Assignment 25

In [1]:
```
import os

import tensorflow as tf
from tensorflow import keras
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade now or ensure your notebook will continue to use TensorFlow 1.x via the `%tensorflow_version 1.x` magic: more info.

In [0]:
```
# import keras
# from keras.datasets import cifar10
# from keras.models import Model, Sequential
# from keras.layers import Dense, Dropout, Flatten, Input, AveragePooli
ng2D, merge, Activation
# from keras.layers import Conv2D, MaxPooling2D, BatchNormalization
# from keras.layers import Concatenate
# from keras.optimizers import Adam
from tensorflow.keras import models, layers
from tensorflow.keras.models import Model
from tensorflow.keras.layers import BatchNormalization, Activation, Fla
tten
from tensorflow.keras.optimizers import Adam
```

In [0]:
```
# Hyperparameters
batch_size = 128
num_classes = 10
epochs = 10
l = 40
num_filter = 12
compression = 0.5
dropout_rate = 0.2
```

Loading data

In [4]:
```
# Load CIFAR10 Data
(X_train, y_train), (X_test, y_test) = tf.keras.datasets.cifar10.load_d
ata()
img_height, img_width, channel = X_train.shape[1],X_train.shape[2],X_tr
ain.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 [==============================] - 13s 0us/step
```

In [5]:
```
X_train.shape
```

Out[5]:
```
(50000, 32, 32, 3)
```

Standarding data

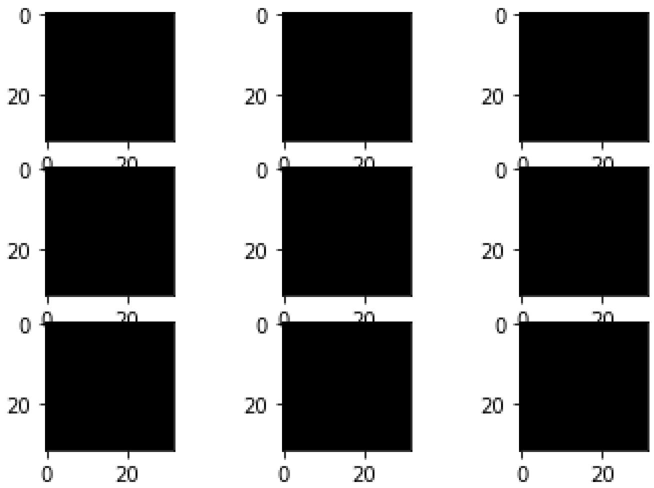
In [0]:
```
def prep_pixels(train, test):
# convert from integers to floats
    train_norm = train.astype('float32')
    test_norm = test.astype('float32')
# normalize to range 0-1
    train_norm = train_norm / 255.0
    test_norm = test_norm / 255.0
# return normalized images
    return train_norm, test_norm
```

In [0]:
```
X_train,X_test=prep_pixels(X_train,X_test)
```

In [8]:
```
#https://machinelearningmastery.com/how-to-configure-image-data-augment
```

```
ation-when-training-deep-learning-neural-networks/
from numpy import expand_dims
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
from keras.preprocessing.image import ImageDataGenerator
from matplotlib import pyplot
c=X_train[1]
c.shape
samples = expand_dims(c, 0)
# create image data augmentation generator
datagen = ImageDataGenerator(rotation_range=90)
# prepare iterator
it = datagen.flow(samples, batch_size=1)
# generate samples and plot
for i in range(9):
    pyplot.subplot(330 + 1 + i)
# generate batch of images
    batch = it.next()
# convert to unsigned integers for viewing
    image = batch[0].astype('uint8')
# plot raw pixel data
    pyplot.imshow(image)
# show the figure

pyplot.show()
```

```
Using TensorFlow backend.
```



In [0]:
```
# Defining the model
```

Model using dense layer

In [0]:
```
# Dense Block
def denseblock(input, num_filter = 64, dropout_rate = 0):
    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), (5,5),k
ernel_initializer="he_uniform" ,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 = 32, dropout_rate = 0):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    Conv2D_BottleNeck = layers.Conv2D(int(num_filter*compression), (5,5
), kernel_initializer="he_uniform" ,padding='same')(relu)
    if dropout_rate>0:
         Conv2D_BottleNeck = layers.Dropout(dropout_rate)(Conv2D_Bottle
Neck)
    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)
    return output
```

In [0]:

```
num_filter = 10
dropout_rate = 0
l = 12
input = layers.Input(shape=(img_height, img_width, channel,))
First_Conv2D = layers.Conv2D(num_filter, (5,5), use_bias=False ,padding
='same')(input)
BatchNorm = layers.BatchNormalization()(First_Conv2D)

First_Block = denseblock(BatchNorm,32, dropout_rate)
First_Transition = transition(First_Block, num_filter, dropout_rate)

Second_Block = denseblock(First_Transition, 16, 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)
```

```
conv_layer = layers.Conv2D(num_filter, (1,1), use_bias=False ,padding=
'same') (input)
last = layers.GlobalMaxPooling2D()(conv_layer)
output = layers.Activation('softmax')(last)
```

In [19]:

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

```
Model: "model_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
input_5 (InputLayer)         [(None, 32, 32, 3)]       0         
_________________________________________________________________
conv2d_215 (Conv2D)          (None, 32, 32, 10)        30        
_________________________________________________________________
global_max_pooling2d_1 (Glob (None, 10)                0         
_________________________________________________________________
activation_208 (Activation)  (None, 10)                0         
=================================================================
Total params: 30
Trainable params: 30
Non-trainable params: 0
_________________________________________________________________
```

In [0]:

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

In [21]:

```
#https://machinelearningmastery.com/how-to-develop-a-cnn-from-scratch-f
or-cifar-10-photo-classification/
def summarize_diagnostics(history):
        # plot loss
        pyplot.subplot(121)
        pyplot.title('Cross Entropy Loss')
        pyplot.plot(history.history['loss'], color='blue', label='trai
n')
        pyplot.plot(history.history['val_loss'], color='orange', label=
```

```
'test')
        pyplot.show()


# run the test harness for evaluating a model
def run_test_harness():

        # define model

        # create data generator
        datagen = ImageDataGenerator(width_shift_range=0.1, height_shif
t_range=0.1, horizontal_flip=True)
        # prepare iterator
        it_train = datagen.flow(X_train, y_train, batch_size=64)
        # fit model
        steps = int(X_train.shape[0] / 64)
        history = model.fit_generator(it_train, steps_per_epoch=steps,
epochs=15, validation_data=(X_test, y_test), verbose=1)
        # evaluate model
        _, acc = model.evaluate(X_test, y_test, verbose=0)
        print('> %.3f' % (acc * 100.0))
        # learning curves
        summarize_diagnostics(history)

# entry point, run the test harness
run_test_harness()
```

```
Epoch 1/15
780/781 [============================>.] - ETA: 0s - loss: 2.3086 - ac
c: 0.1021Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 2s 153us/sample - loss: 2.2
888 - acc: 0.1032
781/781 [==============================] - 22s 28ms/step - loss: 2.3086
- acc: 0.1021 - val_loss: 2.2968 - val_acc: 0.1032
Epoch 2/15
```

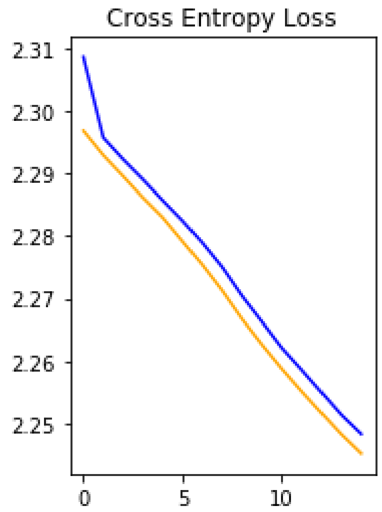
```
780/781 [============================>.] - ETA: 0s - loss: 2.2958 - ac

