In [0]:
```
!zip -r /content/file.zip /content/logss_model_dense
```

```
  adding: content/logss_model_dense/ (stored 0%)
  adding: content/logss_model_dense/events.out.tfevents.1570487317.dea8a26114
66 (deflated 92%)
  adding: content/logss_model_dense/plugins/ (stored 0%)
  adding: content/logss_model_dense/plugins/profile/ (stored 0%)
  adding: content/logss_model_dense/plugins/profile/2019-10-07_22-28-53/ (sto
red 0%)
  adding: content/logss_model_dense/plugins/profile/2019-10-07_22-28-53/loca
l.trace (deflated 93%)
  adding: content/logss_model_dense/events.out.tfevents.1570487333.dea8a26114
66.profile-empty (deflated 5%)
```

In [0]:
```
from google.colab import files
files.download("/content/file.zip")
```

In [0]:
```
# import keras
# from keras.datasets import cifar10
# from keras.models import Model, Sequential
# from keras.layers import Dense, Dropout, Flatten, Input, AveragePooling2D, m
erge, Activation
# from keras.layers import Conv2D, MaxPooling2D, BatchNormalization
# from keras.layers import Concatenate
# from keras.optimizers import Adam
from tensorflow.keras import models, layers
from tensorflow.keras.models import Model
from tensorflow.keras.layers import BatchNormalization, Activation, Flatten
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping, TensorB
oard, ReduceLROnPlateau
```

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]:
```
# Load CIFAR10 Data
num_classes = 10
(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.sha
pe[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)
```

In [7]:
```
X_train.shape
```

Out[7]:
```
(50000, 32, 32, 3)
```

In [8]:
```
X_test.shape
```

Out[8]:
```
(10000, 32, 32, 3)
```

In [0]:
```
# Dense Block
compression = 0.5
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_bia
s=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=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)
    Conv1 = layers.Conv2D(int(num_filter*compression), (1,1), use_bias=False ,
padding='same')(AvgPooling)
    Conv2 = layers.Conv2D(num_classes, (1,1) ,padding='valid')(Conv1)
    Global_pool = layers.GlobalAveragePooling2D()(Conv2)

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

In [0]:
```
# Hyperparameters
batch_size = 128
num_classes = 10
epochs = 35
l = 6
num_filter = 64
compression = 0.5
dropout_rate = 0
```

In [11]:
```
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_cor
e/python/ops/resource_variable_ops.py:1630: calling BaseResourceVariable.__in
it__ (from tensorflow.python.ops.resource_variable_ops) with constraint is de
precated and will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
```

In [0]:
```
#https://arxiv.org/pdf/1608.06993.pdf
# from IPython.display import IFrame, YouTubeVideo
# YouTubeVideo(id='-W6y8xnd--U', width=600)
```

In [13]:
```
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, 64)   1728        input_1[0]
[0]
__________________________________________________________________________________________________
batch_normalization (BatchNorma (None, 32, 32, 64)   256         conv2d[0][0]
__________________________________________________________________________________________________
activation (Activation)         (None, 32, 32, 64)   0           batch_normal
ization[0][0]
__________________________________________________________________________________________________
conv2d_1 (Conv2D)               (None, 32, 32, 32)   18432       activation
[0][0]
__________________________________________________________________________________________________
concatenate (Concatenate)       (None, 32, 32, 96)   0           conv2d[0][0]
                                                                 conv2d_1[0]
[0]
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 32, 32, 96)   384         concatenate
[0][0]
__________________________________________________________________________________________________
activation_1 (Activation)       (None, 32, 32, 96)   0           batch_normal
ization_1[0][0]
__________________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 32, 32, 32)   27648       activation_1
[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 32, 32, 128)  0           concatenate
[0][0]
                                                                 conv2d_2[0]
[0]
__________________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, 32, 32, 128)  512         concatenate_
1[0][0]
__________________________________________________________________________________________________
activation_2 (Activation)       (None, 32, 32, 128)  0           batch_normal
ization_2[0][0]
__________________________________________________________________________________________________
conv2d_3 (Conv2D)               (None, 32, 32, 32)   36864       activation_2
[0][0]
```

