][0]
batch_normalization_24 (BatchNo	(None, 8, 8, 96)	384	concatenate_21[0][0]
activation_24 (Activation)	(None, 8, 8, 96)	0	batch_normalization_24[0][0]
conv2d_25 (Conv2D)	(None, 8, 8, 24)	20736	activation_24[0][0]

concatenate_22 (Concatenate)	(None, 8, 8, 120)	0	concatenate_21[0][0] conv2d_25[0][0]
batch_normalization_25 (BatchNo	(None, 8, 8, 120)	480	concatenate_22[0][0]
activation_25 (Activation)	(None, 8, 8, 120)	0	batch_normalization_25[0][0]
conv2d_26 (Conv2D)	(None, 8, 8, 24)	25920	activation_25[0][0]
concatenate_23 (Concatenate)	(None, 8, 8, 144)	0	concatenate_22[0][0] conv2d_26[0][0]
batch_normalization_26 (BatchNo	(None, 8, 8, 144)	576	concatenate_23[0][0]
activation_26 (Activation)	(None, 8, 8, 144)	0	batch_normalization_26[0][0]
conv2d_27 (Conv2D)	(None, 8, 8, 24)	31104	activation_26[0][0]
concatenate_24 (Concatenate)	(None, 8, 8, 168)	0	concatenate_23[0][0] conv2d_27[0][0]
batch_normalization_27 (BatchNo	(None, 8, 8, 168)	672	concatenate_24[0][0]
activation_27 (Activation)	(None, 8, 8, 168)	0	batch_normalization_27[0][0]
conv2d_28 (Conv2D)	(None, 8, 8, 24)	36288	activation_27[0][0]
concatenate_25 (Concatenate)	(None, 8, 8, 192)	0	concatenate_24[0][0] conv2d_28[0][0]
batch_normalization_28 (BatchNo	(None, 8, 8, 192)	768	concatenate_25[0][0]
activation_28 (Activation)	(None, 8, 8, 192)	0	batch_normalization_28[0][0]
conv2d_29 (Conv2D)	(None, 8, 8, 24)	41472	activation_28[0][0]
concatenate_26 (Concatenate)	(None, 8, 8, 216)	0	concatenate_25[0][0] conv2d_29[0][0]
batch_normalization_29 (BatchNo	(None, 8, 8, 216)	864	concatenate_26[0][0]
activation_29 (Activation)	(None, 8, 8, 216)	0	batch_normalization_29[0][0]
conv2d_30 (Conv2D)	(None, 8, 8, 24)	46656	activation_29[0][0]
concatenate_27 (Concatenate)	(None, 8, 8, 240)	0	concatenate_26[0][0] conv2d_30[0][0]
batch_normalization_30 (BatchNo	(None, 8, 8, 240)	960	concatenate_27[0][0]
activation_30 (Activation)	(None, 8, 8, 240)	0	batch_normalization_30[0][0]
conv2d_31 (Conv2D)	(None, 8, 8, 24)	5760	activation_30[0][0]
average_pooling2d_3 (AveragePoo	(None, 4, 4, 24)	0	conv2d_31[0][0]
batch_normalization_31 (BatchNo	(None, 4, 4, 24)	96	average_pooling2d_3[0][0]
activation_31 (Activation)	(None, 4, 4, 24)	0	batch_normalization_31[0][0]
conv2d_32 (Conv2D)	(None, 4, 4, 24)	5184	activation_31[0][0]
concatenate_28 (Concatenate)	(None, 4, 4, 48)	0	average_pooling2d_3[0][0] conv2d_32[0][0]
batch_normalization_32 (BatchNo	(None, 4, 4, 48)	192	concatenate_28[0][0]
activation_32 (Activation)	(None, 4, 4, 48)	0	batch_normalization_32[0][0]
conv2d_33 (Conv2D)	(None, 4, 4, 24)	10368	activation_32[0][0]
concatenate_29 (Concatenate)	(None, 4, 4, 72)	0	concatenate_28[0][0] conv2d_33[0][0]
batch_normalization_33 (BatchNo	(None, 4, 4, 72)	288	concatenate_29[0][0]

```
activation_33 (Activation)      (None, 4, 4, 72)     0           batch_normalization_33[0][0]
__________________________________________________________________________________________________
conv2d_34 (Conv2D)              (None, 4, 4, 24)     15552       activation_33[0][0]
__________________________________________________________________________________________________
concatenate_30 (Concatenate)    (None, 4, 4, 96)     0           concatenate_29[0][0]
                                                                 conv2d_34[0][0]
__________________________________________________________________________________________________
batch_normalization_34 (BatchNo (None, 4, 4, 96)     384         concatenate_30[0][0]
__________________________________________________________________________________________________
activation_34 (Activation)      (None, 4, 4, 96)     0           batch_normalization_34[0][0]
__________________________________________________________________________________________________
conv2d_35 (Conv2D)              (None, 4, 4, 24)     20736       activation_34[0][0]
__________________________________________________________________________________________________
concatenate_31 (Concatenate)    (None, 4, 4, 120)    0           concatenate_30[0][0]
                                                                 conv2d_35[0][0]
__________________________________________________________________________________________________
batch_normalization_35 (BatchNo (None, 4, 4, 120)    480         concatenate_31[0][0]
__________________________________________________________________________________________________
activation_35 (Activation)      (None, 4, 4, 120)    0           batch_normalization_35[0][0]
__________________________________________________________________________________________________
conv2d_36 (Conv2D)              (None, 4, 4, 24)     25920       activation_35[0][0]
__________________________________________________________________________________________________
concatenate_32 (Concatenate)    (None, 4, 4, 144)    0           concatenate_31[0][0]
