Data Description-

The CIFAR-10 data consists of 60,000 32x32 color images in 10 classes, with 6000 images per class. There are 50,000 training images and 10,000 test images in the official data.

code courtesy-AAIC

In [1]:

```
#importing libraries
import keras
from keras import backend as K
from keras.datasets import cifar10
from keras.models import Model, Sequential
from keras.layers import Dense, Dropout, Flatten, Input, Activation
from keras.layers import Conv2D, BatchNormalization,AveragePooling2D
from keras.layers import Concatenate
from keras.models import load_model
from keras.optimizers import Adam
from keras.preprocessing.image import ImageDataGenerator
from keras.callbacks import ReduceLROnPlateau, ModelCheckpoint, EarlyStopping,
LearningRateScheduler
from keras.callbacks import Callback
```

```
Using TensorFlow backend.
```

In [0]:

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

# Don't pre-allocate memory; allocate as-needed
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]:

```
# Hyperparameters
batch_size =128
num_classes = 10
epochs = 70
num_filter=40
l =6
compression = 1.0
dropout_rate = 0.20
```

In [5]:

```
# Load CIFAR10 Data
(x_train, y_train), (x_test, y_test) = cifar10.load_data()
img_height, img_width, channel = x_train.shape[1],x_train.shape[2],x_train.shape[3]

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

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170500096/170498071 [==============================] - 11s 0us/step
```

In [0]:

```
# Data augementation
datagen_train = ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.125,
    height_shift_range=0.125,
    horizontal_flip=True,
    fill_mode='nearest',
    zoom_range=0.10)

datagen_train.fit(x_train)
```

In [0]:

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

        temp = concat

    return temp
```

In [0]:

```
def transition(input, num_filter, dropout_rate = 0.2):
    global compression
    BatchNorm = BatchNormalization()(input)
    relu = Activation('relu')(BatchNorm)
    Conv2D_BottleNeck = Conv2D(int(num_filter*compression), (1,1), use_bias=False ,padding='same')(
relu)
    if dropout_rate>0:
        Conv2D_BottleNeck = Dropout(dropout_rate)(Conv2D_BottleNeck)
    avg = AveragePooling2D(pool_size=(2,2))(Conv2D_BottleNeck)

    return avg
```

In [0]:

```
def output_layer(input):
    global compression
    BatchNorm = BatchNormalization()(input)
    relu = Activation('relu')(BatchNorm)
    AvgPooling = AveragePooling2D(pool_size=(2,2))(relu)
    flat = Flatten()(AvgPooling)
    output = Dense(num_classes, activation='softmax')(flat)

    return output
```

In [10]:

```
input = Input(shape=(img_height, img_width, channel,))
First_Conv2D = 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/keras/backend/tensorflow_backend.py:66: The name tf.get_default_graph is deprecated. Plea
```

```
se use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:541: The name tf.placeholder is deprecated. Please us
e tf.compat.v1.placeholder instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:4432: The name tf.random_uniform is deprecated. Pleas
e use tf.random.uniform instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:190: The name tf.get_default_session is deprecated. P
lease use tf.compat.v1.get_default_session instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:207: The name tf.global_variables is deprecated. Plea
se use tf.compat.v1.global_variables instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:2041: The name tf.nn.fused_batch_norm is deprecated.
Please use tf.compat.v1.nn.fused_batch_norm instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:3733: calling dropout (from
tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future
version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:4271: The name tf.nn.avg_pool is deprecated. Please u
se tf.nn.avg_pool2d instead.
```

In [11]:

```
model = Model(inputs=[input], outputs=[output])
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, 40)   1080        input_1[0][0]
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 32, 32, 40)   160         conv2d_1[0][0]
__________________________________________________________________________________________________
activation_1 (Activation)       (None, 32, 32, 40)   0           batch_normalization_1[0][0]
__________________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 32, 32, 40)   14400       activation_1[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 32, 32, 40)   0           conv2d_2[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 32, 32, 80)   0           conv2d_1[0][0]
                                                                 dropout_1[0][0]
__________________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, 32, 32, 80)   320         concatenate_1[0][0]
__________________________________________________________________________________________________
activation_2 (Activation)       (None, 32, 32, 80)   0           batch_normalization_2[0][0]
__________________________________________________________________________________________________
conv2d_3 (Conv2D)               (None, 32, 32, 40)   28800       activation_2[0][0]
__________________________________________________________________________________________________
dropout_2 (Dropout)             (None, 32, 32, 40)   0           conv2d_3[0][0]
__________________________________________________________________________________________________
concatenate_2 (Concatenate)     (None, 32, 32, 120)  0           concatenate_1[0][0]
                                                                 dropout_2[0][0]
__________________________________________________________________________________________________
batch_normalization_3 (BatchNor (None, 32, 32, 120)  480         concatenate_2[0][0]
__________________________________________________________________________________________________
activation_3 (Activation)       (None, 32, 32, 120)  0           batch_normalization_3[0][0]
__________________________________________________________________________________________________
conv2d_4 (Conv2D)               (None, 32, 32, 40)   43200       activation_3[0][0]
__________________________________________________________________________________________________
dropout_3 (Dropout)             (None, 32, 32, 40)   0           conv2d_4[0][0]
```

```
__________________________________________________________________________________________________
concatenate_3 (Concatenate)     (None, 32, 32, 160)  0           concatenate_2[0][0]
                                                                 dropout_3[0][0]
__________________________________________________________________________________________________
batch_normalization_4 (BatchNor (None, 32, 32, 160)  640         concatenate_3[0][0]
__________________________________________________________________________________________________
activation_4 (Activation)       (None, 32, 32, 160)  0           batch_normalization_4[0][0]
__________________________________________________________________________________________________
conv2d_5 (Conv2D)               (None, 32, 32, 40)   57600       activation_4[0][0]
__________________________________________________________________________________________________
dropout_4 (Dropout)             (None, 32, 32, 40)   0           conv2d_5[0][0]
__________________________________________________________________________________________________
concatenate_4 (Concatenate)     (None, 32, 32, 200)  0           concatenate_3[0][0]
                                                                 dropout_4[0][0]
__________________________________________________________________________________________________
batch_normalization_5 (BatchNor (None, 32, 32, 200)  800         concatenate_4[0][0]
__________________________________________________________________________________________________
activation_5 (Activation)       (None, 32, 32, 200)  0           batch_normalization_5[0][0]
__________________________________________________________________________________________________
conv2d_6 (Conv2D)               (None, 32, 32, 40)   72000       activation_5[0][0]
__________________________________________________________________________________________________
dropout_5 (Dropout)             (None, 32, 32, 40)   0           conv2d_6[0][0]
__________________________________________________________________________________________________
concatenate_5 (Concatenate)     (None, 32, 32, 240)  0           concatenate_4[0][0]
                                                                 dropout_5[0][0]
