Section 1: Importing libraries and loading data

In [0]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

In [0]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_i
d=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redi
rect_uri=urn%3aietf%3awg%3aoauth%3a2.0%3aoob&response_type=code&scope=email%20h
ttps%3a%2f%2fwww.googleapis.com%2fauth%2fdocs.test%20https%3a%2f%2fwww.googleap
is.com%2fauth%2fdrive%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive.photos.
readonly%20https%3a%2f%2fwww.googleapis.com%2fauth%2fpeopleapi.readonly (http
s://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pf
ee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3aietf%3awg%3aoauth%
3a2.0%3aoob&response_type=code&scope=email%20https%3a%2f%2fwww.googleapis.com%2
fauth%2fdocs.test%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive%20https%3a%
2f%2fwww.googleapis.com%2fauth%2fdrive.photos.readonly%20https%3a%2f%2fwww.goog
leapis.com%2fauth%2fpeopleapi.readonly)

Enter your authorization code:
··········
Mounted at /content/drive
```

1.1 Loading data and specifying label names

In [0]:

```
# Activities are the class labels
# It is a 6 class classification
ACTIVITIES = {
    0: 'WALKING',
    1: 'WALKING_UPSTAIRS',
    2: 'WALKING_DOWNSTAIRS',
    3: 'SITTING',
    4: 'STANDING',
    5: 'LAYING',
}

# Data directory
DATADIR = 'UCI_HAR_Dataset'


# Raw data signals
# Signals are from Accelerometer and Gyroscope
# The signals are in x,y,z directions
# Sensor signals are filtered to have only body acceleration
# excluding the acceleration due to gravity
# Triaxial acceleration from the accelerometer is total acceleration
SIGNALS = [
    "body_acc_x",
    "body_acc_y",
    "body_acc_z",
    "body_gyro_x",
    "body_gyro_y",
    "body_gyro_z",
    "total_acc_x",
    "total_acc_y",
    "total_acc_z"
]

# Utility function to read the data from csv file
def _read_csv(filename):
    return pd.read_csv(filename, delim_whitespace=True, header=None)

# Utility function to load the load
def load_signals(subset):
    signals_data = []

    for signal in SIGNALS:
        filename = f'drive/My Drive/UCI_HAR_Dataset/{subset}/Inertial Signals
        signals_data.append(
            _read_csv(filename).as_matrix()
        )

    # Transpose is used to change the dimensionality of the output,
    # aggregating the signals by combination of sample/timestep.
    # Resultant shape is (7352 train/2947 test samples, 128 timesteps, 9 sign
    return np.transpose(signals_data, (1, 2, 0))
# Utility function to print the confusion matrix
```

1.2 Reading Data

In [0]:
```python

def load_y(subset):
    """
    The objective that we are trying to predict is a integer, from 1 to 6,
    that represents a human activity. We return a binary representation of
    every sample objective as a 6 bits vector using One Hot Encoding
    (https://pandas.pydata.org/pandas-docs/stable/generated/pandas.get_dummie
    """
    filename = f'drive/My Drive/UCI_HAR_Dataset/{subset}/y_{subset}.txt'
    y = _read_csv(filename)[0]

    return pd.get_dummies(y).as_matrix()

#==============================================================

def load_data():
    """
    Obtain the dataset from multiple files.
    Returns: X_train, X_test, y_train, y_test
    """
    X_train, X_test = load_signals('train'), load_signals('test')
    y_train, y_test = load_y('train'), load_y('test')

    return X_train, X_test, y_train, y_test
```

In [0]:
```python
# Loading the train and test data
X_train, X_test, Y_train, Y_test = load_data()
```

Section 2: Tensoflow backend and utility functions

In [0]:
```python
# Importing tensorflow
np.random.seed(42)
import tensorflow as tf
tf.set_random_seed(42)
```

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

In [0]:
```python
# Configuring a session
session_conf = tf.ConfigProto(
    intra_op_parallelism_threads=1,
    inter_op_parallelism_threads=1
)
```

In [0]:
```
# Importing libraries
# Import Keras
from keras import backend as K
sess = tf.Session(graph=tf.get_default_graph(), config=session_conf)
K.set_session(sess)
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers.core import Dense, Dropout
from keras.layers import BatchNormalization
```

```
Using TensorFlow backend.
```

In [0]:
```
# Utility function to count the number of classes
def _count_classes(y):
    return len(set([tuple(category) for category in y]))
```

In [0]:
```
timesteps = len(X_train[0])
input_dim = len(X_train[0][0])
n_classes = _count_classes(Y_train)

print('Number of timesteps are for each of the input dimensions',timesteps)
print('the input dimensions are ',input_dim)
print('size of training data is:',len(X_train))
```

```
Number of timesteps are for each of the input dimensions 128
the input dimensions are  9
size of training data is: 7352
```

In [0]:
```
import warnings
warnings.filterwarnings('ignore')


#function for saving and opening the file
import pickle
def savetofile(obj,filename):
  pickle.dump(obj,open(filename+".p",'wb'))

def openfromfile(filename):
  temp = pickle.load(open(filename+".p",'rb'))
  return temp
```

In [0]:
```
# Initializing batch size and number of epochs for all the models
epochs = 30
batch_size = 16

```

In [0]:

```
#functions to plot confusion matrix
import itertools
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report,accuracy_score
plt.rcParams["font.family"] = 'DejaVu Sans'

def plt_confusion_matrix(cm, classes,
                          normalize=False,
                          title='Confusion matrix',
                          cmap=plt.cm.Blues):
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=90)
    plt.yticks(tick_marks, classes)

    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")

    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

In [0]:

```python
#plotting the accuracy and classification report

from datetime import datetime
def perform_model(y_test,y_pred, class_labels, cm_normalize=True, \
                 print_cm=True, cm_cmap=plt.cm.Greens):

    results = dict()
    Y_true = pd.Series([ACTIVITIES[y] for y in np.argmax(y_test, axis=1)])
    Y_pred = pd.Series([ACTIVITIES[y] for y in np.argmax(y_pred, axis=1)])
    # calculate overall accuracty of the model
    accuracy = accuracy_score(y_true=Y_true, y_pred=Y_pred)
    # store accuracy in results
    results['accuracy'] = accuracy
    print('For test data')
    print('---------------------')
    print('|      Accuracy      |')
    print('---------------------')
    print('\n    {}\n\n'.format(accuracy))


    # confusion matrix
    cm = confusion_matrix(y_test,y_pred)
    results['confusion_matrix'] = cm
    if print_cm:
        print('--------------------')
        print('| Confusion Matrix |')
        print('--------------------')
        print('\n {}'.format(cm))

    # plot confusin matrix
    #plt.figure(figsize=(8,8))
    #plt.grid(b=False)
    #plot_confusion_matrix(cm, classes=class_labels, normalize=True, title='N
    #plt.show()

    # get classification report
    print('-------------------------')
    print('| Classifiction Report |')
    print('-------------------------')
    class_report = classification_report(Y_true, Y_pred)
    # store report in results
    results['class_report'] = classification_report
    print(class_report)

    # add the trained  model to the results
    #results['model'] = model

    return results,cm
```