```
__________________________________________________________________________________________________
____________________
concatenate_2 (Concatenate)     (None, 32, 32, 160)  0           concatenate_
1[0][0]
                                                                 conv2d_3[0]
[0]
__________________________________________________________________________________________________
____________________
batch_normalization_3 (BatchNor (None, 32, 32, 160)  640         concatenate_
2[0][0]
__________________________________________________________________________________________________
____________________
activation_3 (Activation)       (None, 32, 32, 160)  0           batch_normal
ization_3[0][0]
__________________________________________________________________________________________________
____________________
conv2d_4 (Conv2D)               (None, 32, 32, 32)   46080       activation_3
[0][0]
__________________________________________________________________________________________________
____________________
concatenate_3 (Concatenate)     (None, 32, 32, 192)  0           concatenate_
2[0][0]
                                                                 conv2d_4[0]
[0]
__________________________________________________________________________________________________
____________________
batch_normalization_4 (BatchNor (None, 32, 32, 192)  768         concatenate_
3[0][0]
__________________________________________________________________________________________________
____________________
activation_4 (Activation)       (None, 32, 32, 192)  0           batch_normal
ization_4[0][0]
__________________________________________________________________________________________________
____________________
conv2d_5 (Conv2D)               (None, 32, 32, 32)   55296       activation_4
[0][0]
__________________________________________________________________________________________________
____________________
concatenate_4 (Concatenate)     (None, 32, 32, 224)  0           concatenate_
3[0][0]
                                                                 conv2d_5[0]
[0]
__________________________________________________________________________________________________
____________________
batch_normalization_5 (BatchNor (None, 32, 32, 224)  896         concatenate_
4[0][0]
__________________________________________________________________________________________________
____________________
activation_5 (Activation)       (None, 32, 32, 224)  0           batch_normal
ization_5[0][0]
__________________________________________________________________________________________________
____________________
conv2d_6 (Conv2D)               (None, 32, 32, 32)   64512       activation_5
[0][0]
__________________________________________________________________________________________________
____________________
concatenate_5 (Concatenate)     (None, 32, 32, 256)  0           concatenate_
```

```
4[0][0]
                                                                 conv2d_6[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_6 (BatchNor (None, 32, 32, 256)  1024        concatenate_
5[0][0]
__________________________________________________________________________
_____________________
activation_6 (Activation)       (None, 32, 32, 256)  0           batch_normal
ization_6[0][0]
__________________________________________________________________________
_____________________
conv2d_7 (Conv2D)               (None, 32, 32, 32)   8192        activation_6
[0][0]
__________________________________________________________________________
_____________________
average_pooling2d (AveragePooli (None, 16, 16, 32)   0           conv2d_7[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_7 (BatchNor (None, 16, 16, 32)   128         average_pool
ing2d[0][0]
__________________________________________________________________________
_____________________
activation_7 (Activation)       (None, 16, 16, 32)   0           batch_normal
ization_7[0][0]
__________________________________________________________________________
_____________________
conv2d_8 (Conv2D)               (None, 16, 16, 32)   9216        activation_7
[0][0]
__________________________________________________________________________
_____________________
concatenate_6 (Concatenate)     (None, 16, 16, 64)   0           average_pool
ing2d[0][0]
                                                                 conv2d_8[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_8 (BatchNor (None, 16, 16, 64)   256         concatenate_
6[0][0]
__________________________________________________________________________
_____________________
activation_8 (Activation)       (None, 16, 16, 64)   0           batch_normal
ization_8[0][0]
__________________________________________________________________________
_____________________
conv2d_9 (Conv2D)               (None, 16, 16, 32)   18432       activation_8
[0][0]
__________________________________________________________________________
_____________________
concatenate_7 (Concatenate)     (None, 16, 16, 96)   0           concatenate_
6[0][0]
                                                                 conv2d_9[0]
[0]
__________________________________________________________________________
_____________________
```