                                                                 conv2d_36[0][0]
__________________________________________________________________________________________________
batch_normalization_36 (BatchNo (None, 4, 4, 144)    576         concatenate_32[0][0]
__________________________________________________________________________________________________
activation_36 (Activation)      (None, 4, 4, 144)    0           batch_normalization_36[0][0]
__________________________________________________________________________________________________
conv2d_37 (Conv2D)              (None, 4, 4, 24)     31104       activation_36[0][0]
__________________________________________________________________________________________________
concatenate_33 (Concatenate)    (None, 4, 4, 168)    0           concatenate_32[0][0]
                                                                 conv2d_37[0][0]
__________________________________________________________________________________________________
batch_normalization_37 (BatchNo (None, 4, 4, 168)    672         concatenate_33[0][0]
__________________________________________________________________________________________________
activation_37 (Activation)      (None, 4, 4, 168)    0           batch_normalization_37[0][0]
__________________________________________________________________________________________________
conv2d_38 (Conv2D)              (None, 4, 4, 24)     36288       activation_37[0][0]
__________________________________________________________________________________________________
concatenate_34 (Concatenate)    (None, 4, 4, 192)    0           concatenate_33[0][0]
                                                                 conv2d_38[0][0]
__________________________________________________________________________________________________
batch_normalization_38 (BatchNo (None, 4, 4, 192)    768         concatenate_34[0][0]
__________________________________________________________________________________________________
activation_38 (Activation)      (None, 4, 4, 192)    0           batch_normalization_38[0][0]
__________________________________________________________________________________________________
conv2d_39 (Conv2D)              (None, 4, 4, 24)     41472       activation_38[0][0]
__________________________________________________________________________________________________
concatenate_35 (Concatenate)    (None, 4, 4, 216)    0           concatenate_34[0][0]
                                                                 conv2d_39[0][0]
__________________________________________________________________________________________________
batch_normalization_39 (BatchNo (None, 4, 4, 216)    864         concatenate_35[0][0]
__________________________________________________________________________________________________
activation_39 (Activation)      (None, 4, 4, 216)    0           batch_normalization_39[0][0]
__________________________________________________________________________________________________
conv2d_40 (Conv2D)              (None, 4, 4, 24)     46656       activation_39[0][0]
__________________________________________________________________________________________________
concatenate_36 (Concatenate)    (None, 4, 4, 240)    0           concatenate_35[0][0]
                                                                 conv2d_40[0][0]
__________________________________________________________________________________________________
batch_normalization_40 (BatchNo (None, 4, 4, 240)    960         concatenate_36[0][0]
__________________________________________________________________________________________________
activation_40 (Activation)      (None, 4, 4, 240)    0           batch_normalization_40[0][0]
__________________________________________________________________________________________________
average_pooling2d_4 (AveragePoo (None, 2, 2, 240)    0           activation_40[0][0]
__________________________________________________________________________________________________
conv2d_41 (Conv2D)              (None, 2, 2, 10)     2400        average_pooling2d_4[0][0]
__________________________________________________________________________________________________
global_max_pooling2d_1 (GlobalM (None, 10)           0           conv2d_41[0][0]
__________________________________________________________________________________________________
activation_41 (Activation)      (None, 10)           0           global_max_pooling2d_1[0][0]
==================================================================================================
Total params: 974,568
Trainable params: 964,008
Non-trainable params: 10,560
__________________________________________________________________________________________________
```