Section 3: Deep learning Architecture and Models

so we will be implememting 4 different architectures here with different batchnormalization layers and dropout rates,and optimizers

3.1 Model 1: LSTM(32) + Batchnormalization + Dropout(0.3) + RmsProp

In [0]:

```
# Initiliazing the sequential model
n_hidden = 32
model = Sequential()
# Configuring the parameters
model.add(LSTM(n_hidden, input_shape=(timesteps, input_dim)))


# Adding a BatchNormalization layer
model.add(BatchNormalization())

#adding a dropout layer
model.add(Dropout(0.3))

# Adding a dense output layer with sigmoid activation
model.add(Dense(n_classes, activation='sigmoid'))
model.summary()
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:541: The name tf.placeholder is deprecated. Please use tf.c
ompat.v1.placeholder instead.

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

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:148: The name tf.placeholder_with_default is deprecated. Pl
ease use tf.compat.v1.placeholder_with_default instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:3733: calling dropout (from tensorflow.python.ops.nn_ops) w
ith 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 - kee
p_prob`.
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 32)                5376
_________________________________________________________________
batch_normalization_1 (Batch (None, 32)                128
_________________________________________________________________
dropout_1 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 198
=================================================================
Total params: 5,702
Trainable params: 5,638
Non-trainable params: 64
_________________________________________________________________
```

In [0]:

```
# Compiling the model
model.compile(loss='categorical_crossentropy',
              optimizer='rmsprop',
              metrics=['accuracy'])


# Training the model
history_1 = model.fit(X_train,
          Y_train,
          batch_size=batch_size,
          validation_data=(X_test, Y_test),
          epochs=epochs)
```

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

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:3576: The name tf.log is deprecated. Please use tf.math.log
instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_core/
python/ops/math_grad.py:1424: where (from tensorflow.python.ops.array_ops) is d
eprecated 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
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:1033: The name tf.assign_add is deprecated. Please use tf.c
ompat.v1.assign_add instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:1020: The name tf.assign is deprecated. Please use tf.compa
t.v1.assign instead.

Train on 7352 samples, validate on 2947 samples
Epoch 1/30
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:190: The name tf.get_default_session is deprecated. Please
use tf.compat.v1.get_default_session instead.

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

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:216: The name tf.is_variable_initialized is deprecated. Ple
ase use tf.compat.v1.is_variable_initialized instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:223: The name tf.variables_initializer is deprecated. Pleas
e use tf.compat.v1.variables_initializer instead.

7352/7352 [==============================] - 119s 16ms/step - loss: 1.0557 - ac
c: 0.5335 - val_loss: 0.8607 - val_acc: 0.5881
Epoch 2/30
7352/7352 [==============================] - 102s 14ms/step - loss: 0.7560 - ac
```

```
c: 0.5817 - val_loss: 0.7688 - val_acc: 0.6098
Epoch 3/30
7352/7352 [==============================] - 99s 13ms/step - loss: 0.6784 - ac
c: 0.6178 - val_loss: 0.6830 - val_acc: 0.6485
Epoch 4/30
7352/7352 [==============================] - 98s 13ms/step - loss: 0.5846 - ac
c: 0.7167 - val_loss: 0.6987 - val_acc: 0.6980
Epoch 5/30
7352/7352 [==============================] - 106s 14ms/step - loss: 0.3940 - ac
c: 0.8414 - val_loss: 0.4036 - val_acc: 0.8521
Epoch 6/30
7352/7352 [==============================] - 107s 15ms/step - loss: 0.2726 - ac
c: 0.9132 - val_loss: 0.4896 - val_acc: 0.8578
Epoch 7/30
7352/7352 [==============================] - 102s 14ms/step - loss: 0.2279 - ac
c: 0.9203 - val_loss: 0.3373 - val_acc: 0.8850
Epoch 8/30
7352/7352 [==============================] - 102s 14ms/step - loss: 0.2101 - ac
c: 0.9275 - val_loss: 0.3588 - val_acc: 0.8914
Epoch 9/30
7352/7352 [==============================] - 102s 14ms/step - loss: 0.1973 - ac
c: 0.9248 - val_loss: 0.4287 - val_acc: 0.8918
Epoch 10/30
7352/7352 [==============================] - 103s 14ms/step - loss: 0.2004 - ac
c: 0.9286 - val_loss: 0.5229 - val_acc: 0.8649
Epoch 11/30
7352/7352 [==============================] - 104s 14ms/step - loss: 0.1723 - ac
c: 0.9372 - val_loss: 0.3266 - val_acc: 0.9033
Epoch 12/30
7352/7352 [==============================] - 105s 14ms/step - loss: 0.1780 - ac
c: 0.9370 - val_loss: 0.3539 - val_acc: 0.8951
Epoch 13/30
7352/7352 [==============================] - 102s 14ms/step - loss: 0.1753 - ac
c: 0.9359 - val_loss: 0.3288 - val_acc: 0.9138
Epoch 14/30
7352/7352 [==============================] - 107s 15ms/step - loss: 0.1772 - ac
c: 0.9380 - val_loss: 0.3317 - val_acc: 0.9152
Epoch 15/30
7352/7352 [==============================] - 103s 14ms/step - loss: 0.1775 - ac
c: 0.9378 - val_loss: 0.4120 - val_acc: 0.9026
Epoch 16/30
7352/7352 [==============================] - 104s 14ms/step - loss: 0.1622 - ac
c: 0.9402 - val_loss: 0.3215 - val_acc: 0.9162
Epoch 17/30
7352/7352 [==============================] - 110s 15ms/step - loss: 0.1615 - ac
c: 0.9415 - val_loss: 0.5116 - val_acc: 0.8833
Epoch 18/30
7352/7352 [==============================] - 109s 15ms/step - loss: 0.1731 - ac
c: 0.9429 - val_loss: 0.3719 - val_acc: 0.9118
Epoch 19/30
7352/7352 [==============================] - 107s 15ms/step - loss: 0.1662 - ac
c: 0.9423 - val_loss: 0.4025 - val_acc: 0.9114
Epoch 20/30
7352/7352 [==============================] - 104s 14ms/step - loss: 0.1660 - ac
c: 0.9438 - val_loss: 0.3589 - val_acc: 0.9026
Epoch 21/30
7352/7352 [==============================] - 112s 15ms/step - loss: 0.1589 - ac
```