__________________________________________________________________________________________________
batch_normalization_6 (BatchNor (None, 32, 32, 240)  960         concatenate_5[0][0]
__________________________________________________________________________________________________
activation_6 (Activation)       (None, 32, 32, 240)  0           batch_normalization_6[0][0]
__________________________________________________________________________________________________
conv2d_7 (Conv2D)               (None, 32, 32, 40)   9600        activation_6[0][0]
__________________________________________________________________________________________________
dropout_6 (Dropout)             (None, 32, 32, 40)   0           conv2d_7[0][0]
__________________________________________________________________________________________________
average_pooling2d_1 (AveragePoo (None, 16, 16, 40)   0           dropout_6[0][0]
__________________________________________________________________________________________________
batch_normalization_7 (BatchNor (None, 16, 16, 40)   160         average_pooling2d_1[0][0]
__________________________________________________________________________________________________
activation_7 (Activation)       (None, 16, 16, 40)   0           batch_normalization_7[0][0]
__________________________________________________________________________________________________
conv2d_8 (Conv2D)               (None, 16, 16, 40)   14400       activation_7[0][0]
__________________________________________________________________________________________________
dropout_7 (Dropout)             (None, 16, 16, 40)   0           conv2d_8[0][0]
__________________________________________________________________________________________________
concatenate_6 (Concatenate)     (None, 16, 16, 80)   0           average_pooling2d_1[0][0]
                                                                 dropout_7[0][0]
__________________________________________________________________________________________________
batch_normalization_8 (BatchNor (None, 16, 16, 80)   320         concatenate_6[0][0]
__________________________________________________________________________________________________
activation_8 (Activation)       (None, 16, 16, 80)   0           batch_normalization_8[0][0]
__________________________________________________________________________________________________
conv2d_9 (Conv2D)               (None, 16, 16, 40)   28800       activation_8[0][0]
__________________________________________________________________________________________________
dropout_8 (Dropout)             (None, 16, 16, 40)   0           conv2d_9[0][0]
__________________________________________________________________________________________________
concatenate_7 (Concatenate)     (None, 16, 16, 120)  0           concatenate_6[0][0]
                                                                 dropout_8[0][0]
__________________________________________________________________________________________________
batch_normalization_9 (BatchNor (None, 16, 16, 120)  480         concatenate_7[0][0]
__________________________________________________________________________________________________
activation_9 (Activation)       (None, 16, 16, 120)  0           batch_normalization_9[0][0]
__________________________________________________________________________________________________
conv2d_10 (Conv2D)              (None, 16, 16, 40)   43200       activation_9[0][0]
__________________________________________________________________________________________________
dropout_9 (Dropout)             (None, 16, 16, 40)   0           conv2d_10[0][0]
__________________________________________________________________________________________________
concatenate_8 (Concatenate)     (None, 16, 16, 160)  0           concatenate_7[0][0]
                                                                 dropout_9[0][0]
__________________________________________________________________________________________________
batch_normalization_10 (BatchNo (None, 16, 16, 160)  640         concatenate_8[0][0]
__________________________________________________________________________________________________
activation_10 (Activation)      (None, 16, 16, 160)  0           batch_normalization_10[0][0]
__________________________________________________________________________________________________
conv2d_11 (Conv2D)              (None, 16, 16, 40)   57600       activation_10[0][0]
__________________________________________________________________________________________________
dropout_10 (Dropout)            (None, 16, 16, 40)   0           conv2d_11[0][0]
__________________________________________________________________________________________________
concatenate_9 (Concatenate)     (None, 16, 16, 200)  0           concatenate_8[0][0]
```