In [0]:

```
history = 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 = 2,
    validation_data=(X_test, y_test),
    callbacks = [model_chkpt, early_stop]
)
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:422: The name tf.global_variables is deprecated. Plea
se use tf.compat.v1.global_variables instead.

Epoch 1/150
 - 246s - loss: 1.0587 - accuracy: 0.6205 - val_loss: 0.9501 - val_accuracy: 0.6849

Epoch 00001: val_accuracy improved from -inf to 0.68490, saving model to 001-0.685.hdf5
Epoch 2/150
 - 232s - loss: 0.6046 - accuracy: 0.7899 - val_loss: 0.9797 - val_accuracy: 0.7065

Epoch 00002: val_accuracy improved from 0.68490 to 0.70650, saving model to 002-0.706.hdf5
Epoch 3/150
 - 232s - loss: 0.4676 - accuracy: 0.8376 - val_loss: 0.5694 - val_accuracy: 0.8145

Epoch 00003: val_accuracy improved from 0.70650 to 0.81450, saving model to 003-0.814.hdf5
Epoch 4/150
 - 232s - loss: 0.3899 - accuracy: 0.8647 - val_loss: 0.4849 - val_accuracy: 0.8446

Epoch 00004: val_accuracy improved from 0.81450 to 0.84460, saving model to 004-0.845.hdf5
Epoch 5/150
 - 232s - loss: 0.3370 - accuracy: 0.8820 - val_loss: 0.4464 - val_accuracy: 0.8512

Epoch 00005: val_accuracy improved from 0.84460 to 0.85120, saving model to 005-0.851.hdf5
Epoch 6/150
 - 231s - loss: 0.2964 - accuracy: 0.8967 - val_loss: 0.5265 - val_accuracy: 0.8343

Epoch 00006: val_accuracy did not improve from 0.85120
Epoch 7/150
 - 231s - loss: 0.2606 - accuracy: 0.9091 - val_loss: 0.3698 - val_accuracy: 0.8822

Epoch 00007: val_accuracy improved from 0.85120 to 0.88220, saving model to 007-0.882.hdf5
Epoch 8/150
 - 231s - loss: 0.2356 - accuracy: 0.9183 - val_loss: 0.4749 - val_accuracy: 0.8586

Epoch 00008: val_accuracy did not improve from 0.88220
Epoch 9/150
 - 233s - loss: 0.2140 - accuracy: 0.9246 - val_loss: 0.5490 - val_accuracy: 0.8462

Epoch 00009: val_accuracy did not improve from 0.88220
Epoch 10/150
 - 234s - loss: 0.1963 - accuracy: 0.9310 - val_loss: 0.3899 - val_accuracy: 0.8797

Epoch 00010: val_accuracy did not improve from 0.88220
Epoch 11/150
 - 233s - loss: 0.1792 - accuracy: 0.9365 - val_loss: 0.4276 - val_accuracy: 0.8777

Epoch 00011: val_accuracy did not improve from 0.88220
Epoch 12/150
 - 232s - loss: 0.1671 - accuracy: 0.9412 - val_loss: 0.3884 - val_accuracy: 0.8864

Epoch 00012: val_accuracy improved from 0.88220 to 0.88640, saving model to 012-0.886.hdf5
Epoch 13/150
 - 233s - loss: 0.1554 - accuracy: 0.9449 - val_loss: 0.4333 - val_accuracy: 0.8721

Epoch 00013: val_accuracy did not improve from 0.88640
Epoch 14/150
 - 232s - loss: 0.1430 - accuracy: 0.9493 - val_loss: 0.3686 - val_accuracy: 0.8935

Epoch 00014: val_accuracy improved from 0.88640 to 0.89350, saving model to 014-0.893.hdf5
Epoch 15/150
 - 232s - loss: 0.1340 - accuracy: 0.9522 - val_loss: 0.3495 - val_accuracy: 0.8967

Epoch 00015: val_accuracy improved from 0.89350 to 0.89670, saving model to 015-0.897.hdf5
```

```
Epoch 00015: val_accuracy improved from 0.89350 to 0.89670, saving model to 015-0.897.hdf5
Epoch 16/150
 - 232s - loss: 0.1242 - accuracy: 0.9559 - val_loss: 0.3584 - val_accuracy: 0.8995

Epoch 00016: val_accuracy improved from 0.89670 to 0.89950, saving model to 016-0.900.hdf5
Epoch 17/150
 - 233s - loss: 0.1176 - accuracy: 0.9584 - val_loss: 0.3525 - val_accuracy: 0.9027

Epoch 00017: val_accuracy improved from 0.89950 to 0.90270, saving model to 017-0.903.hdf5
Epoch 18/150
 - 232s - loss: 0.1129 - accuracy: 0.9599 - val_loss: 0.4571 - val_accuracy: 0.8809

Epoch 00018: val_accuracy did not improve from 0.90270
Epoch 19/150
 - 232s - loss: 0.1051 - accuracy: 0.9625 - val_loss: 0.4063 - val_accuracy: 0.8971

Epoch 00019: val_accuracy did not improve from 0.90270
Epoch 20/150
 - 232s - loss: 0.1005 - accuracy: 0.9645 - val_loss: 0.3349 - val_accuracy: 0.9074

Epoch 00020: val_accuracy improved from 0.90270 to 0.90740, saving model to 020-0.907.hdf5
Epoch 21/150
 - 232s - loss: 0.0963 - accuracy: 0.9661 - val_loss: 0.3973 - val_accuracy: 0.8994

Epoch 00021: val_accuracy did not improve from 0.90740
Epoch 22/150
 - 232s - loss: 0.0922 - accuracy: 0.9675 - val_loss: 0.3651 - val_accuracy: 0.9028

Epoch 00022: val_accuracy did not improve from 0.90740
Epoch 23/150
 - 232s - loss: 0.0872 - accuracy: 0.9689 - val_loss: 0.3826 - val_accuracy: 0.9004

Epoch 00023: val_accuracy did not improve from 0.90740
Epoch 24/150
 - 232s - loss: 0.0840 - accuracy: 0.9704 - val_loss: 0.4157 - val_accuracy: 0.8979

Epoch 00024: val_accuracy did not improve from 0.90740
Epoch 25/150
 - 234s - loss: 0.0801 - accuracy: 0.9714 - val_loss: 0.4416 - val_accuracy: 0.8958

Epoch 00025: val_accuracy did not improve from 0.90740
Epoch 26/150
 - 234s - loss: 0.0781 - accuracy: 0.9726 - val_loss: 0.3744 - val_accuracy: 0.9085

Epoch 00026: val_accuracy improved from 0.90740 to 0.90850, saving model to 026-0.909.hdf5
Epoch 27/150
 - 233s - loss: 0.0750 - accuracy: 0.9734 - val_loss: 0.4448 - val_accuracy: 0.8954

Epoch 00027: val_accuracy did not improve from 0.90850
Epoch 28/150
 - 232s - loss: 0.0714 - accuracy: 0.9746 - val_loss: 0.4535 - val_accuracy: 0.8972

Epoch 00028: val_accuracy did not improve from 0.90850
Epoch 29/150
 - 232s - loss: 0.0696 - accuracy: 0.9756 - val_loss: 0.5164 - val_accuracy: 0.8848

Epoch 00029: val_accuracy did not improve from 0.90850
Epoch 30/150
 - 232s - loss: 0.0664 - accuracy: 0.9766 - val_loss: 0.5058 - val_accuracy: 0.8879

Epoch 00030: val_accuracy did not improve from 0.90850
```