```
c: 0.9415 - val_loss: 0.3407 - val_acc: 0.9060
Epoch 22/30
7352/7352 [==============================] - 107s 15ms/step - loss: 0.1512 - ac
c: 0.9430 - val_loss: 0.3713 - val_acc: 0.9138
Epoch 23/30
7352/7352 [==============================] - 109s 15ms/step - loss: 0.1483 - ac
c: 0.9431 - val_loss: 0.4803 - val_acc: 0.9087
Epoch 24/30
7352/7352 [==============================] - 108s 15ms/step - loss: 0.1438 - ac
c: 0.9433 - val_loss: 0.4046 - val_acc: 0.9104
Epoch 25/30
7352/7352 [==============================] - 107s 15ms/step - loss: 0.1795 - ac
c: 0.9408 - val_loss: 0.5475 - val_acc: 0.8989
Epoch 26/30
7352/7352 [==============================] - 108s 15ms/step - loss: 0.1472 - ac
c: 0.9471 - val_loss: 0.5127 - val_acc: 0.9023
Epoch 27/30
7352/7352 [==============================] - 110s 15ms/step - loss: 0.1427 - ac
c: 0.9460 - val_loss: 0.5528 - val_acc: 0.8968
Epoch 28/30
7352/7352 [==============================] - 109s 15ms/step - loss: 0.1526 - ac
c: 0.9489 - val_loss: 0.5177 - val_acc: 0.9026
Epoch 29/30
7352/7352 [==============================] - 101s 14ms/step - loss: 0.1452 - ac
c: 0.9448 - val_loss: 0.6232 - val_acc: 0.8931
Epoch 30/30
7352/7352 [==============================] - 104s 14ms/step - loss: 0.1468 - ac
c: 0.9455 - val_loss: 0.4055 - val_acc: 0.9189
```

In [0]:

```
score = model_1.evaluate(X_test,Y_test)
print('loss on test data is',score[0])
print('Accuracy on test data is:',score[1])

```

```
2947/2947 [==============================] - 2s 776us/step
loss on test data is 0.409051617424
Accuracy on test data is: 0.905666779776
```

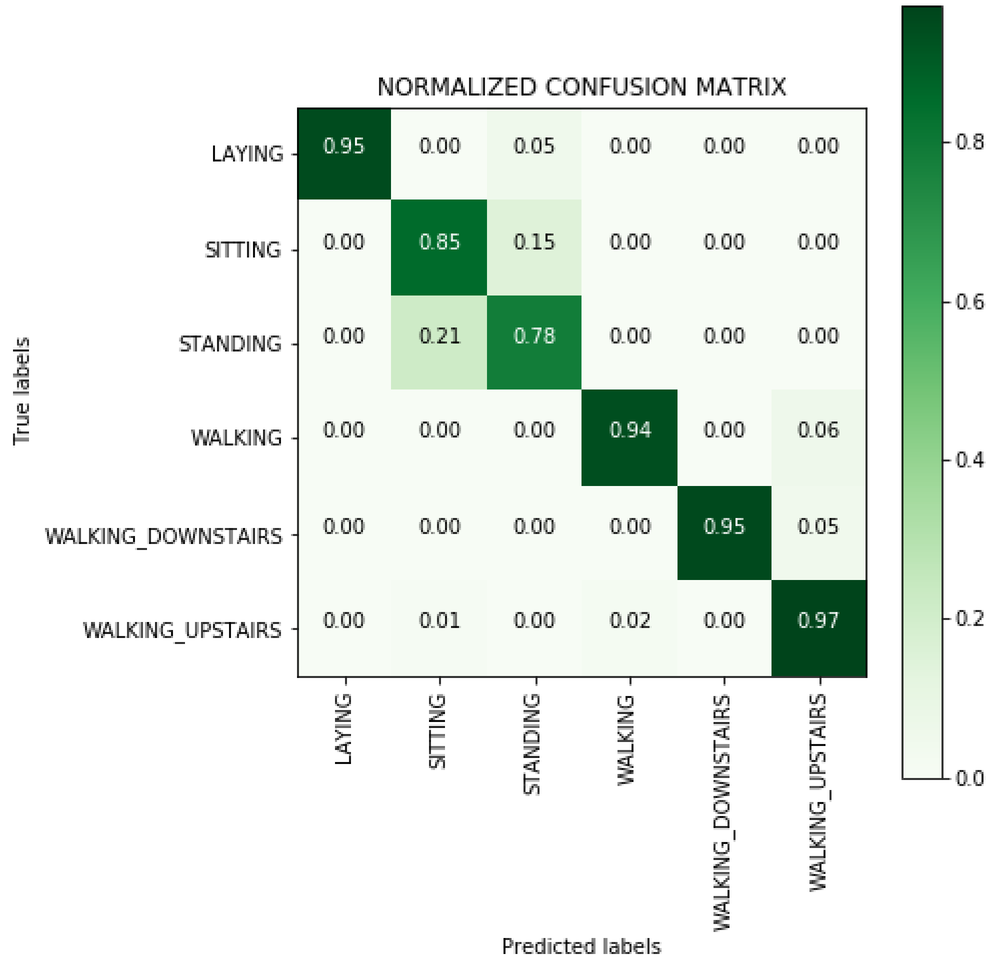
In [0]:

```
model_1 = openfromfile('model_lstm1')#getting the saved model
```

In [0]:
```
labels=['LAYING', 'SITTING','STANDING','WALKING','WALKING_DOWNSTAIRS','WALKIN
y_pred=model_1.predict(X_test)
results_mod_1,cm_1 =  perform_model(Y_test,y_pred,labels, cm_normalize=True,
                  print_cm=True, cm_cmap=plt.cm.Greens)


#Get the confusion matrix

cm_df=confusion_matrix(Y_test, y_pred) #Prepare the confusion matrix by using
classes=list(cm_df.index) #Class names = Index Names or Column Names in cm_df

#Plot a Non-Normalized confusion matrix
#plot_confusion_matrix(cm_df, classes, normalize=False, title="NON-NORMALIZED

#Plot a Normalized confusion matrix
plot_confusion_matrix(cm_df, classes, normalize=True, title="NORMALIZED CONFU
```

```
For test data
---------------------
|      Accuracy      |
---------------------

    0.9056667797760435



--------------------
| Confusion Matrix |
--------------------

 Pred                  LAYING  SITTING  STANDING  WALKING  WALKING_DOWNSTAIRS
\
True
LAYING                   509        1        27        0                   0
SITTING                    0      418        72        1                   0
STANDING                   0      114       417        1                   0
WALKING                    0        0         0      466                   0
WALKING_DOWNSTAIRS         0        0         0        0                 401
WALKING_UPSTAIRS           0        4         0        8                   1