```
concatenate_9 (Concatenate)     (None, 16, 16, 200)  0           concatenate_8[0][0]
                                                                 dropout_10[0][0]
__________________________________________________________________________________________________
batch_normalization_11 (BatchNo (None, 16, 16, 200)  800         concatenate_9[0][0]
__________________________________________________________________________________________________
activation_11 (Activation)      (None, 16, 16, 200)  0           batch_normalization_11[0][0]
__________________________________________________________________________________________________
conv2d_12 (Conv2D)              (None, 16, 16, 40)   72000       activation_11[0][0]
__________________________________________________________________________________________________
dropout_11 (Dropout)            (None, 16, 16, 40)   0           conv2d_12[0][0]
__________________________________________________________________________________________________
concatenate_10 (Concatenate)    (None, 16, 16, 240)  0           concatenate_9[0][0]
                                                                 dropout_11[0][0]
__________________________________________________________________________________________________
batch_normalization_12 (BatchNo (None, 16, 16, 240)  960         concatenate_10[0][0]
__________________________________________________________________________________________________
activation_12 (Activation)      (None, 16, 16, 240)  0           batch_normalization_12[0][0]
__________________________________________________________________________________________________
conv2d_13 (Conv2D)              (None, 16, 16, 40)   9600        activation_12[0][0]
__________________________________________________________________________________________________
dropout_12 (Dropout)            (None, 16, 16, 40)   0           conv2d_13[0][0]
__________________________________________________________________________________________________
average_pooling2d_2 (AveragePoo (None, 8, 8, 40)     0           dropout_12[0][0]
__________________________________________________________________________________________________
batch_normalization_13 (BatchNo (None, 8, 8, 40)     160         average_pooling2d_2[0][0]
__________________________________________________________________________________________________
activation_13 (Activation)      (None, 8, 8, 40)     0           batch_normalization_13[0][0]
__________________________________________________________________________________________________
conv2d_14 (Conv2D)              (None, 8, 8, 40)     14400       activation_13[0][0]
__________________________________________________________________________________________________
dropout_13 (Dropout)            (None, 8, 8, 40)     0           conv2d_14[0][0]
__________________________________________________________________________________________________
concatenate_11 (Concatenate)    (None, 8, 8, 80)     0           average_pooling2d_2[0][0]
                                                                 dropout_13[0][0]
__________________________________________________________________________________________________
batch_normalization_14 (BatchNo (None, 8, 8, 80)     320         concatenate_11[0][0]
__________________________________________________________________________________________________
activation_14 (Activation)      (None, 8, 8, 80)     0           batch_normalization_14[0][0]
__________________________________________________________________________________________________
conv2d_15 (Conv2D)              (None, 8, 8, 40)     28800       activation_14[0][0]
__________________________________________________________________________________________________
dropout_14 (Dropout)            (None, 8, 8, 40)     0           conv2d_15[0][0]
__________________________________________________________________________________________________
concatenate_12 (Concatenate)    (None, 8, 8, 120)    0           concatenate_11[0][0]
                                                                 dropout_14[0][0]
__________________________________________________________________________________________________
batch_normalization_15 (BatchNo (None, 8, 8, 120)    480         concatenate_12[0][0]
__________________________________________________________________________________________________
activation_15 (Activation)      (None, 8, 8, 120)    0           batch_normalization_15[0][0]
__________________________________________________________________________________________________
conv2d_16 (Conv2D)              (None, 8, 8, 40)     43200       activation_15[0][0]
__________________________________________________________________________________________________
dropout_15 (Dropout)            (None, 8, 8, 40)     0           conv2d_16[0][0]
__________________________________________________________________________________________________
concatenate_13 (Concatenate)    (None, 8, 8, 160)    0           concatenate_12[0][0]
                                                                 dropout_15[0][0]
__________________________________________________________________________________________________
batch_normalization_16 (BatchNo (None, 8, 8, 160)    640         concatenate_13[0][0]
__________________________________________________________________________________________________
activation_16 (Activation)      (None, 8, 8, 160)    0           batch_normalization_16[0][0]
__________________________________________________________________________________________________
conv2d_17 (Conv2D)              (None, 8, 8, 40)     57600       activation_16[0][0]
__________________________________________________________________________________________________
dropout_16 (Dropout)            (None, 8, 8, 40)     0           conv2d_17[0][0]
__________________________________________________________________________________________________
concatenate_14 (Concatenate)    (None, 8, 8, 200)    0           concatenate_13[0][0]
                                                                 dropout_16[0][0]
__________________________________________________________________________________________________
batch_normalization_17 (BatchNo (None, 8, 8, 200)    800         concatenate_14[0][0]
__________________________________________________________________________________________________
activation_17 (Activation)      (None, 8, 8, 200)    0           batch_normalization_17[0][0]
__________________________________________________________________________________________________
conv2d_18 (Conv2D)              (None, 8, 8, 40)     72000       activation_17[0][0]
__________________________________________________________________________________________________
dropout_17 (Dropout)            (None, 8, 8, 40)     0           conv2d_18[0][0]
__________________________________________________________________________________________________
concatenate_15 (Concatenate)    (None, 8, 8, 240)    0           concatenate_14[0][0]
                                                                 dropout_17[0][0]
                                                                 dropout_17[0][0]