```
batch_normalization_9 (BatchNor (None, 16, 16, 96)   384         concatenate_
7[0][0]
__________________________________________________________________________
_____________________
activation_9 (Activation)       (None, 16, 16, 96)   0           batch_normal
ization_9[0][0]
__________________________________________________________________________
_____________________
conv2d_10 (Conv2D)              (None, 16, 16, 32)   27648       activation_9
[0][0]
__________________________________________________________________________
_____________________
concatenate_8 (Concatenate)     (None, 16, 16, 128)  0           concatenate_
7[0][0]
                                                                 conv2d_10[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_10 (BatchNo (None, 16, 16, 128)  512         concatenate_
8[0][0]
__________________________________________________________________________
_____________________
activation_10 (Activation)      (None, 16, 16, 128)  0           batch_normal
ization_10[0][0]
__________________________________________________________________________
_____________________
conv2d_11 (Conv2D)              (None, 16, 16, 32)   36864       activation_1
0[0][0]
__________________________________________________________________________
_____________________
concatenate_9 (Concatenate)     (None, 16, 16, 160)  0           concatenate_
8[0][0]
                                                                 conv2d_11[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_11 (BatchNo (None, 16, 16, 160)  640         concatenate_
9[0][0]
__________________________________________________________________________
_____________________
activation_11 (Activation)      (None, 16, 16, 160)  0           batch_normal
ization_11[0][0]
__________________________________________________________________________
_____________________
conv2d_12 (Conv2D)              (None, 16, 16, 32)   46080       activation_1
1[0][0]
__________________________________________________________________________
_____________________
concatenate_10 (Concatenate)    (None, 16, 16, 192)  0           concatenate_
9[0][0]
                                                                 conv2d_12[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_12 (BatchNo (None, 16, 16, 192)  768         concatenate_
10[0][0]
__________________________________________________________________________
```

```
_____________________
activation_12 (Activation)      (None, 16, 16, 192)  0           batch_normal
ization_12[0][0]
_____________________________________________________________________________
_____________________
conv2d_13 (Conv2D)              (None, 16, 16, 32)   55296       activation_1
2[0][0]
_____________________________________________________________________________
_____________________
concatenate_11 (Concatenate)    (None, 16, 16, 224)  0           concatenate_
10[0][0]
                                                                 conv2d_13[0]
[0]
_____________________________________________________________________________
_____________________
batch_normalization_13 (BatchNo (None, 16, 16, 224)  896         concatenate_
11[0][0]
_____________________________________________________________________________
_____________________
activation_13 (Activation)      (None, 16, 16, 224)  0           batch_normal
ization_13[0][0]
_____________________________________________________________________________
_____________________
conv2d_14 (Conv2D)              (None, 16, 16, 32)   7168        activation_1
3[0][0]
_____________________________________________________________________________
_____________________
average_pooling2d_1 (AveragePoo (None, 8, 8, 32)     0           conv2d_14[0]
[0]
_____________________________________________________________________________
_____________________
batch_normalization_14 (BatchNo (None, 8, 8, 32)     128         average_pool
ing2d_1[0][0]
_____________________________________________________________________________
_____________________
activation_14 (Activation)      (None, 8, 8, 32)     0           batch_normal
ization_14[0][0]
_____________________________________________________________________________
_____________________
conv2d_15 (Conv2D)              (None, 8, 8, 32)     9216        activation_1
4[0][0]
_____________________________________________________________________________
_____________________
concatenate_12 (Concatenate)    (None, 8, 8, 64)     0           average_pool
ing2d_1[0][0]
                                                                 conv2d_15[0]
[0]
_____________________________________________________________________________
_____________________
batch_normalization_15 (BatchNo (None, 8, 8, 64)     256         concatenate_
12[0][0]
_____________________________________________________________________________
_____________________
activation_15 (Activation)      (None, 8, 8, 64)     0           batch_normal
ization_15[0][0]
_____________________________________________________________________________
_____________________
```