Pred                 WALKING_UPSTAIRS
True
LAYING                              0
SITTING                             0
STANDING                            0
WALKING                            30
WALKING_DOWNSTAIRS                 19
WALKING_UPSTAIRS                  458
-------------------------
| Classification Report |
-------------------------
                    precision    recall  f1-score   support

            LAYING       1.00      0.95      0.97       537
           SITTING       0.78      0.85      0.81       491
          STANDING       0.81      0.78      0.80       532
           WALKING       0.98      0.94      0.96       496
```

```
WALKING_DOWNSTAIRS       1.00      0.95      0.98       420
  WALKING_UPSTAIRS       0.90      0.97      0.94       471

       avg / total       0.91      0.91      0.91      2947
```



3.2 : LSTM(80 cells) + LSTM (35 cells) + Dropout(0.4) +Dropout(0.2) + 1 BatchNormalization layers + Adam Optimizer

In [0]:

```python
from keras.layers import BatchNormalization

model = Sequential()

model.add(LSTM(80,input_shape =(timesteps,input_dim),return_sequences = True
model.add(BatchNormalization())
model.add(Dropout(0.4))


model.add(LSTM(35))
model.add(Dropout(0.2))

model.add(Dense(n_classes,activation = 'sigmoid'))#adding the output layer
print(model.summary())

```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_2 (LSTM)                (None, 128, 80)           28800
_________________________________________________________________
batch_normalization_2 (Batch (None, 128, 80)           320
_________________________________________________________________
dropout_2 (Dropout)          (None, 128, 80)           0
_________________________________________________________________
lstm_3 (LSTM)                (None, 35)                16240
_________________________________________________________________
dropout_3 (Dropout)          (None, 35)                0
_________________________________________________________________
dense_2 (Dense)              (None, 6)                 216
=================================================================
Total params: 45,576
Trainable params: 45,416
Non-trainable params: 160
_________________________________________________________________
None
```

In [0]:
```
model.compile(loss = 'categorical_crossentropy',optimizer = 'adam',metrics =
history = model.fit(X_train,Y_train,batch_size = batch_size,validation_data =
                    epochs = epochs)
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 208s 28ms/step - loss: 0.9093 - ac
c: 0.7252 - val_loss: 0.5509 - val_acc: 0.8582
Epoch 2/30
7352/7352 [==============================] - 203s 28ms/step - loss: 0.3749 - ac
c: 0.8898 - val_loss: 0.9213 - val_acc: 0.6827
Epoch 3/30
7352/7352 [==============================] - 208s 28ms/step - loss: 0.2522 - ac
c: 0.9208 - val_loss: 0.3453 - val_acc: 0.8884
Epoch 4/30
7352/7352 [==============================] - 209s 28ms/step - loss: 0.2355 - ac
c: 0.9223 - val_loss: 0.2817 - val_acc: 0.9094
Epoch 5/30
7352/7352 [==============================] - 211s 29ms/step - loss: 0.2029 - ac
c: 0.9285 - val_loss: 0.3546 - val_acc: 0.8809
Epoch 6/30
7352/7352 [==============================] - 210s 29ms/step - loss: 0.1750 - ac
c: 0.9357 - val_loss: 0.3565 - val_acc: 0.8968
Epoch 7/30
7352/7352 [==============================] - 209s 28ms/step - loss: 0.1619 - ac
c: 0.9404 - val_loss: 0.2893 - val_acc: 0.9067
Epoch 8/30
7352/7352 [==============================] - 210s 29ms/step - loss: 0.1537 - ac
c: 0.9433 - val_loss: 0.2291 - val_acc: 0.9121
Epoch 9/30
7352/7352 [==============================] - 195s 27ms/step - loss: 0.1653 - ac
c: 0.9363 - val_loss: 0.3283 - val_acc: 0.9019
Epoch 10/30
7352/7352 [==============================] - 201s 27ms/step - loss: 0.1395 - ac
c: 0.9468 - val_loss: 0.2660 - val_acc: 0.9145
Epoch 11/30
7352/7352 [==============================] - 201s 27ms/step - loss: 0.1305 - ac
c: 0.9476 - val_loss: 0.2538 - val_acc: 0.9135
Epoch 12/30
7352/7352 [==============================] - 196s 27ms/step - loss: 0.1824 - ac
c: 0.9300 - val_loss: 0.4976 - val_acc: 0.8069
Epoch 13/30
7352/7352 [==============================] - 194s 26ms/step - loss: 0.1628 - ac
c: 0.9382 - val_loss: 0.2509 - val_acc: 0.9179
Epoch 14/30
7352/7352 [==============================] - 204s 28ms/step - loss: 0.1564 - ac
c: 0.9373 - val_loss: 0.2320 - val_acc: 0.9189
Epoch 15/30
7352/7352 [==============================] - 197s 27ms/step - loss: 0.1537 - ac
c: 0.9422 - val_loss: 0.2283 - val_acc: 0.9213
Epoch 16/30
7352/7352 [==============================] - 204s 28ms/step - loss: 0.1347 - ac
c: 0.9471 - val_loss: 0.2534 - val_acc: 0.9189
Epoch 17/30
7352/7352 [==============================] - 199s 27ms/step - loss: 0.1292 - ac
c: 0.9487 - val_loss: 0.2549 - val_acc: 0.9226
```

```
Epoch 18/30
7352/7352 [==============================] - 204s 28ms/step - loss: 0.1252 - ac
c: 0.9479 - val_loss: 0.2785 - val_acc: 0.9158
Epoch 19/30
7352/7352 [==============================] - 207s 28ms/step - loss: 0.1290 - ac
c: 0.9471 - val_loss: 0.2822 - val_acc: 0.9220
Epoch 20/30
7352/7352 [==============================] - 210s 29ms/step - loss: 0.1272 - ac
c: 0.9516 - val_loss: 0.2545 - val_acc: 0.9128
Epoch 21/30
7352/7352 [==============================] - 208s 28ms/step - loss: 0.1292 - ac
c: 0.9491 - val_loss: 0.2950 - val_acc: 0.9101
Epoch 22/30
7352/7352 [==============================] - 212s 29ms/step - loss: 0.1397 - ac
c: 0.9455 - val_loss: 0.2285 - val_acc: 0.9237
Epoch 23/30
7352/7352 [==============================] - 196s 27ms/step - loss: 0.1251 - ac
c: 0.9527 - val_loss: 0.2074 - val_acc: 0.9108
Epoch 24/30
7352/7352 [==============================] - 197s 27ms/step - loss: 0.1215 - ac
c: 0.9493 - val_loss: 0.2607 - val_acc: 0.9155
Epoch 25/30
7352/7352 [==============================] - 199s 27ms/step - loss: 0.1208 - ac
c: 0.9508 - val_loss: 0.2148 - val_acc: 0.9220
Epoch 26/30
7352/7352 [==============================] - 194s 26ms/step - loss: 0.1205 - ac
c: 0.9512 - val_loss: 0.2908 - val_acc: 0.9040
Epoch 27/30
7352/7352 [==============================] - 194s 26ms/step - loss: 0.1197 - ac
c: 0.9521 - val_loss: 0.2617 - val_acc: 0.9104
Epoch 28/30
7352/7352 [==============================] - 193s 26ms/step - loss: 0.1305 - ac
c: 0.9483 - val_loss: 0.2899 - val_acc: 0.9162
Epoch 29/30
7352/7352 [==============================] - 189s 26ms/step - loss: 0.1221 - ac
c: 0.9508 - val_loss: 0.3288 - val_acc: 0.9114
Epoch 30/30
7352/7352 [==============================] - 185s 25ms/step - loss: 0.1298 - ac
c: 0.9499 - val_loss: 0.2430 - val_acc: 0.9121
```