__________________________________________________________________________________________________
batch_normalization_18 (BatchNo (None, 8, 8, 240)    960         concatenate_15[0][0]
__________________________________________________________________________________________________
activation_18 (Activation)      (None, 8, 8, 240)    0           batch_normalization_18[0][0]
__________________________________________________________________________________________________
conv2d_19 (Conv2D)              (None, 8, 8, 40)     9600        activation_18[0][0]
__________________________________________________________________________________________________
dropout_18 (Dropout)            (None, 8, 8, 40)     0           conv2d_19[0][0]
__________________________________________________________________________________________________
average_pooling2d_3 (AveragePoo (None, 4, 4, 40)     0           dropout_18[0][0]
__________________________________________________________________________________________________
batch_normalization_19 (BatchNo (None, 4, 4, 40)     160         average_pooling2d_3[0][0]
__________________________________________________________________________________________________
activation_19 (Activation)      (None, 4, 4, 40)     0           batch_normalization_19[0][0]
__________________________________________________________________________________________________
conv2d_20 (Conv2D)              (None, 4, 4, 40)     14400       activation_19[0][0]
__________________________________________________________________________________________________
dropout_19 (Dropout)            (None, 4, 4, 40)     0           conv2d_20[0][0]
__________________________________________________________________________________________________
concatenate_16 (Concatenate)    (None, 4, 4, 80)     0           average_pooling2d_3[0][0]
                                                                 dropout_19[0][0]
__________________________________________________________________________________________________
batch_normalization_20 (BatchNo (None, 4, 4, 80)     320         concatenate_16[0][0]
__________________________________________________________________________________________________
activation_20 (Activation)      (None, 4, 4, 80)     0           batch_normalization_20[0][0]
__________________________________________________________________________________________________
conv2d_21 (Conv2D)              (None, 4, 4, 40)     28800       activation_20[0][0]
__________________________________________________________________________________________________
dropout_20 (Dropout)            (None, 4, 4, 40)     0           conv2d_21[0][0]
__________________________________________________________________________________________________
concatenate_17 (Concatenate)    (None, 4, 4, 120)    0           concatenate_16[0][0]
                                                                 dropout_20[0][0]
__________________________________________________________________________________________________
batch_normalization_21 (BatchNo (None, 4, 4, 120)    480         concatenate_17[0][0]
__________________________________________________________________________________________________
activation_21 (Activation)      (None, 4, 4, 120)    0           batch_normalization_21[0][0]
__________________________________________________________________________________________________
conv2d_22 (Conv2D)              (None, 4, 4, 40)     43200       activation_21[0][0]
__________________________________________________________________________________________________
dropout_21 (Dropout)            (None, 4, 4, 40)     0           conv2d_22[0][0]
__________________________________________________________________________________________________
concatenate_18 (Concatenate)    (None, 4, 4, 160)    0           concatenate_17[0][0]
                                                                 dropout_21[0][0]
__________________________________________________________________________________________________
batch_normalization_22 (BatchNo (None, 4, 4, 160)    640         concatenate_18[0][0]
__________________________________________________________________________________________________
activation_22 (Activation)      (None, 4, 4, 160)    0           batch_normalization_22[0][0]
__________________________________________________________________________________________________
conv2d_23 (Conv2D)              (None, 4, 4, 40)     57600       activation_22[0][0]
__________________________________________________________________________________________________
dropout_22 (Dropout)            (None, 4, 4, 40)     0           conv2d_23[0][0]
__________________________________________________________________________________________________
concatenate_19 (Concatenate)    (None, 4, 4, 200)    0           concatenate_18[0][0]
                                                                 dropout_22[0][0]
__________________________________________________________________________________________________
batch_normalization_23 (BatchNo (None, 4, 4, 200)    800         concatenate_19[0][0]
__________________________________________________________________________________________________
activation_23 (Activation)      (None, 4, 4, 200)    0           batch_normalization_23[0][0]
__________________________________________________________________________________________________
conv2d_24 (Conv2D)              (None, 4, 4, 40)     72000       activation_23[0][0]
__________________________________________________________________________________________________
dropout_23 (Dropout)            (None, 4, 4, 40)     0           conv2d_24[0][0]
__________________________________________________________________________________________________
concatenate_20 (Concatenate)    (None, 4, 4, 240)    0           concatenate_19[0][0]
                                                                 dropout_23[0][0]
__________________________________________________________________________________________________
batch_normalization_24 (BatchNo (None, 4, 4, 240)    960         concatenate_20[0][0]
__________________________________________________________________________________________________
activation_24 (Activation)      (None, 4, 4, 240)    0           batch_normalization_24[0][0]
__________________________________________________________________________________________________
average_pooling2d_4 (AveragePoo (None, 2, 2, 240)    0           activation_24[0][0]
__________________________________________________________________________________________________
flatten_1 (Flatten)             (None, 960)          0           average_pooling2d_4[0][0]
__________________________________________________________________________________________________
dense_1 (Dense)                 (None, 10)           9610        flatten_1[0][0]
==================================================================================================
Total params: 916,930
Total params: 916,930
Trainable params: 910,210
Non-trainable params: 6,720
_________________________________________________________________
```

In [12]:

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

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optimizers.py:793: The name t
f.train.Optimizer is deprecated. Please use tf.compat.v1.train.Optimizer instead.
```