c: 0.1090Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 68us/sample - loss: 2.28
98 - acc: 0.1346
781/781 [==============================] - 19s 24ms/step - loss: 2.2958
- acc: 0.1091 - val_loss: 2.2929 - val_acc: 0.1346
Epoch 3/15
780/781 [============================>.] - ETA: 0s - loss: 2.2923 - ac
c: 0.1288Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 66us/sample - loss: 2.28
35 - acc: 0.1378
781/781 [==============================] - 19s 24ms/step - loss: 2.2923
- acc: 0.1288 - val_loss: 2.2896 - val_acc: 0.1378
Epoch 4/15
780/781 [============================>.] - ETA: 0s - loss: 2.2891 - ac
c: 0.1359Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 69us/sample - loss: 2.28
30 - acc: 0.1553
781/781 [==============================] - 19s 24ms/step - loss: 2.2891
- acc: 0.1359 - val_loss: 2.2862 - val_acc: 0.1553
Epoch 5/15
778/781 [============================>.] - ETA: 0s - loss: 2.2857 - ac
c: 0.1446Epoch 1/15
10000/781 [============================================================
```

```
=======================================================================

=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 68us/sample - loss: 2.28
13 - acc: 0.1320
781/781 [==============================] - 19s 25ms/step - loss: 2.2857
- acc: 0.1445 - val_loss: 2.2830 - val_acc: 0.1320
Epoch 6/15
779/781 [============================>.] - ETA: 0s - loss: 2.2825 - ac
c: 0.1471Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 70us/sample - loss: 2.27
78 - acc: 0.1554
781/781 [==============================] - 19s 24ms/step - loss: 2.2825
- acc: 0.1472 - val_loss: 2.2792 - val_acc: 0.1554
Epoch 7/15
779/781 [============================>.] - ETA: 0s - loss: 2.2789 - ac
c: 0.1503Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 70us/sample - loss: 2.27
78 - acc: 0.1560
781/781 [==============================] - 19s 24ms/step - loss: 2.2789
- acc: 0.1502 - val_loss: 2.2754 - val_acc: 0.1560
Epoch 8/15
780/781 [============================>.] - ETA: 0s - loss: 2.2750 - ac
c: 0.1525Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
```

```
=======================================================================

========================================] - 1s 75us/sample - loss: 2.27
40 - acc: 0.1551
781/781 [==============================] - 19s 24ms/step - loss: 2.2750
 - acc: 0.1526 - val_loss: 2.2713 - val_acc: 0.1551
Epoch 9/15
779/781 [============================>.] - ETA: 0s - loss: 2.2704 - ac
c: 0.1503Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 73us/sample - loss: 2.26
28 - acc: 0.1549
781/781 [==============================] - 19s 24ms/step - loss: 2.2704
 - acc: 0.1502 - val_loss: 2.2667 - val_acc: 0.1549
Epoch 10/15
780/781 [============================>.] - ETA: 0s - loss: 2.2663 - ac
c: 0.1525Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 69us/sample - loss: 2.25
89 - acc: 0.1568
781/781 [==============================] - 19s 24ms/step - loss: 2.2663
 - acc: 0.1525 - val_loss: 2.2626 - val_acc: 0.1568
Epoch 11/15
778/781 [============================>.] - ETA: 0s - loss: 2.2622 - ac
c: 0.1546Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 69us/sample - loss: 2.25
33 - acc: 0.1534
```