In [0]:

```
score = model.evaluate(X_test,Y_test)
print('loss on test data is',score[0])
print('Accuracy on test data is:',score[1])


history_lstm2 = savetofile(history,'history_lstm2')
model_lstm2 = savetofile(model,'model_lstm2')
```

```
2947/2947 [==============================] - 12s 4ms/step
loss on test data is 0.24302211337054586
Accuracy on test data is: 0.9121140142517815
```

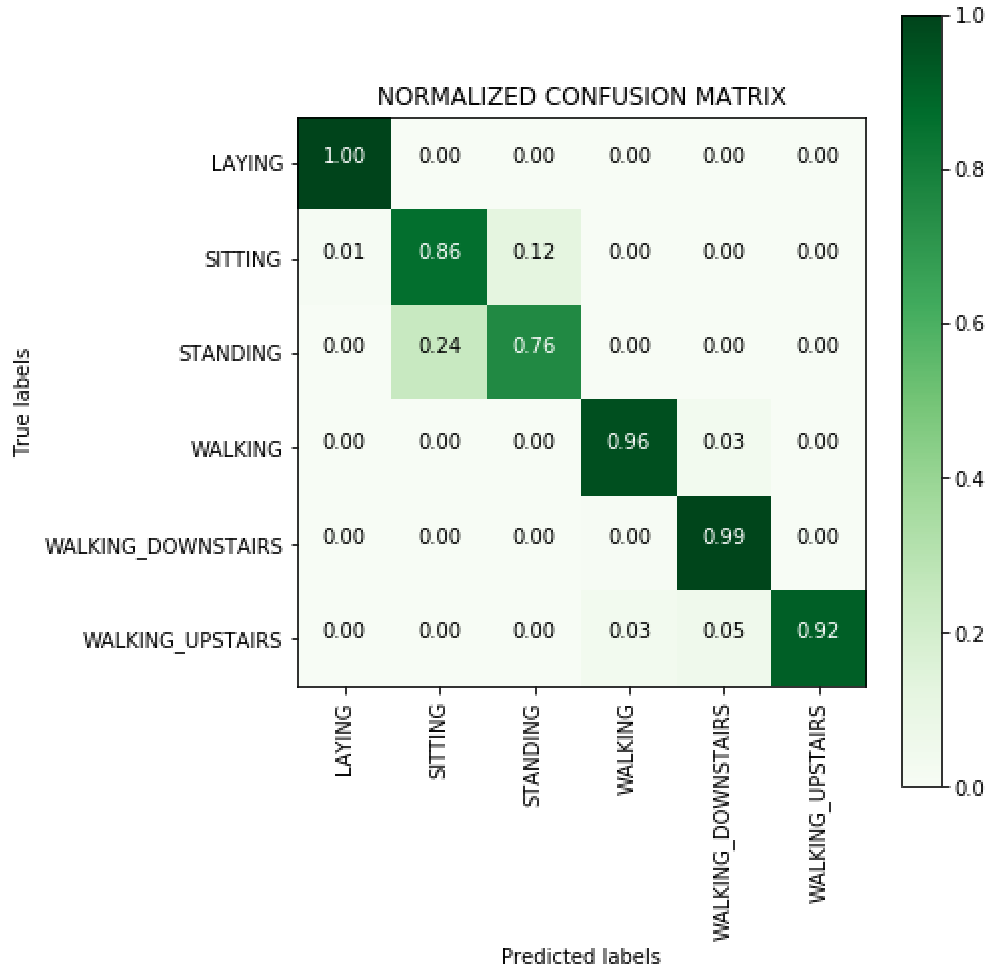
In [0]:

```
model_2 = openfromfile('model_lstm2')
#history_2 = openfromfile('history_lstm2')

```

In [0]:
```
y_pred=model_2.predict(X_test)
results_mod_2,cm_2 =  perform_model(Y_test,y_pred,labels, cm_normalize=True,
                     print_cm=True, cm_cmap=plt.cm.Greens)


#Get the confusion matrix

cm_df=confusion_matrix(Y_test, y_pred) #Prepare the confusion matrix by using
classes=list(cm_df.index) #Class names = Index Names or Column Names in cm_df

#Plot a Non-Normalized confusion matrix
#plot_confusion_matrix(cm_df, classes, normalize=False, title="NON-NORMALIZED

#Plot a Normalized confusion matrix
plot_confusion_matrix(cm_df, classes, normalize=True, title="NORMALIZED CONFU
```

```
For test data
---------------------
|      Accuracy      |
---------------------

    0.9121140142517815



--------------------
| Confusion Matrix |
--------------------

 Pred                    LAYING  SITTING  STANDING  WALKING  WALKING_DOWNSTAIRS
\
True
LAYING                     537        0         0        0                   0
SITTING                      6      423        61        0                   0
STANDING                     0      129       402        1                   0
WALKING                      0        0         0      478                  17
WALKING_DOWNSTAIRS           0        0         0        2                 417
WALKING_UPSTAIRS             0        0         0       15                  25

Pred                    WALKING_UPSTAIRS
True
LAYING                                 0
SITTING                                1
STANDING                               0
WALKING                                1
WALKING_DOWNSTAIRS                     1
WALKING_UPSTAIRS                     431
-------------------------
| Classifiction Report |
-------------------------
                    precision    recall  f1-score   support

            LAYING       0.99      1.00      0.99       537
           SITTING       0.77      0.86      0.81       491
          STANDING       0.87      0.76      0.81       532
           WALKING       0.96      0.96      0.96       496
WALKING_DOWNSTAIRS       0.91      0.99      0.95       420
```

```
WALKING_UPSTAIRS       0.99      0.92      0.95       471

     avg / total       0.92      0.91      0.91      2947
```



3.3: Conv1d(64) +Conv1d(48) +Maxpooling(2) + Batchnormalization + Dropout(0.5) +Dense(100)