In [0]:

```python
import datetime
#https://www.tensorflow.org/api_docs/python/tf/keras/callbacks/LearningRateScheduler
def scheduler(epoch):
    if epoch < 40:
        return 0.001
    else:
        return 0.0001

lr_scheduler = LearningRateScheduler(scheduler)
log_dir="logs_1/fit/" + datetime.datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=0)
```

In [15]:

```python
model.fit_generator(
    datagen_train.flow(x_train, y_train, batch_size=batch_size),
    steps_per_epoch=(len(x_train)/batch_size),
    epochs=epochs,
    verbose = 1,
    validation_data=(x_test, y_test),
    callbacks = [lr_scheduler,tensorboard_callback])
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/tensorflow/python/ops/math_grad.py:1250: add_dispatch_support.<locals>.wrapper (from
tensorflow.python.ops.array_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
Epoch 1/70
391/390 [==============================] - 211s 540ms/step - loss: 1.5100 - acc: 0.4470 -
val_loss: 2.7423 - val_acc: 0.3576
Epoch 2/70
391/390 [==============================] - 198s 506ms/step - loss: 1.1204 - acc: 0.5968 -
val_loss: 1.5332 - val_acc: 0.5534
Epoch 3/70
391/390 [==============================] - 198s 507ms/step - loss: 0.9607 - acc: 0.6568 -
val_loss: 1.1071 - val_acc: 0.6465
Epoch 4/70
391/390 [==============================] - 197s 504ms/step - loss: 0.8546 - acc: 0.6959 -
val_loss: 1.2624 - val_acc: 0.6381
Epoch 5/70
391/390 [==============================] - 198s 506ms/step - loss: 0.7766 - acc: 0.7297 -
val_loss: 0.9153 - val_acc: 0.7136
Epoch 6/70
391/390 [==============================] - 198s 506ms/step - loss: 0.7187 - acc: 0.7486 -
val_loss: 1.6129 - val_acc: 0.6111
Epoch 7/70
391/390 [==============================] - 198s 506ms/step - loss: 0.6717 - acc: 0.7639 -
val_loss: 0.9025 - val_acc: 0.7292
Epoch 8/70
391/390 [==============================] - 197s 504ms/step - loss: 0.6443 - acc: 0.7762 -
val_loss: 0.8948 - val_acc: 0.7267
Epoch 9/70
391/390 [==============================] - 198s 507ms/step - loss: 0.6071 - acc: 0.7881 -
val_loss: 1.3329 - val_acc: 0.6607
Epoch 10/70
391/390 [==============================] - 198s 506ms/step - loss: 0.5877 - acc: 0.7953
```

```
391/390 [==============================] - 198s 506ms/step - loss: 0.5877 - acc: 0.7953 -
val_loss: 0.8611 - val_acc: 0.7451
Epoch 11/70
391/390 [==============================] - 198s 508ms/step - loss: 0.5605 - acc: 0.8053 -
val_loss: 0.9375 - val_acc: 0.7440
Epoch 12/70
391/390 [==============================] - 198s 507ms/step - loss: 0.5446 - acc: 0.8113 -
val_loss: 1.0601 - val_acc: 0.7033
Epoch 13/70
391/390 [==============================] - 198s 506ms/step - loss: 0.5219 - acc: 0.8186 -
val_loss: 0.6539 - val_acc: 0.8001
Epoch 14/70
391/390 [==============================] - 198s 508ms/step - loss: 0.5105 - acc: 0.8227 -
val_loss: 0.8048 - val_acc: 0.7762
Epoch 15/70
391/390 [==============================] - 199s 509ms/step - loss: 0.4903 - acc: 0.8298 -
val_loss: 0.8658 - val_acc: 0.7736
Epoch 16/70
391/390 [==============================] - 198s 507ms/step - loss: 0.4793 - acc: 0.8336 -
val_loss: 1.0217 - val_acc: 0.7267
Epoch 17/70
391/390 [==============================] - 199s 508ms/step - loss: 0.4691 - acc: 0.8369 -
val_loss: 0.5411 - val_acc: 0.8330
Epoch 18/70
391/390 [==============================] - 199s 508ms/step - loss: 0.4502 - acc: 0.8435 -
val_loss: 0.6012 - val_acc: 0.8161
Epoch 19/70
391/390 [==============================] - 199s 508ms/step - loss: 0.4472 - acc: 0.8456 -
val_loss: 0.7027 - val_acc: 0.7960
Epoch 20/70
391/390 [==============================] - 199s 508ms/step - loss: 0.4353 - acc: 0.8500 -
val_loss: 0.7391 - val_acc: 0.7977
Epoch 21/70