```
conv2d_16 (Conv2D)              (None, 8, 8, 32)     18432       activation_1
5[0][0]
__________________________________________________________________________
_____________________
concatenate_13 (Concatenate)    (None, 8, 8, 96)     0           concatenate_
12[0][0]
                                                                 conv2d_16[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_16 (BatchNo (None, 8, 8, 96)     384         concatenate_
13[0][0]
__________________________________________________________________________
_____________________
activation_16 (Activation)      (None, 8, 8, 96)     0           batch_normal
ization_16[0][0]
__________________________________________________________________________
_____________________
conv2d_17 (Conv2D)              (None, 8, 8, 32)     27648       activation_1
6[0][0]
__________________________________________________________________________
_____________________
concatenate_14 (Concatenate)    (None, 8, 8, 128)    0           concatenate_
13[0][0]
                                                                 conv2d_17[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_17 (BatchNo (None, 8, 8, 128)    512         concatenate_
14[0][0]
__________________________________________________________________________
_____________________
activation_17 (Activation)      (None, 8, 8, 128)    0           batch_normal
ization_17[0][0]
__________________________________________________________________________
_____________________
conv2d_18 (Conv2D)              (None, 8, 8, 32)     36864       activation_1
7[0][0]
__________________________________________________________________________
_____________________
concatenate_15 (Concatenate)    (None, 8, 8, 160)    0           concatenate_
14[0][0]
                                                                 conv2d_18[0]
[0]
__________________________________________________________________________
_____________________
batch_normalization_18 (BatchNo (None, 8, 8, 160)    640         concatenate_
15[0][0]
__________________________________________________________________________
_____________________
activation_18 (Activation)      (None, 8, 8, 160)    0           batch_normal
ization_18[0][0]
__________________________________________________________________________
_____________________
conv2d_19 (Conv2D)              (None, 8, 8, 32)     46080       activation_1
8[0][0]
__________________________________________________________________________
```

```
_____________________
concatenate_16 (Concatenate)    (None, 8, 8, 192)    0           concatenate_
15[0][0]
                                                                 conv2d_19[0]
[0]
_____________________________________________________________________________
_____________________
batch_normalization_19 (BatchNo (None, 8, 8, 192)    768         concatenate_
16[0][0]
_____________________________________________________________________________
_____________________
activation_19 (Activation)      (None, 8, 8, 192)    0           batch_normal
ization_19[0][0]
_____________________________________________________________________________
_____________________
conv2d_20 (Conv2D)              (None, 8, 8, 32)     55296       activation_1
9[0][0]
_____________________________________________________________________________
_____________________
concatenate_17 (Concatenate)    (None, 8, 8, 224)    0           concatenate_
16[0][0]
                                                                 conv2d_20[0]
[0]
_____________________________________________________________________________
_____________________
batch_normalization_20 (BatchNo (None, 8, 8, 224)    896         concatenate_
17[0][0]
_____________________________________________________________________________
_____________________
activation_20 (Activation)      (None, 8, 8, 224)    0           batch_normal
ization_20[0][0]
_____________________________________________________________________________
_____________________
conv2d_21 (Conv2D)              (None, 8, 8, 32)     7168        activation_2
0[0][0]
_____________________________________________________________________________
_____________________
average_pooling2d_2 (AveragePoo (None, 4, 4, 32)     0           conv2d_21[0]
[0]
_____________________________________________________________________________
_____________________
batch_normalization_21 (BatchNo (None, 4, 4, 32)     128         average_pool
ing2d_2[0][0]
_____________________________________________________________________________
_____________________
activation_21 (Activation)      (None, 4, 4, 32)     0           batch_normal
ization_21[0][0]
_____________________________________________________________________________
_____________________
conv2d_22 (Conv2D)              (None, 4, 4, 32)     9216        activation_2
1[0][0]
_____________________________________________________________________________
_____________________
concatenate_18 (Concatenate)    (None, 4, 4, 64)     0           average_pool
ing2d_2[0][0]
                                                                 conv2d_22[0]
[0]
```

```
_____
_____
batch_normalization_22 (BatchNo (None, 4, 4, 64)     256         concatenate_
18[0][0]
_____
_____
activation_22 (Activation)      (None, 4, 4, 64)     0           batch_normal
ization_22[0][0]
_____
_____
conv2d_23 (Conv2D)              (None, 4, 4, 32)     18432       activation_2
2[0][0]
_____
_____
concatenate_19 (Concatenate)    (None, 4, 4, 96)     0           concatenate_
18[0][0]
                                                                 conv2d_23[0]
[0]
_____
_____
batch_normalization_23 (BatchNo (None, 4, 4, 96)     384         concatenate_
19[0][0]
_____
_____
activation_23 (Activation)      (None, 4, 4, 96)     0           batch_normal
ization_23[0][0]
_____
_____
conv2d_24 (Conv2D)              (None, 4, 4, 32)     27648       activation_2
3[0][0]
_____
_____
concatenate_20 (Concatenate)    (None, 4, 4, 128)    0           concatenate_
19[0][0]
                                                                 conv2d_24[0]
[0]
_____
_____
batch_normalization_24 (BatchNo (None, 4, 4, 128)    512         concatenate_
20[0][0]
_____
_____
activation_24 (Activation)      (None, 4, 4, 128)    0           batch_normal
ization_24[0][0]
_____
_____
conv2d_25 (Conv2D)              (None, 4, 4, 32)     36864       activation_2
4[0][0]
_____
_____
concatenate_21 (Concatenate)    (None, 4, 4, 160)    0           concatenate_
20[0][0]
                                                                 conv2d_25[0]
[0]
_____
_____
batch_normalization_25 (BatchNo (None, 4, 4, 160)    640         concatenate_
```