In [0]:

```
#implementing 1 dimensional convnet with 3d tensor as input
from keras.layers import Flatten
from keras.layers.convolutional import Conv1D
from keras.layers.convolutional import MaxPooling1D
from keras.initializers import he_normal
from keras.layers import BatchNormalization

```

In [0]:

```
import warnings
warnings.filterwarnings('ignore')
```

In [0]:

```
#defining the model
# we will be tuning the model with different number of filters and different

model = Sequential()
model.add(Conv1D(filters = 64,kernel_size = 3,activation = 'relu',kernel_init
model.add(Conv1D(filters = 48,kernel_size = 3,activation = 'relu',kernel_init
model.add(MaxPooling1D(pool_size = 2))
model.add(BatchNormalization())

#adding the dropout layer
model.add(Dropout(0.5))

model.add(Flatten())
model.add(Dense(100,activation = 'relu',kernel_initializer = he_normal(seed =
model.add(BatchNormalization())
model.add(Dropout(0.5))
model.add(Dense(n_classes,activation = 'softmax'))

print(model.summary())

#compiling with adam optimizer

model.compile(loss = 'categorical_crossentropy',optimizer = 'adam',metrics =
history = model.fit(X_train,Y_train,batch_size = batch_size,epochs = epochs,v
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:4479: The name tf.truncated_normal is deprecated. Please us
e tf.random.truncated_normal instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/te
nsorflow_backend.py:4267: The name tf.nn.max_pool is deprecated. Please use tf.
nn.max_pool2d instead.

Model: "sequential_3"
```

Layer (type)	Output Shape	Param #
conv1d_1 (Conv1D)	(None, 126, 64)	1792
conv1d_2 (Conv1D)	(None, 124, 48)	9264
max_pooling1d_1 (MaxPooling1	(None, 62, 48)	0
batch_normalization_2 (Batch	(None, 62, 48)	192
dropout_2 (Dropout)	(None, 62, 48)	0
flatten_1 (Flatten)	(None, 2976)	0
dense_2 (Dense)	(None, 100)	297700
batch_normalization_3 (Batch	(None, 100)	400
dropout_3 (Dropout)	(None, 100)	0

```
dense_3 (Dense)              (None, 6)                 606
=================================================================
Total params: 309,954
Trainable params: 309,658
Non-trainable params: 296
_________________________________________________________________
None
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 11s 2ms/step - loss: 0.5626 - acc:
0.7969 - val_loss: 0.3584 - val_acc: 0.8728
Epoch 2/30
7352/7352 [==============================] - 5s 621us/step - loss: 0.2560 - ac
c: 0.9013 - val_loss: 0.5298 - val_acc: 0.8334
Epoch 3/30
7352/7352 [==============================] - 5s 634us/step - loss: 0.2091 - ac
c: 0.9222 - val_loss: 0.3970 - val_acc: 0.8846
Epoch 4/30
7352/7352 [==============================] - 5s 625us/step - loss: 0.1758 - ac
c: 0.9302 - val_loss: 0.5070 - val_acc: 0.8490
Epoch 5/30
7352/7352 [==============================] - 4s 595us/step - loss: 0.1681 - ac
c: 0.9362 - val_loss: 0.3683 - val_acc: 0.8897
Epoch 6/30
7352/7352 [==============================] - 4s 611us/step - loss: 0.1576 - ac
c: 0.9378 - val_loss: 0.3331 - val_acc: 0.9169
Epoch 7/30
7352/7352 [==============================] - 5s 623us/step - loss: 0.1458 - ac
c: 0.9429 - val_loss: 0.3711 - val_acc: 0.9080
Epoch 8/30
7352/7352 [==============================] - 4s 608us/step - loss: 0.1390 - ac
c: 0.9437 - val_loss: 0.3642 - val_acc: 0.8985
Epoch 9/30
7352/7352 [==============================] - 5s 620us/step - loss: 0.1341 - ac
c: 0.9437 - val_loss: 0.3172 - val_acc: 0.9169
Epoch 10/30
7352/7352 [==============================] - 4s 590us/step - loss: 0.1328 - ac
c: 0.9457 - val_loss: 0.3769 - val_acc: 0.9040
Epoch 11/30
7352/7352 [==============================] - 4s 602us/step - loss: 0.1248 - ac
c: 0.9505 - val_loss: 0.3528 - val_acc: 0.9158
Epoch 12/30
7352/7352 [==============================] - 5s 649us/step - loss: 0.1213 - ac
c: 0.9480 - val_loss: 0.3666 - val_acc: 0.9080
Epoch 13/30
7352/7352 [==============================] - 4s 608us/step - loss: 0.1278 - ac
c: 0.9456 - val_loss: 0.3829 - val_acc: 0.9040
Epoch 14/30
7352/7352 [==============================] - 5s 634us/step - loss: 0.1251 - ac
c: 0.9504 - val_loss: 0.3763 - val_acc: 0.9128
Epoch 15/30
7352/7352 [==============================] - 5s 620us/step - loss: 0.1154 - ac
c: 0.9525 - val_loss: 0.3565 - val_acc: 0.9131
Epoch 16/30
7352/7352 [==============================] - 4s 592us/step - loss: 0.1133 - ac
c: 0.9531 - val_loss: 0.3323 - val_acc: 0.9206
Epoch 17/30
```

```
7352/7352 [==============================] - 4s 610us/step - loss: 0.1072 - ac
c: 0.9546 - val_loss: 0.3604 - val_acc: 0.9172
Epoch 18/30
7352/7352 [==============================] - 4s 567us/step - loss: 0.1032 - ac
c: 0.9587 - val_loss: 0.4090 - val_acc: 0.8751
Epoch 19/30
7352/7352 [==============================] - 4s 534us/step - loss: 0.1017 - ac
c: 0.9576 - val_loss: 0.3916 - val_acc: 0.9179
Epoch 20/30
7352/7352 [==============================] - 4s 573us/step - loss: 0.1054 - ac
c: 0.9547 - val_loss: 0.3769 - val_acc: 0.9053
Epoch 21/30
7352/7352 [==============================] - 4s 550us/step - loss: 0.1063 - ac
c: 0.9547 - val_loss: 0.3801 - val_acc: 0.9203
Epoch 22/30
7352/7352 [==============================] - 4s 560us/step - loss: 0.0979 - ac
c: 0.9589 - val_loss: 0.3861 - val_acc: 0.9097
Epoch 23/30
7352/7352 [==============================] - 4s 558us/step - loss: 0.0957 - ac
c: 0.9581 - val_loss: 0.3184 - val_acc: 0.9253
Epoch 24/30
7352/7352 [==============================] - 4s 537us/step - loss: 0.0931 - ac
c: 0.9614 - val_loss: 0.3612 - val_acc: 0.9084
Epoch 25/30
7352/7352 [==============================] - 4s 560us/step - loss: 0.0977 - ac
c: 0.9592 - val_loss: 0.3736 - val_acc: 0.9223
Epoch 26/30
7352/7352 [==============================] - 4s 578us/step - loss: 0.0941 - ac
c: 0.9584 - val_loss: 0.4046 - val_acc: 0.9186
Epoch 27/30
7352/7352 [==============================] - 4s 545us/step - loss: 0.1000 - ac
c: 0.9591 - val_loss: 0.3557 - val_acc: 0.9019
Epoch 28/30
7352/7352 [==============================] - 4s 602us/step - loss: 0.0870 - ac
c: 0.9645 - val_loss: 0.3838 - val_acc: 0.9203
Epoch 29/30
7352/7352 [==============================] - 4s 542us/step - loss: 0.0909 - ac
c: 0.9608 - val_loss: 0.3836 - val_acc: 0.9070
Epoch 30/30
7352/7352 [==============================] - 4s 525us/step - loss: 0.0835 - ac
c: 0.9645 - val_loss: 0.3845 - val_acc: 0.9091
```