391/390 [==============================] - 199s 508ms/step - loss: 0.4235 - acc: 0.8544 -
val_loss: 0.5249 - val_acc: 0.8379
Epoch 22/70
391/390 [==============================] - 199s 509ms/step - loss: 0.4149 - acc: 0.8553 -
val_loss: 0.7811 - val_acc: 0.7781
Epoch 23/70
391/390 [==============================] - 198s 508ms/step - loss: 0.4079 - acc: 0.8567 -
val_loss: 0.6919 - val_acc: 0.8097
Epoch 24/70
391/390 [==============================] - 198s 506ms/step - loss: 0.3964 - acc: 0.8618 -
val_loss: 0.6356 - val_acc: 0.8185
Epoch 25/70
391/390 [==============================] - 198s 506ms/step - loss: 0.3867 - acc: 0.8652 -
val_loss: 0.5262 - val_acc: 0.8461
Epoch 26/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3780 - acc: 0.8678 -
val_loss: 0.7747 - val_acc: 0.8015
Epoch 27/70
391/390 [==============================] - 199s 508ms/step - loss: 0.3812 - acc: 0.8669 -
val_loss: 0.7552 - val_acc: 0.7912
Epoch 28/70
391/390 [==============================] - 199s 508ms/step - loss: 0.3722 - acc: 0.8707 -
val_loss: 0.7959 - val_acc: 0.7865
Epoch 29/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3608 - acc: 0.8742 -
val_loss: 0.5487 - val_acc: 0.8405
Epoch 30/70
391/390 [==============================] - 198s 506ms/step - loss: 0.3567 - acc: 0.8752 -
val_loss: 0.5023 - val_acc: 0.8510
Epoch 31/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3477 - acc: 0.8789 -
val_loss: 0.5204 - val_acc: 0.8497
Epoch 32/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3400 - acc: 0.8810 -
val_loss: 0.6326 - val_acc: 0.8157
Epoch 33/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3404 - acc: 0.8801 -
val_loss: 0.5889 - val_acc: 0.8412
Epoch 34/70
391/390 [==============================] - 198s 508ms/step - loss: 0.3353 - acc: 0.8824 -
val_loss: 0.5548 - val_acc: 0.8493
Epoch 35/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3305 - acc: 0.8864 -
val_loss: 0.5869 - val_acc: 0.8288
Epoch 36/70
Epoch 36/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3250 - acc: 0.8871 -
val_loss: 0.5617 - val_acc: 0.8424
Epoch 37/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3153 - acc: 0.8900 -
val_loss: 0.4223 - val_acc: 0.8737
Epoch 38/70
391/390 [==============================] - 198s 506ms/step - loss: 0.3121 - acc: 0.8905 -
val_loss: 0.9475 - val_acc: 0.7833
Epoch 39/70
391/390 [==============================] - 198s 506ms/step - loss: 0.3118 - acc: 0.8910 -
val_loss: 0.3633 - val_acc: 0.8900
Epoch 40/70
391/390 [==============================] - 198s 507ms/step - loss: 0.3089 - acc: 0.8920 -
val_loss: 0.5189 - val_acc: 0.8545
Epoch 41/70
391/390 [==============================] - 198s 507ms/step - loss: 0.2617 - acc: 0.9084 -
val_loss: 0.3721 - val_acc: 0.8887
Epoch 42/70
391/390 [==============================] - 199s 508ms/step - loss: 0.2404 - acc: 0.9150 -
val_loss: 0.3381 - val_acc: 0.9015
Epoch 43/70
391/390 [==============================] - 199s 508ms/step - loss: 0.2374 - acc: 0.9171 -
val_loss: 0.3555 - val_acc: 0.8964
Epoch 44/70
391/390 [==============================] - 198s 508ms/step - loss: 0.2336 - acc: 0.9190 -
val_loss: 0.3398 - val_acc: 0.9009
Epoch 45/70
391/390 [==============================] - 199s 509ms/step - loss: 0.2309 - acc: 0.9185 -
val_loss: 0.3387 - val_acc: 0.8990
Epoch 46/70
391/390 [==============================] - 199s 509ms/step - loss: 0.2244 - acc: 0.9217 -
val_loss: 0.3418 - val_acc: 0.9013
Epoch 47/70
391/390 [==============================] - 199s 508ms/step - loss: 0.2281 - acc: 0.9208 -
val_loss: 0.3541 - val_acc: 0.8965
Epoch 48/70
391/390 [==============================] - 199s 509ms/step - loss: 0.2189 - acc: 0.9231 -
val_loss: 0.3634 - val_acc: 0.8972
Epoch 49/70