```
21[0][0]
__________________________________________________________________________________________
_____________________
activation_25 (Activation)      (None, 4, 4, 160)    0           batch_normal
ization_25[0][0]
__________________________________________________________________________________________
_____________________
conv2d_26 (Conv2D)              (None, 4, 4, 32)     46080       activation_2
5[0][0]
__________________________________________________________________________________________
_____________________
concatenate_22 (Concatenate)    (None, 4, 4, 192)    0           concatenate_
21[0][0]
                                                                 conv2d_26[0]
[0]
__________________________________________________________________________________________
_____________________
batch_normalization_26 (BatchNo (None, 4, 4, 192)    768         concatenate_
22[0][0]
__________________________________________________________________________________________
_____________________
activation_26 (Activation)      (None, 4, 4, 192)    0           batch_normal
ization_26[0][0]
__________________________________________________________________________________________
_____________________
conv2d_27 (Conv2D)              (None, 4, 4, 32)     55296       activation_2
6[0][0]
__________________________________________________________________________________________
_____________________
concatenate_23 (Concatenate)    (None, 4, 4, 224)    0           concatenate_
22[0][0]
                                                                 conv2d_27[0]
[0]
__________________________________________________________________________________________
_____________________
batch_normalization_27 (BatchNo (None, 4, 4, 224)    896         concatenate_
23[0][0]
__________________________________________________________________________________________
_____________________
activation_27 (Activation)      (None, 4, 4, 224)    0           batch_normal
ization_27[0][0]
__________________________________________________________________________________________
_____________________
average_pooling2d_3 (AveragePoo (None, 2, 2, 224)    0           activation_2
7[0][0]
__________________________________________________________________________________________
_____________________
conv2d_28 (Conv2D)              (None, 2, 2, 32)     7168        average_pool
ing2d_3[0][0]
__________________________________________________________________________________________
_____________________
conv2d_29 (Conv2D)              (None, 2, 2, 10)     330         conv2d_28[0]
[0]
__________________________________________________________________________________________
_____________________
global_average_pooling2d (Globa (None, 10)           0           conv2d_29[0]
[0]
```

```
_________________________________________________________________
_____________________
activation_28 (Activation)      (None, 10)           0           global_avera
ge_pooling2d[0][0]
==================================================================================
====================
Total params: 876,426
Trainable params: 868,810
Non-trainable params: 7,616
_________________________________________________________________
_____________________
```

In [0]:
```
X_train = X_train.astype('float32')
X_test = X_test.astype('float32')

mean = X_train.mean(0)
std = X_train.std(0)
def preprocess_data(data_set):
    # mean = np.array([125.3, 123.0, 113.9])
    # std = np.array([63.0, 62.1, 66.7])

    data_set -= mean
    data_set /= std
    return data_set

X_train = preprocess_data(X_train)
X_test = preprocess_data(X_test)
```

In [16]:
```
# Data augementation
from keras.preprocessing.image import ImageDataGenerator
datagen_train = ImageDataGenerator(
    width_shift_range=0.125,
    height_shift_range=0.125,
    horizontal_flip=True,
)

datagen_train.fit(X_train)
```

```
Using TensorFlow backend.
```

In [0]:
```
checkpoint_3 = ModelCheckpoint("model_dense.h5",monitor="val_acc",mode="max",s
ave_best_only = True,verbose=1)
NAME = 'model_dense'
tensorboard_2 = TensorBoard(log_dir='logss\{}'.format(NAME),update_freq='epoc
h',batch_size=batch_size)
callbacks_2 = [tensorboard_2,checkpoint_3]
```

In [0]:
```
# determine Loss function and Optimizer
model.compile(loss='categorical_crossentropy',
              optimizer=Adam(),
              metrics=['accuracy'])
```

In [22]:
```
history = model.fit_generator(datagen_train.flow(X_train, y_train, batch_size=
batch_size),steps_per_epoch=(len(X_train)/batch_size)*5,
    epochs=epochs,
    verbose = 1,
    validation_data=(X_test, y_test),
    callbacks = callbacks_2
)
```