In [0]:

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

```
10000/10000 [==============================] - 4s 417us/step
Test loss: 0.5058346040025353
Test accuracy: 0.8878999948501587
```

In [0]:

```
# reduce lr = ReduceLROnPlateau(monitor = 'val loss', factor = 0.1, patience = 5, min lr = 0.00000
```

```
1)

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')


filepath = "{epoch:03d}-{val_accuracy:.3f}.hdf5"
model_chkpt = ModelCheckpoint(filepath, monitor = 'val_accuracy', save_best_only=True, verbose = 1)


#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='au
')


model.load_weights('026-0.909.hdf5')


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 = 30,
    validation_data=(X_test, y_test),
    callbacks=[model_chkpt,early_stop])
```

```
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            (None, 32, 32, 3)    0
__________________________________________________________________________________________________
conv2d_1 (Conv2D)               (None, 32, 32, 24)   648         input_1[0][0]
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 32, 32, 24)   96          conv2d_1[0][0]
__________________________________________________________________________________________________
activation_1 (Activation)       (None, 32, 32, 24)   0           batch_normalization_1[0][0]
__________________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 32, 32, 24)   5184        activation_1[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 32, 32, 48)   0           conv2d_1[0][0]
                                                                 conv2d_2[0][0]
__________________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, 32, 32, 48)   192         concatenate_1[0][0]
__________________________________________________________________________________________________
activation_2 (Activation)       (None, 32, 32, 48)   0           batch_normalization_2[0][0]
__________________________________________________________________________________________________
conv2d_3 (Conv2D)               (None, 32, 32, 24)   10368       activation_2[0][0]
__________________________________________________________________________________________________
concatenate_2 (Concatenate)     (None, 32, 32, 72)   0           concatenate_1[0][0]
                                                                 conv2d_3[0][0]
__________________________________________________________________________________________________
batch_normalization_3 (BatchNor (None, 32, 32, 72)   288         concatenate_2[0][0]
__________________________________________________________________________________________________
```