```
781/781 [==============================] - 19s 24ms/step - loss: 2.2622

- acc: 0.1546 - val_loss: 2.2588 - val_acc: 0.1534
Epoch 12/15
780/781 [============================>.] - ETA: 0s - loss: 2.2585 - ac
c: 0.1528Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 74us/sample - loss: 2.25
26 - acc: 0.1563
781/781 [==============================] - 19s 24ms/step - loss: 2.2585
- acc: 0.1527 - val_loss: 2.2552 - val_acc: 0.1563
Epoch 13/15
778/781 [============================>.] - ETA: 0s - loss: 2.2550 - ac
c: 0.1565Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 74us/sample - loss: 2.24
38 - acc: 0.1568
781/781 [==============================] - 19s 24ms/step - loss: 2.2550
- acc: 0.1565 - val_loss: 2.2517 - val_acc: 0.1568
Epoch 14/15
778/781 [============================>.] - ETA: 0s - loss: 2.2514 - ac
c: 0.1572Epoch 1/15
10000/781 [============================================================
=======================================================================
=======================================================================
=======================================================================
=======================================================================
========================================] - 1s 78us/sample - loss: 2.23
64 - acc: 0.1552
781/781 [==============================] - 19s 24ms/step - loss: 2.2514
- acc: 0.1573 - val_loss: 2.2482 - val_acc: 0.1552
Epoch 15/15
```

```
779/781 [============================>.] - ETA: 0s - loss: 2.2483 - ac

c: 0.1597Epoch 1/15
10000/781 [========================================================================
========================================================================
========================================================================
========================================================================
========================================================================
========================================] - 1s 76us/sample - loss: 2.23
66 - acc: 0.1569
781/781 [==============================] - 19s 24ms/step - loss: 2.2483
- acc: 0.1597 - val_loss: 2.2452 - val_acc: 0.1569
> 15.690
```



train_loss: 0.1203 train_acc: 0.9561

val_loss: 0.6271 val_acc: 0.8439

Model without dense layer

In [0]:
```
from keras import regularizers
```

```
# Dense Block
def denseblock(input, num_filter = 12, dropout_rate = 0.2):
    global compression
    temp = input
    for _ in range(l):
        BatchNorm = layers.BatchNormalization()(temp)
        relu = layers.Activation('relu')(BatchNorm)
        Conv2D_3_3 = layers.Conv2D(int(num_filter*compression), (5,5),
use_bias=False ,padding='same')(relu)
        if dropout_rate>0:
            Conv2D_3_3 = layers.Dropout(dropout_rate)(Conv2D_3_3)
        concat = layers.Concatenate(axis=-1)([temp,Conv2D_3_3])

        temp = concat

    return temp

## transition Blosck
def transition(input, num_filter = 12, dropout_rate = 0.2):
    global compression
    BatchNorm = layers.BatchNormalization()(input)
    relu = layers.Activation('relu')(BatchNorm)
    Conv2D_BottleNeck = layers.Conv2D(int(num_filter*compression), (5,5
), use_bias=False ,padding='same')(relu)
    if dropout_rate>0:
         Conv2D_BottleNeck = layers.Dropout(dropout_rate)(Conv2D_Bottle
Neck)
    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. MaxPooling2D(pool_size=(2,2))(relu)

    output = layers.Conv2D(filters=10,kernel_size=(2,2),activation='sof
tmax')(AvgPooling)
```

```python
    flat = layers.Flatten()(output)
    return flat



num_filter = 12
dropout_rate = 0
l = 12
input = layers.Input(shape=(img_height, img_width, channel,))
First_Conv2D = layers.Conv2D(32, (3,3), use_bias=False ,padding='same')
(input)

First_Block = denseblock(First_Conv2D,10, dropout_rate)
First_Transition = transition(First_Block, 64, dropout_rate)

Second_Block = denseblock(First_Transition, 10, dropout_rate)
Second_Transition = transition(Second_Block, 32, dropout_rate)

Third_Block = denseblock(Second_Transition, num_filter, dropout_rate)
Third_Transition = transition(Third_Block, 32, dropout_rate)

conv_layer = layers.Conv2D(num_filter, (1,1), use_bias=False ,padding=
'same')(input)
last = layers.GlobalMaxPooling2D()(conv_layer)
output = layers.Activation('softmax')(last)
```

In [23]:
```python
model = Model(inputs=[input], outputs=[output])
model.summary()
```

```
Model: "model_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_6 (InputLayer)         [(None, 32, 32, 3)]       0
_________________________________________________________________
conv2d_256 (Conv2D)          (None, 32, 32, 12)        36
_________________________________________________________________
global_max_pooling2d_2 (Glob (None, 12)                0
```