```
Epoch 1/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.8582 - acc: 0.
6952Epoch 1/35
10000/1953 [==============================================================
==============================================================================
==========] - 10s 968us/sample - loss: 0.7712 - acc: 0.7534

Epoch 00001: val_acc improved from -inf to 0.75340, saving model to model_den
se.h5
1954/1953 [==============================] - 829s 424ms/step - loss: 0.8581 -
acc: 0.6952 - val_loss: 0.7602 - val_acc: 0.7534
Epoch 2/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.4530 - acc: 0.
8430Epoch 1/35
10000/1953 [==============================================================
==============================================================================
==========] - 9s 855us/sample - loss: 0.5275 - acc: 0.7822

Epoch 00002: val_acc improved from 0.75340 to 0.78220, saving model to model_
dense.h5
1954/1953 [==============================] - 813s 416ms/step - loss: 0.4530 -
acc: 0.8430 - val_loss: 0.6827 - val_acc: 0.7822
Epoch 3/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.3410 - acc: 0.
8811Epoch 1/35
10000/1953 [==============================================================
==============================================================================
==========] - 9s 857us/sample - loss: 0.3822 - acc: 0.8438

Epoch 00003: val_acc improved from 0.78220 to 0.84380, saving model to model_
dense.h5
1954/1953 [==============================] - 811s 415ms/step - loss: 0.3410 -
acc: 0.8811 - val_loss: 0.4823 - val_acc: 0.8438
Epoch 4/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.2758 - acc: 0.
9040Epoch 1/35
10000/1953 [==============================================================
==============================================================================
==========] - 9s 856us/sample - loss: 0.3995 - acc: 0.8614

Epoch 00004: val_acc improved from 0.84380 to 0.86140, saving model to model_
dense.h5
1954/1953 [==============================] - 814s 417ms/step - loss: 0.2758 -
acc: 0.9040 - val_loss: 0.4315 - val_acc: 0.8614
Epoch 5/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.2279 - acc: 0.
9203Epoch 1/35
10000/1953 [==============================================================
==============================================================================
==========] - 9s 857us/sample - loss: 0.3589 - acc: 0.8584

Epoch 00005: val_acc did not improve from 0.86140
1954/1953 [==============================] - 814s 417ms/step - loss: 0.2278 -
acc: 0.9202 - val_loss: 0.4558 - val_acc: 0.8584
Epoch 6/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.1930 - acc: 0.
9320Epoch 1/35
```

```
10000/1953 [==============================================================
==============================================================================
===========] - 9s 855us/sample - loss: 0.5857 - acc: 0.8447

Epoch 00006: val_acc did not improve from 0.86140
1954/1953 [==============================] - 812s 416ms/step - loss: 0.1930 -
acc: 0.9320 - val_loss: 0.5696 - val_acc: 0.8447
Epoch 7/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.1652 - acc: 0.
9420Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 859us/sample - loss: 0.3140 - acc: 0.8722

Epoch 00007: val_acc improved from 0.86140 to 0.87220, saving model to model_
dense.h5
1954/1953 [==============================] - 811s 415ms/step - loss: 0.1652 -
acc: 0.9420 - val_loss: 0.4294 - val_acc: 0.8722
Epoch 8/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.1444 - acc: 0.
9483Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 856us/sample - loss: 0.4902 - acc: 0.8596

Epoch 00008: val_acc did not improve from 0.87220
1954/1953 [==============================] - 814s 417ms/step - loss: 0.1444 -
acc: 0.9483 - val_loss: 0.5420 - val_acc: 0.8596
Epoch 9/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.1259 - acc: 0.
9553Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 857us/sample - loss: 0.5188 - acc: 0.8702