activation_3 (Activation)	(None, 32, 32, 72)	0	batch_normalization_3[0][0]
conv2d_4 (Conv2D)	(None, 32, 32, 24)	15552	activation_3[0][0]
concatenate_3 (Concatenate)	(None, 32, 32, 96)	0	concatenate_2[0][0] conv2d_4[0][0]
batch_normalization_4 (BatchNor	(None, 32, 32, 96)	384	concatenate_3[0][0]
activation_4 (Activation)	(None, 32, 32, 96)	0	batch_normalization_4[0][0]
conv2d_5 (Conv2D)	(None, 32, 32, 24)	20736	activation_4[0][0]
concatenate_4 (Concatenate)	(None, 32, 32, 120)	0	concatenate_3[0][0] conv2d_5[0][0]
batch_normalization_5 (BatchNor	(None, 32, 32, 120)	480	concatenate_4[0][0]
activation_5 (Activation)	(None, 32, 32, 120)	0	batch_normalization_5[0][0]
conv2d_6 (Conv2D)	(None, 32, 32, 24)	25920	activation_5[0][0]
concatenate_5 (Concatenate)	(None, 32, 32, 144)	0	concatenate_4[0][0] conv2d_6[0][0]
batch_normalization_6 (BatchNor	(None, 32, 32, 144)	576	concatenate_5[0][0]
activation_6 (Activation)	(None, 32, 32, 144)	0	batch_normalization_6[0][0]
conv2d_7 (Conv2D)	(None, 32, 32, 24)	31104	activation_6[0][0]
concatenate_6 (Concatenate)	(None, 32, 32, 168)	0	concatenate_5[0][0] conv2d_7[0][0]
batch_normalization_7 (BatchNor	(None, 32, 32, 168)	672	concatenate_6[0][0]
activation_7 (Activation)	(None, 32, 32, 168)	0	batch_normalization_7[0][0]
conv2d_8 (Conv2D)	(None, 32, 32, 24)	36288	activation_7[0][0]
concatenate_7 (Concatenate)	(None, 32, 32, 192)	0	concatenate_6[0][0] conv2d_8[0][0]
batch_normalization_8 (BatchNor	(None, 32, 32, 192)	768	concatenate_7[0][0]
activation_8 (Activation)	(None, 32, 32, 192)	0	batch_normalization_8[0][0]
conv2d_9 (Conv2D)	(None, 32, 32, 24)	41472	activation_8[0][0]
concatenate_8 (Concatenate)	(None, 32, 32, 216)	0	concatenate_7[0][0] conv2d_9[0][0]
batch_normalization_9 (BatchNor	(None, 32, 32, 216)	864	concatenate_8[0][0]
activation_9 (Activation)	(None, 32, 32, 216)	0	batch_normalization_9[0][0]
conv2d_10 (Conv2D)	(None, 32, 32, 24)	46656	activation_9[0][0]
concatenate_9 (Concatenate)	(None, 32, 32, 240)	0	concatenate_8[0][0] conv2d_10[0][0]
batch_normalization_10 (BatchNo	(None, 32, 32, 240)	960	concatenate_9[0][0]
activation_10 (Activation)	(None, 32, 32, 240)	0	batch_normalization_10[0][0]
conv2d_11 (Conv2D)	(None, 32, 32, 24)	5760	activation_10[0][0]
average_pooling2d_1 (AveragePoo	(None, 16, 16, 24)	0	conv2d_11[0][0]
batch_normalization_11 (BatchNo	(None, 16, 16, 24)	96	average_pooling2d_1[0][0]
activation_11 (Activation)	(None, 16, 16, 24)	0	batch_normalization_11[0][0]
conv2d_12 (Conv2D)	(None, 16, 16, 24)	5184	activation_11[0][0]
concatenate_10 (Concatenate)	(None, 16, 16, 48)	0	average_pooling2d_1[0][0] conv2d_12[0][0]

batch_normalization_12 (BatchNo	(None, 16, 16, 48)	192	concatenate_10[0][0]
activation_12 (Activation)	(None, 16, 16, 48)	0	batch_normalization_12[0][0]
conv2d_13 (Conv2D)	(None, 16, 16, 24)	10368	activation_12[0][0]
concatenate_11 (Concatenate)	(None, 16, 16, 72)	0	concatenate_10[0][0] conv2d_13[0][0]
batch_normalization_13 (BatchNo	(None, 16, 16, 72)	288	concatenate_11[0][0]
activation_13 (Activation)	(None, 16, 16, 72)	0	batch_normalization_13[0][0]
conv2d_14 (Conv2D)	(None, 16, 16, 24)	15552	activation_13[0][0]
concatenate_12 (Concatenate)	(None, 16, 16, 96)	0	concatenate_11[0][0] conv2d_14[0][0]
batch_normalization_14 (BatchNo	(None, 16, 16, 96)	384	concatenate_12[0][0]
activation_14 (Activation)	(None, 16, 16, 96)	0	batch_normalization_14[0][0]
conv2d_15 (Conv2D)	(None, 16, 16, 24)	20736	activation_14[0][0]
concatenate_13 (Concatenate)	(None, 16, 16, 120)	0	concatenate_12[0][0] conv2d_15[0][0]
batch_normalization_15 (BatchNo	(None, 16, 16, 120)	480	concatenate_13[0][0]
activation_15 (Activation)	(None, 16, 16, 120)	0	batch_normalization_15[0][0]
conv2d_16 (Conv2D)	(None, 16, 16, 24)	25920	activation_15[0][0]
concatenate_14 (Concatenate)	(None, 16, 16, 144)	0	concatenate_13[0][0] conv2d_16[0][0]
batch_normalization_16 (BatchNo	(None, 16, 16, 144)	576	concatenate_14[0][0]
activation_16 (Activation)	(None, 16, 16, 144)	0	batch_normalization_16[0][0]
conv2d_17 (Conv2D)	(None, 16, 16, 24)	31104	activation_16[0][0]
concatenate_15 (Concatenate)	(None, 16, 16, 168)	0	concatenate_14[0][0] conv2d_17[0][0]
batch_normalization_17 (BatchNo	(None, 16, 16, 168)	672	concatenate_15[0][0]
activation_17 (Activation)	(None, 16, 16, 168)	0	batch_normalization_17[0][0]
conv2d_18 (Conv2D)	(None, 16, 16, 24)	36288	activation_17[0][0]
concatenate_16 (Concatenate)	(None, 16, 16, 192)	0	concatenate_15[0][0] conv2d_18[0][0]
batch_normalization_18 (BatchNo	(None, 16, 16, 192)	768	concatenate_16[0][0]
activation_18 (Activation)	(None, 16, 16, 192)	0	batch_normalization_18[0][0]
conv2d_19 (Conv2D)	(None, 16, 16, 24)	41472	activation_18[0][0]
concatenate_17 (Concatenate)	(None, 16, 16, 216)	0	concatenate_16[0][0] conv2d_19[0][0]
batch_normalization_19 (BatchNo	(None, 16, 16, 216)	864	concatenate_17[0][0]
activation_19 (Activation)	(None, 16, 16, 216)	0	batch_normalization_19[0][0]
conv2d_20 (Conv2D)	(None, 16, 16, 24)	46656	activation_19[0][0]
concatenate_18 (Concatenate)	(None, 16, 16, 240)	0	concatenate_17[0][0] conv2d_20[0][0]
batch_normalization_20 (BatchNo	(None, 16, 16, 240)	960	concatenate_18[0][0]
activation_20 (Activation)	(None, 16, 16, 240)	0	batch_normalization_20[0][0]