391/390 [==============================] - 199s 508ms/step - loss: 0.2197 - acc: 0.9231 -
val_loss: 0.3521 - val_acc: 0.8990
Epoch 50/70
391/390 [==============================] - 199s 508ms/step - loss: 0.2207 - acc: 0.9232 -
val_loss: 0.3578 - val_acc: 0.8979
Epoch 51/70
391/390 [==============================] - 198s 506ms/step - loss: 0.2189 - acc: 0.9227 -
val_loss: 0.3585 - val_acc: 0.8971
Epoch 52/70
391/390 [==============================] - 198s 506ms/step - loss: 0.2140 - acc: 0.9244 -
val_loss: 0.3273 - val_acc: 0.9057
Epoch 53/70
391/390 [==============================] - 198s 506ms/step - loss: 0.2082 - acc: 0.9258 -
val_loss: 0.3601 - val_acc: 0.8975
Epoch 54/70
391/390 [==============================] - 198s 505ms/step - loss: 0.2142 - acc: 0.9255 -
val_loss: 0.3600 - val_acc: 0.8976
Epoch 55/70
391/390 [==============================] - 197s 505ms/step - loss: 0.2099 - acc: 0.9264 -
val_loss: 0.3438 - val_acc: 0.9031
Epoch 56/70
391/390 [==============================] - 198s 506ms/step - loss: 0.2084 - acc: 0.9254 -
val_loss: 0.3546 - val_acc: 0.9030
Epoch 57/70
391/390 [==============================] - 199s 508ms/step - loss: 0.2086 - acc: 0.9267 -
val_loss: 0.3458 - val_acc: 0.9035
Epoch 58/70
391/390 [==============================] - 199s 510ms/step - loss: 0.2071 - acc: 0.9278 -
val_loss: 0.3546 - val_acc: 0.8999
Epoch 59/70
391/390 [==============================] - 200s 510ms/step - loss: 0.2072 - acc: 0.9259 -
val_loss: 0.3521 - val_acc: 0.9033
Epoch 60/70
391/390 [==============================] - 198s 505ms/step - loss: 0.2030 - acc: 0.9289 -
val_loss: 0.3394 - val_acc: 0.9033
Epoch 61/70
391/390 [==============================] - 197s 504ms/step - loss: 0.2075 - acc: 0.9271 -
```

```
val_loss: 0.3456 - val_acc: 0.9037
Epoch 62/70
391/390 [==============================] - 197s 505ms/step - loss: 0.2045 - acc: 0.9281 -
val_loss: 0.3546 - val_acc: 0.9012
Epoch 63/70
391/390 [==============================] - 197s 505ms/step - loss: 0.2024 - acc: 0.9288 -
val_loss: 0.3599 - val_acc: 0.9008
Epoch 64/70
391/390 [==============================] - 197s 505ms/step - loss: 0.2017 - acc: 0.9285 -
val_loss: 0.3680 - val_acc: 0.8974
Epoch 65/70
391/390 [==============================] - 197s 505ms/step - loss: 0.2044 - acc: 0.9284 -
val_loss: 0.3334 - val_acc: 0.9059
Epoch 66/70
391/390 [==============================] - 197s 505ms/step - loss: 0.2008 - acc: 0.9290 -
val_loss: 0.3548 - val_acc: 0.9003
Epoch 67/70
391/390 [==============================] - 197s 504ms/step - loss: 0.1992 - acc: 0.9302 -
val_loss: 0.3617 - val_acc: 0.9007
Epoch 68/70
391/390 [==============================] - 197s 505ms/step - loss: 0.2011 - acc: 0.9297 -
val_loss: 0.3599 - val_acc: 0.8989
Epoch 69/70
391/390 [==============================] - 199s 508ms/step - loss: 0.1967 - acc: 0.9299 -
val_loss: 0.3602 - val_acc: 0.9008
Epoch 70/70
391/390 [==============================] - 199s 508ms/step - loss: 0.1990 - acc: 0.9306 -
val_loss: 0.3400 - val_acc: 0.9045
```

Out[15]:

```
<keras.callbacks.History at 0x7fc2496b1668>
```

In [16]:

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

```
10000/10000 [==============================] - 13s 1ms/step
Test loss: 0.33996419424414637
Test accuracy: 0.9045
```

In [18]:

```
# Load the TensorBoard notebook extension
%load_ext tensorboard
%tensorboard --logdir logs_1/fit
```

In [19]:

```
#save model weights
model.save_weights("dnst_model.h5")
print("saved model")
```

```
saved model
```

steps used-

1-load the cifar10 data and split into train and test data.

2-define all the required paarmeters.

3-define the model architecture.

4-apply the model and evaluate its test performance,