Epoch 00009: val_acc did not improve from 0.87220
1954/1953 [==============================] - 817s 418ms/step - loss: 0.1259 -
acc: 0.9552 - val_loss: 0.5179 - val_acc: 0.8702
Epoch 10/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.1111 - acc: 0.
9606Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 858us/sample - loss: 0.5359 - acc: 0.8763

Epoch 00010: val_acc improved from 0.87220 to 0.87630, saving model to model_
dense.h5
1954/1953 [==============================] - 815s 417ms/step - loss: 0.1111 -
acc: 0.9606 - val_loss: 0.4730 - val_acc: 0.8763
Epoch 11/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0982 - acc: 0.
9651Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 855us/sample - loss: 0.2809 - acc: 0.8931

Epoch 00011: val_acc improved from 0.87630 to 0.89310, saving model to model_
```

```
dense.h5
1954/1953 [==============================] - 813s 416ms/step - loss: 0.0982 -
acc: 0.9651 - val_loss: 0.4108 - val_acc: 0.8931
Epoch 12/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0885 - acc: 0.
9682Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 855us/sample - loss: 0.5778 - acc: 0.8650

Epoch 00012: val_acc did not improve from 0.89310
1954/1953 [==============================] - 817s 418ms/step - loss: 0.0885 -
acc: 0.9682 - val_loss: 0.5875 - val_acc: 0.8650
Epoch 13/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0799 - acc: 0.
9715Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 868us/sample - loss: 0.3935 - acc: 0.8876

Epoch 00013: val_acc did not improve from 0.89310
1954/1953 [==============================] - 817s 418ms/step - loss: 0.0799 -
acc: 0.9715 - val_loss: 0.4731 - val_acc: 0.8876
Epoch 14/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0735 - acc: 0.
9738Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 858us/sample - loss: 0.3456 - acc: 0.8898

Epoch 00014: val_acc did not improve from 0.89310
1954/1953 [==============================] - 814s 416ms/step - loss: 0.0735 -
acc: 0.9738 - val_loss: 0.4670 - val_acc: 0.8898
Epoch 15/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0683 - acc: 0.
9760Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 858us/sample - loss: 0.7455 - acc: 0.8888

Epoch 00015: val_acc did not improve from 0.89310
1954/1953 [==============================] - 812s 416ms/step - loss: 0.0683 -
acc: 0.9760 - val_loss: 0.5049 - val_acc: 0.8888
Epoch 16/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0623 - acc: 0.
9780Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 860us/sample - loss: 0.3478 - acc: 0.8793

Epoch 00016: val_acc did not improve from 0.89310
1954/1953 [==============================] - 814s 417ms/step - loss: 0.0623 -
acc: 0.9780 - val_loss: 0.5715 - val_acc: 0.8793
Epoch 17/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0583 - acc: 0.
9788Epoch 1/35
10000/1953 [==============================================================
```

```
==============================================================================
===========] - 9s 861us/sample - loss: 0.3910 - acc: 0.8963

Epoch 00017: val_acc improved from 0.89310 to 0.89630, saving model to model_
dense.h5
1954/1953 [==============================] - 818s 418ms/step - loss: 0.0583 -
acc: 0.9788 - val_loss: 0.4818 - val_acc: 0.8963
Epoch 18/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0545 - acc: 0.
9807Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 859us/sample - loss: 0.7254 - acc: 0.8965

Epoch 00018: val_acc improved from 0.89630 to 0.89650, saving model to model_
dense.h5
1954/1953 [==============================] - 814s 417ms/step - loss: 0.0545 -
acc: 0.9807 - val_loss: 0.4743 - val_acc: 0.8965
Epoch 19/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0504 - acc: 0.
9821Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 861us/sample - loss: 0.3733 - acc: 0.8976

Epoch 00019: val_acc improved from 0.89650 to 0.89760, saving model to model_
dense.h5
1954/1953 [==============================] - 814s 417ms/step - loss: 0.0504 -
acc: 0.9821 - val_loss: 0.5073 - val_acc: 0.8976
Epoch 20/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0488 - acc: 0.
9827Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 859us/sample - loss: 0.3946 - acc: 0.9055