conv2d_21 (Conv2D)	(None, 16, 16, 24)	5760	activation_20[0][0]
average_pooling2d_2 (AveragePoo	(None, 8, 8, 24)	0	conv2d_21[0][0]
batch_normalization_21 (BatchNo	(None, 8, 8, 24)	96	average_pooling2d_2[0][0]
activation_21 (Activation)	(None, 8, 8, 24)	0	batch_normalization_21[0][0]
conv2d_22 (Conv2D)	(None, 8, 8, 24)	5184	activation_21[0][0]
concatenate_19 (Concatenate)	(None, 8, 8, 48)	0	average_pooling2d_2[0][0] conv2d_22[0][0]
batch_normalization_22 (BatchNo	(None, 8, 8, 48)	192	concatenate_19[0][0]
activation_22 (Activation)	(None, 8, 8, 48)	0	batch_normalization_22[0][0]
conv2d_23 (Conv2D)	(None, 8, 8, 24)	10368	activation_22[0][0]
concatenate_20 (Concatenate)	(None, 8, 8, 72)	0	concatenate_19[0][0] conv2d_23[0][0]
batch_normalization_23 (BatchNo	(None, 8, 8, 72)	288	concatenate_20[0][0]
activation_23 (Activation)	(None, 8, 8, 72)	0	batch_normalization_23[0][0]
conv2d_24 (Conv2D)	(None, 8, 8, 24)	15552	activation_23[0][0]
concatenate_21 (Concatenate)	(None, 8, 8, 96)	0	concatenate_20[0][0] conv2d_24[0][0]
batch_normalization_24 (BatchNo	(None, 8, 8, 96)	384	concatenate_21[0][0]
activation_24 (Activation)	(None, 8, 8, 96)	0	batch_normalization_24[0][0]
conv2d_25 (Conv2D)	(None, 8, 8, 24)	20736	activation_24[0][0]
concatenate_22 (Concatenate)	(None, 8, 8, 120)	0	concatenate_21[0][0] conv2d_25[0][0]
batch_normalization_25 (BatchNo	(None, 8, 8, 120)	480	concatenate_22[0][0]
activation_25 (Activation)	(None, 8, 8, 120)	0	batch_normalization_25[0][0]
conv2d_26 (Conv2D)	(None, 8, 8, 24)	25920	activation_25[0][0]
concatenate_23 (Concatenate)	(None, 8, 8, 144)	0	concatenate_22[0][0] conv2d_26[0][0]
batch_normalization_26 (BatchNo	(None, 8, 8, 144)	576	concatenate_23[0][0]
activation_26 (Activation)	(None, 8, 8, 144)	0	batch_normalization_26[0][0]
conv2d_27 (Conv2D)	(None, 8, 8, 24)	31104	activation_26[0][0]
concatenate_24 (Concatenate)	(None, 8, 8, 168)	0	concatenate_23[0][0] conv2d_27[0][0]
batch_normalization_27 (BatchNo	(None, 8, 8, 168)	672	concatenate_24[0][0]
activation_27 (Activation)	(None, 8, 8, 168)	0	batch_normalization_27[0][0]
conv2d_28 (Conv2D)	(None, 8, 8, 24)	36288	activation_27[0][0]
concatenate_25 (Concatenate)	(None, 8, 8, 192)	0	concatenate_24[0][0] conv2d_28[0][0]
batch_normalization_28 (BatchNo	(None, 8, 8, 192)	768	concatenate_25[0][0]
activation_28 (Activation)	(None, 8, 8, 192)	0	batch_normalization_28[0][0]
conv2d_29 (Conv2D)	(None, 8, 8, 24)	41472	activation_28[0][0]
concatenate_26 (Concatenate)	(None, 8, 8, 216)	0	concatenate_25[0][0] conv2d_29[0][0]
batch_normalization_29 (BatchNo	(None, 8, 8, 216)	864	concatenate_26[0][0]