Type *Markdown* and LaTeX: α^2

In [0]:

```
score = model.evaluate(X_test,Y_test)
print('Loss on test data is:',score[0])
print('accuracy on test data is:',score[1])
```

```
2947/2947 [==============================] - 0s 117us/step
Loss on test data is: 0.3845438683092381
accuracy on test data is: 0.9090600610790635
```

In [0]:

```
history_cnn = savetofile(history,'history_cnn')
model_cnn = savetofile(model,'model_cnn')
```

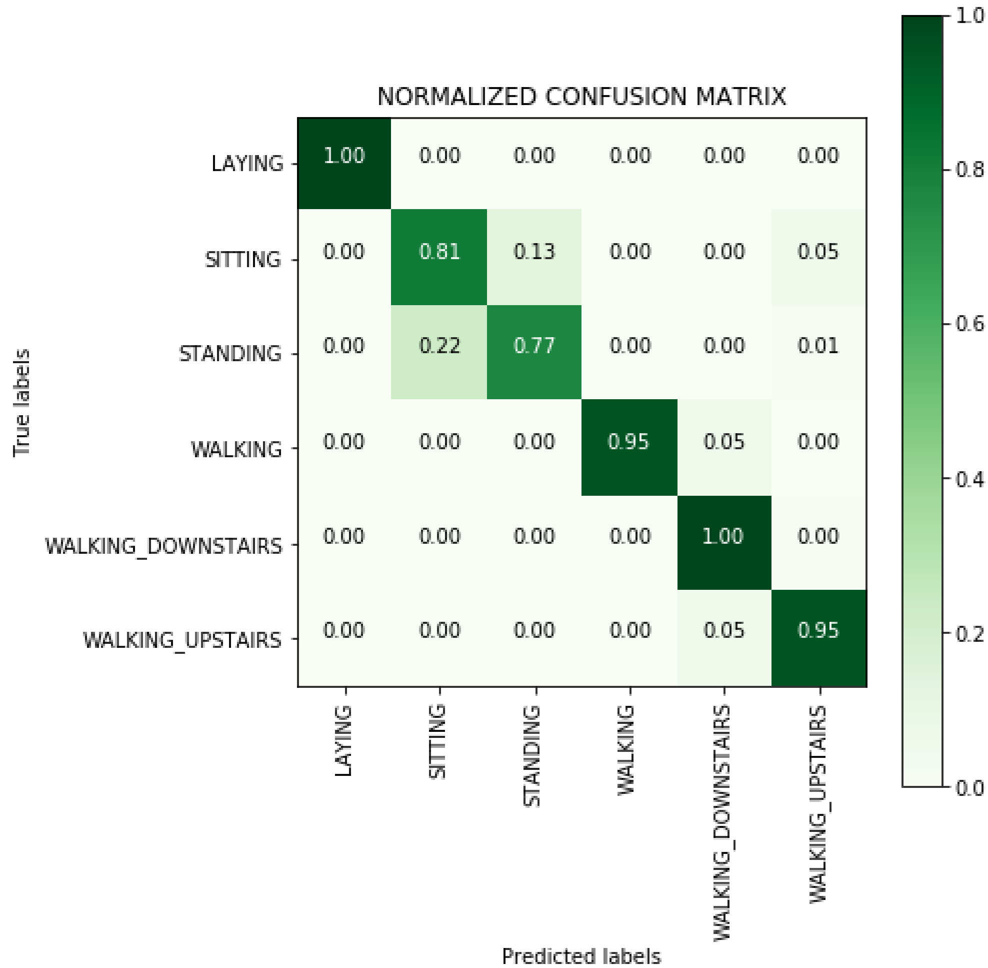
In [0]:
```
model_3 = openfromfile('model_cnn')
#history_3 = openfromfile('history_cnn')
```

In [0]:

```
y_pred=model_3.predict(X_test)
results_mod_3,cm_3 =  perform_model(Y_test,y_pred,labels, cm_normalize=True,
                  print_cm=True, cm_cmap=plt.cm.Greens)


#Get the confusion matrix

cm_df=confusion_matrix(Y_test, y_pred) #Prepare the confusion matrix by using
classes=list(cm_df.index) #Class names = Index Names or Column Names in cm_df

#Plot a Non-Normalized confusion matrix
#plot_confusion_matrix(cm_df, classes, normalize=False, title="NON-NORMALIZED

#Plot a Normalized confusion matrix
plot_confusion_matrix(cm_df, classes, normalize=True, title="NORMALIZED CONFU
```

```
For test data
---------------------
|      Accuracy      |
---------------------

    0.9090600610790635



--------------------
| Confusion Matrix |
--------------------

 Pred                LAYING  SITTING  STANDING  WALKING  WALKING_DOWNSTAIRS
\
True
LAYING                  537        0         0        0                   0
SITTING                   0      399        66        0                   0
STANDING                  0      115       409        1                   0
WALKING                   0        0         0      469                  26
WALKING_DOWNSTAIRS        0        0         0        0                 418
WALKING_UPSTAIRS          0        0         0        0                  24

Pred               WALKING_UPSTAIRS
True
LAYING                            0
SITTING                          26
STANDING                          7
WALKING                           1
WALKING_DOWNSTAIRS                2
WALKING_UPSTAIRS                447
-------------------------
| Classifiction Report |
-------------------------
                   precision    recall  f1-score   support

            LAYING       1.00      1.00      1.00       537
           SITTING       0.78      0.81      0.79       491
          STANDING       0.86      0.77      0.81       532
           WALKING       1.00      0.95      0.97       496
WALKING_DOWNSTAIRS       0.89      1.00      0.94       420
```

```
WALKING_UPSTAIRS       0.93      0.95      0.94       471

      avg / total       0.91      0.91      0.91      2947
```