Epoch 00020: val_acc improved from 0.89760 to 0.90550, saving model to model_
dense.h5
1954/1953 [==============================] - 816s 418ms/step - loss: 0.0488 -
acc: 0.9827 - val_loss: 0.4279 - val_acc: 0.9055
Epoch 21/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0455 - acc: 0.
9840Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 858us/sample - loss: 0.4234 - acc: 0.9008

Epoch 00021: val_acc did not improve from 0.90550
1954/1953 [==============================] - 816s 418ms/step - loss: 0.0455 -
acc: 0.9839 - val_loss: 0.4930 - val_acc: 0.9008
Epoch 22/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0438 - acc: 0.
9847Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 867us/sample - loss: 0.4884 - acc: 0.9041
```

```
Epoch 00022: val_acc did not improve from 0.90550
1954/1953 [==============================] - 814s 417ms/step - loss: 0.0439 -
acc: 0.9847 - val_loss: 0.4589 - val_acc: 0.9041
Epoch 23/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0413 - acc: 0.
9855Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 855us/sample - loss: 0.5515 - acc: 0.8945

Epoch 00023: val_acc did not improve from 0.90550
1954/1953 [==============================] - 812s 416ms/step - loss: 0.0413 -
acc: 0.9855 - val_loss: 0.5492 - val_acc: 0.8945
Epoch 24/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0395 - acc: 0.
9862Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 861us/sample - loss: 0.7714 - acc: 0.8984

Epoch 00024: val_acc did not improve from 0.90550
1954/1953 [==============================] - 815s 417ms/step - loss: 0.0395 -
acc: 0.9862 - val_loss: 0.5492 - val_acc: 0.8984
Epoch 25/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0383 - acc: 0.
9865Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 857us/sample - loss: 0.5539 - acc: 0.9007

Epoch 00025: val_acc did not improve from 0.90550
1954/1953 [==============================] - 816s 418ms/step - loss: 0.0382 -
acc: 0.9865 - val_loss: 0.4738 - val_acc: 0.9007
Epoch 26/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0363 - acc: 0.
9874Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 854us/sample - loss: 0.5164 - acc: 0.9046

Epoch 00026: val_acc did not improve from 0.90550
1954/1953 [==============================] - 814s 417ms/step - loss: 0.0363 -
acc: 0.9874 - val_loss: 0.4864 - val_acc: 0.9046
Epoch 27/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0337 - acc: 0.
9883Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 858us/sample - loss: 0.6035 - acc: 0.8855

Epoch 00027: val_acc did not improve from 0.90550
1954/1953 [==============================] - 813s 416ms/step - loss: 0.0337 -
acc: 0.9883 - val_loss: 0.6773 - val_acc: 0.8855
Epoch 28/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0338 - acc: 0.
9879Epoch 1/35
10000/1953 [==============================================================
```

```
==============================================================================
===========] - 9s 861us/sample - loss: 0.5395 - acc: 0.8857

Epoch 00028: val_acc did not improve from 0.90550
1954/1953 [==============================] - 816s 418ms/step - loss: 0.0338 -
acc: 0.9879 - val_loss: 0.5979 - val_acc: 0.8857
Epoch 29/35
1953/1953 [============================>.] - ETA: 0s - loss: 0.0319 - acc: 0.
9889Epoch 1/35
10000/1953 [==============================================================
==============================================================================
===========] - 9s 857us/sample - loss: 0.3917 - acc: 0.8982

Epoch 00029: val_acc did not improve from 0.90550
1954/1953 [==============================] - 817s 418ms/step - loss: 0.0319 -
acc: 0.9889 - val_loss: 0.5456 - val_acc: 0.8982
Epoch 30/35
1771/1953 [==========================>...] - ETA: 1:15 - loss: 0.0311 - acc:
0.9890Buffered data was truncated after reaching the output size limit.
```

In [25]:
```
# Test the model
score = model.evaluate(X_test, y_test, verbose=1)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
10000/10000 [==============================] - 11s 1ms/sample - loss: 0.4859
- acc: 0.9141
Test loss: 0.4859287844727747
Test accuracy: 0.9141
```

In [0]:
```
# Save the trained weights in to .h5 format
model.save_weights("DNST_model.h5")
print("Saved model to disk")
```

```
Saved model to disk
```

In [0]:
```

```