activation_29 (Activation)	(None, 8, 8, 216)	0	batch_normalization_29[0][0]
conv2d_30 (Conv2D)	(None, 8, 8, 24)	46656	activation_29[0][0]
concatenate_27 (Concatenate)	(None, 8, 8, 240)	0	concatenate_26[0][0] conv2d_30[0][0]
batch_normalization_30 (BatchNo	(None, 8, 8, 240)	960	concatenate_27[0][0]
activation_30 (Activation)	(None, 8, 8, 240)	0	batch_normalization_30[0][0]
conv2d_31 (Conv2D)	(None, 8, 8, 24)	5760	activation_30[0][0]
average_pooling2d_3 (AveragePoo	(None, 4, 4, 24)	0	conv2d_31[0][0]
batch_normalization_31 (BatchNo	(None, 4, 4, 24)	96	average_pooling2d_3[0][0]
activation_31 (Activation)	(None, 4, 4, 24)	0	batch_normalization_31[0][0]
conv2d_32 (Conv2D)	(None, 4, 4, 24)	5184	activation_31[0][0]
concatenate_28 (Concatenate)	(None, 4, 4, 48)	0	average_pooling2d_3[0][0] conv2d_32[0][0]
batch_normalization_32 (BatchNo	(None, 4, 4, 48)	192	concatenate_28[0][0]
activation_32 (Activation)	(None, 4, 4, 48)	0	batch_normalization_32[0][0]
conv2d_33 (Conv2D)	(None, 4, 4, 24)	10368	activation_32[0][0]
concatenate_29 (Concatenate)	(None, 4, 4, 72)	0	concatenate_28[0][0] conv2d_33[0][0]
batch_normalization_33 (BatchNo	(None, 4, 4, 72)	288	concatenate_29[0][0]
activation_33 (Activation)	(None, 4, 4, 72)	0	batch_normalization_33[0][0]
conv2d_34 (Conv2D)	(None, 4, 4, 24)	15552	activation_33[0][0]
concatenate_30 (Concatenate)	(None, 4, 4, 96)	0	concatenate_29[0][0] conv2d_34[0][0]
batch_normalization_34 (BatchNo	(None, 4, 4, 96)	384	concatenate_30[0][0]
activation_34 (Activation)	(None, 4, 4, 96)	0	batch_normalization_34[0][0]
conv2d_35 (Conv2D)	(None, 4, 4, 24)	20736	activation_34[0][0]
concatenate_31 (Concatenate)	(None, 4, 4, 120)	0	concatenate_30[0][0] conv2d_35[0][0]
batch_normalization_35 (BatchNo	(None, 4, 4, 120)	480	concatenate_31[0][0]
activation_35 (Activation)	(None, 4, 4, 120)	0	batch_normalization_35[0][0]
conv2d_36 (Conv2D)	(None, 4, 4, 24)	25920	activation_35[0][0]
concatenate_32 (Concatenate)	(None, 4, 4, 144)	0	concatenate_31[0][0] conv2d_36[0][0]
batch_normalization_36 (BatchNo	(None, 4, 4, 144)	576	concatenate_32[0][0]
activation_36 (Activation)	(None, 4, 4, 144)	0	batch_normalization_36[0][0]
conv2d_37 (Conv2D)	(None, 4, 4, 24)	31104	activation_36[0][0]
concatenate_33 (Concatenate)	(None, 4, 4, 168)	0	concatenate_32[0][0] conv2d_37[0][0]
batch_normalization_37 (BatchNo	(None, 4, 4, 168)	672	concatenate_33[0][0]
activation_37 (Activation)	(None, 4, 4, 168)	0	batch_normalization_37[0][0]
conv2d_38 (Conv2D)	(None, 4, 4, 24)	36288	activation_37[0][0]
concatenate_34 (Concatenate)	(None, 4, 4, 192)	0	concatenate_33[0][0]

```
                                                                 conv2d_38[0][0]
__________________________________________________________________________________________________
batch_normalization_38 (BatchNo (None, 4, 4, 192)    768         concatenate_34[0][0]
__________________________________________________________________________________________________
activation_38 (Activation)      (None, 4, 4, 192)    0           batch_normalization_38[0][0]
__________________________________________________________________________________________________
conv2d_39 (Conv2D)              (None, 4, 4, 24)     41472       activation_38[0][0]
__________________________________________________________________________________________________
concatenate_35 (Concatenate)    (None, 4, 4, 216)    0           concatenate_34[0][0]
                                                                 conv2d_39[0][0]
__________________________________________________________________________________________________
batch_normalization_39 (BatchNo (None, 4, 4, 216)    864         concatenate_35[0][0]
__________________________________________________________________________________________________
activation_39 (Activation)      (None, 4, 4, 216)    0           batch_normalization_39[0][0]
__________________________________________________________________________________________________
conv2d_40 (Conv2D)              (None, 4, 4, 24)     46656       activation_39[0][0]
__________________________________________________________________________________________________
concatenate_36 (Concatenate)    (None, 4, 4, 240)    0           concatenate_35[0][0]
                                                                 conv2d_40[0][0]