```
activation_248 (Activation)  (None, 12)               0
=================================================================
Total params: 36
Trainable params: 36
Non-trainable params: 0
_________________________________________________________________
```

In [0]:
```
# determine Loss function and Optimizer
#a=keras.optimizers.Adam(learning_rate=0.001, beta_1=0.9, beta_2=0.999,
 amsgrad=False)
model.compile(loss='categorical_crossentropy',
              optimizer='Adam', metrics=['accuracy'])
```

In [0]:
```
def summarize_diagnostics(history):
        # plot loss
        pyplot.subplot(121)
        pyplot.title('Cross Entropy Loss')
        pyplot.plot(history.history['loss'], color='blue', label='trai
n')
        pyplot.plot(history.history['val_loss'], color='orange', label=
'test')
        pyplot.show()


# run the test harness for evaluating a model
def run_test_harness():

        # define model

        # create data generator
        datagen = ImageDataGenerator(width_shift_range=0.1, height_shif
t_range=0.1, horizontal_flip=True)
        # prepare iterator
        it_train = datagen.flow(X_train, y_train, batch_size=60)
        # fit model
        steps = int(X_train.shape[0] / 39)
        history = model.fit_generator(it_train, steps_per_epoch=steps,
```

```
epochs=20, validation_data=(X_test, y_test), verbose=1)
        # evaluate model
        _, acc = model.evaluate(X_test, y_test, verbose=0)
        print('> %.3f' % (acc * 100.0))
        # learning curves
        summarize_diagnostics(history)

# entry point, run the test harness
```

In [0]:
```
from keras.models import load_model
#saving model weights
model.save('my_model.h5')
```

JUST CONTINUING THE MODEL FOR ANOTHER 5 EPOCHS

In [0]:
```
def summarize_diagnostics(history):
        # plot loss
        pyplot.subplot(121)
        pyplot.title('Cross Entropy Loss')
        pyplot.plot(history.history['loss'], color='blue', label='trai
n')
        pyplot.plot(history.history['val_loss'], color='orange', label=
'test')
        pyplot.show()


# run the test harness for evaluating a model
def run_test_harness():

        # define model

        # create data generator
        datagen = ImageDataGenerator(width_shift_range=0.1, height_shif
t_range=0.1, horizontal_flip=True)
        # prepare iterator
        it_train = datagen.flow(X_train, y_train, batch_size=60)
        # fit model
```

```
        steps = int(X_train.shape[0] / 39)
        history = model.fit_generator(it_train, steps_per_epoch=steps,
epochs=5, validation_data=(X_test, y_test), verbose=1)
        # evaluate model
        _, acc = model.evaluate(X_test, y_test, verbose=0)
        print('> %.3f' % (acc * 100.0))
        # learning curves
        summarize_diagnostics(history)

# entry point, run the test harness
```

train_loss: 0.0350 train_acc: 0.9877

val_loss: 0.5632 val_acc: 0.8954

In [31]:
```
from prettytable import PrettyTable

conclusion= PrettyTable()
conclusion.field_names = [ "Model", 'epochs','train_loss','train acc',
"test loss",'test acc']

conclusion.add_row(["model with dense layer", 75,0.1203, 0.956, 0.6271,
0.843])
conclusion.add_row(["model without dense layer",205, 0.035, 0.987,0.563
,0.895])


print(conclusion)
```

```
+---------------------------+--------+------------+-----------+--------
---+----------+
|           Model           | epochs | train_loss | train acc | test lo
ss | test acc |
+---------------------------+--------+------------+-----------+--------
---+----------+
|   model with dense layer  |   75   |   0.1203   |   0.956   |   0.627
1  |  0.843   |
| model without dense layer |  205   |   0.035    |   0.987   |   0.563
   |  0.895   |
```

+-------------------------+--------+-----------+----------+--------
---+----------+

Conclusion

> Overfitting is one the problem in this assignment since dropouts was excluded.
>
> Even tried using L2 regularization but still models are overfitting.
>
> Loss on test data doesnot change after certain number of iterations which can be seen from plots.