__________________________________________________________________________________________________
batch_normalization_40 (BatchNo (None, 4, 4, 240)    960         concatenate_36[0][0]
__________________________________________________________________________________________________
activation_40 (Activation)      (None, 4, 4, 240)    0           batch_normalization_40[0][0]
__________________________________________________________________________________________________
average_pooling2d_4 (AveragePoo (None, 2, 2, 240)    0           activation_40[0][0]
__________________________________________________________________________________________________
conv2d_41 (Conv2D)              (None, 2, 2, 10)     2400        average_pooling2d_4[0][0]
__________________________________________________________________________________________________
global_max_pooling2d_1 (GlobalM (None, 10)           0           conv2d_41[0][0]
__________________________________________________________________________________________________
activation_41 (Activation)      (None, 10)           0           global_max_pooling2d_1[0][0]
==================================================================================================
Total params: 974,568
Trainable params: 964,008
Non-trainable params: 10,560
__________________________________________________________________________________________________
None
Epoch 31/150
1954/1953 [==============================] - 241s 123ms/step - loss: 0.0748 - accuracy: 0.9738 - v
al_loss: 0.3629 - val_accuracy: 0.9081

Epoch 00031: val_accuracy improved from -inf to 0.90810, saving model to 031-0.908.hdf5
Epoch 32/150
1954/1953 [==============================] - 236s 121ms/step - loss: 0.0715 - accuracy: 0.9747 - v
al_loss: 0.4749 - val_accuracy: 0.8947

Epoch 00032: val_accuracy did not improve from 0.90810
Epoch 33/150
1954/1953 [==============================] - 237s 121ms/step - loss: 0.0700 - accuracy: 0.9752 - v
al_loss: 0.4094 - val_accuracy: 0.8994

Epoch 00033: val_accuracy did not improve from 0.90810
Epoch 34/150
1954/1953 [==============================] - 240s 123ms/step - loss: 0.0667 - accuracy: 0.9766 - v
al_loss: 0.3743 - val_accuracy: 0.9124

Epoch 00034: val_accuracy improved from 0.90810 to 0.91240, saving model to 034-0.912.hdf5
Epoch 35/150
1954/1953 [==============================] - 237s 121ms/step - loss: 0.0645 - accuracy: 0.9772 - v
al_loss: 0.4359 - val_accuracy: 0.8992

Epoch 00035: val_accuracy did not improve from 0.91240
Epoch 36/150
1954/1953 [==============================] - 235s 120ms/step - loss: 0.0623 - accuracy: 0.9781 - v
al_loss: 0.3888 - val_accuracy: 0.9084

Epoch 00036: val_accuracy did not improve from 0.91240
Epoch 37/150
1954/1953 [==============================] - 236s 121ms/step - loss: 0.0603 - accuracy: 0.9792 - v
al_loss: 0.3959 - val_accuracy: 0.9086

Epoch 00037: val_accuracy did not improve from 0.91240
Epoch 38/150
1954/1953 [==============================] - 236s 121ms/step - loss: 0.0594 - accuracy: 0.9790 - v
al_loss: 0.3856 - val_accuracy: 0.9131

Epoch 00038: val_accuracy improved from 0.91240 to 0.91310, saving model to 038-0.913.hdf5
```

```
Epoch 39/150
1954/1953 [==============================] - 236s 121ms/step - loss: 0.0581 - accuracy: 0.9796 - v
al_loss: 0.5289 - val_accuracy: 0.8884

Epoch 00039: val_accuracy did not improve from 0.91310
Epoch 40/150
1954/1953 [==============================] - 236s 121ms/step - loss: 0.0562 - accuracy: 0.9802 - v
al_loss: 0.4577 - val_accuracy: 0.9012

Epoch 00040: val_accuracy did not improve from 0.91310
Epoch 41/150
1954/1953 [==============================] - 236s 121ms/step - loss: 0.0543 - accuracy: 0.9808 - v
al_loss: 0.3901 - val_accuracy: 0.9104

Epoch 00041: val_accuracy did not improve from 0.91310
```

Out[0]:

```
<keras.callbacks.callbacks.History at 0x7f1901df1fd0>
```

In [0]:

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

```
10000/10000 [==============================] - 4s 401us/step
Test loss: 0.39009565761350096
Test accuracy: 0.9103999733924866
```

In [0]:

```
model.load_weights('038-0.913.hdf5')
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 [==============================] - 21s 415us/step
10000/10000 [==============================] - 4s 402us/step
```

In [0]:

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

```
0.9830999970436096 0.913100004196167
```