3.4 LSTM(100) + Dropout(0.7) + LSTM(50) + Dropout(0.7) + RmsProp

In [0]:
```
from keras.regularizers import L1L2
reg = L1L2(0.01,0.01)
```

In [0]:

```
model = Sequential()
model.add(LSTM(100, input_shape=(timesteps, input_dim), kernel_initializer='g
model.add(BatchNormalization())
model.add(Dropout(0.70))
model.add(LSTM(50))
model.add(Dropout(0.70))
model.add(Dense(n_classes, activation='sigmoid'))
print("Model Summary: ")
model.summary()
```

```
Model Summary:
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
lstm_1 (LSTM)                (None, 128, 100)          44000     
_________________________________________________________________
batch_normalization_1 (Batch (None, 128, 100)          400       
_________________________________________________________________
dropout_1 (Dropout)          (None, 128, 100)          0         
_________________________________________________________________
lstm_2 (LSTM)                (None, 50)                30200     
_________________________________________________________________
dropout_2 (Dropout)          (None, 50)                0         
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 306       
=================================================================
Total params: 74,906
Trainable params: 74,706
Non-trainable params: 200
_________________________________________________________________
```

In [0]:

```
 #Compiling the model
model.compile(loss='binary_crossentropy',
              optimizer='rmsprop',
              metrics=['accuracy'])
#checkpoint_3 = ModelCheckpoint("model_7.h5",monitor="val_acc",mode="max",sav
# Training the model
history = model.fit(X_train,
          Y_train,
          batch_size=batch_size,
          validation_data=(X_test, Y_test),
          epochs=30)
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 142s 19ms/step - loss: 1.7124 - ac
c: 0.8491 - val_loss: 1.1561 - val_acc: 0.8787
Epoch 2/30
7352/7352 [==============================] - 155s 21ms/step - loss: 0.6482 - ac
c: 0.9057 - val_loss: 0.2787 - val_acc: 0.9185
Epoch 3/30
7352/7352 [==============================] - 149s 20ms/step - loss: 0.1732 - ac
c: 0.9380 - val_loss: 0.1416 - val_acc: 0.9497
Epoch 4/30
7352/7352 [==============================] - 144s 20ms/step - loss: 0.1283 - ac
c: 0.9560 - val_loss: 0.2491 - val_acc: 0.9179
Epoch 5/30
7352/7352 [==============================] - 139s 19ms/step - loss: 0.1061 - ac
c: 0.9635 - val_loss: 0.1095 - val_acc: 0.9603
Epoch 6/30
7352/7352 [==============================] - 142s 19ms/step - loss: 0.0932 - ac
c: 0.9675 - val_loss: 0.0858 - val_acc: 0.9711
Epoch 7/30
7352/7352 [==============================] - 147s 20ms/step - loss: 0.0934 - ac
c: 0.9688 - val_loss: 0.1242 - val_acc: 0.9653
Epoch 8/30
7352/7352 [==============================] - 149s 20ms/step - loss: 0.0859 - ac
c: 0.9701 - val_loss: 0.0848 - val_acc: 0.9737
Epoch 9/30
7352/7352 [==============================] - 136s 18ms/step - loss: 0.0819 - ac
c: 0.9717 - val_loss: 0.1062 - val_acc: 0.9677
Epoch 10/30
7352/7352 [==============================] - 131s 18ms/step - loss: 0.0792 - ac
c: 0.9730 - val_loss: 0.1340 - val_acc: 0.9670
Epoch 11/30
7352/7352 [==============================] - 132s 18ms/step - loss: 0.0764 - ac
c: 0.9738 - val_loss: 0.1133 - val_acc: 0.9653
Epoch 12/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0774 - ac
c: 0.9730 - val_loss: 0.1358 - val_acc: 0.9663
Epoch 13/30
7352/7352 [==============================] - 132s 18ms/step - loss: 0.0765 - ac
c: 0.9749 - val_loss: 0.1131 - val_acc: 0.9694
Epoch 14/30
7352/7352 [==============================] - 132s 18ms/step - loss: 0.0756 - ac
c: 0.9743 - val_loss: 0.1204 - val_acc: 0.9635
Epoch 15/30
```

```
7352/7352 [==============================] - 132s 18ms/step - loss: 0.0728 - ac
c: 0.9741 - val_loss: 0.1308 - val_acc: 0.9645
Epoch 16/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0733 - ac
c: 0.9745 - val_loss: 0.1361 - val_acc: 0.9671
Epoch 17/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0723 - ac
c: 0.9728 - val_loss: 0.1258 - val_acc: 0.9702
Epoch 18/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0709 - ac
c: 0.9758 - val_loss: 0.1152 - val_acc: 0.9683
Epoch 19/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0714 - ac
c: 0.9759 - val_loss: 0.1075 - val_acc: 0.9705
Epoch 20/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0740 - ac
c: 0.9752 - val_loss: 0.1498 - val_acc: 0.9664
Epoch 21/30
7352/7352 [==============================] - 137s 19ms/step - loss: 0.0663 - ac
c: 0.9757 - val_loss: 0.1044 - val_acc: 0.9693
Epoch 22/30
7352/7352 [==============================] - 135s 18ms/step - loss: 0.0712 - ac
c: 0.9762 - val_loss: 0.0955 - val_acc: 0.9718
Epoch 23/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0718 - ac
c: 0.9758 - val_loss: 0.1498 - val_acc: 0.9660
Epoch 24/30
7352/7352 [==============================] - 135s 18ms/step - loss: 0.0676 - ac
c: 0.9755 - val_loss: 0.1322 - val_acc: 0.9703
Epoch 25/30
7352/7352 [==============================] - 136s 19ms/step - loss: 0.0683 - ac
c: 0.9767 - val_loss: 0.1402 - val_acc: 0.9680
Epoch 26/30
7352/7352 [==============================] - 135s 18ms/step - loss: 0.0682 - ac
c: 0.9765 - val_loss: 0.1425 - val_acc: 0.9695
Epoch 27/30
7352/7352 [==============================] - 135s 18ms/step - loss: 0.0683 - ac
c: 0.9766 - val_loss: 0.1134 - val_acc: 0.9727
Epoch 28/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0671 - ac
c: 0.9760 - val_loss: 0.1154 - val_acc: 0.9719
Epoch 29/30
7352/7352 [==============================] - 134s 18ms/step - loss: 0.0652 - ac
c: 0.9771 - val_loss: 0.1547 - val_acc: 0.9682
Epoch 30/30
7352/7352 [==============================] - 136s 18ms/step - loss: 0.0698 - ac
c: 0.9764 - val_loss: 0.1435 - val_acc: 0.9731
```

In [0]:

```
model_4 = openfromfile('model_final')
history_4 = openfromfile('history_final')
```

In [0]:

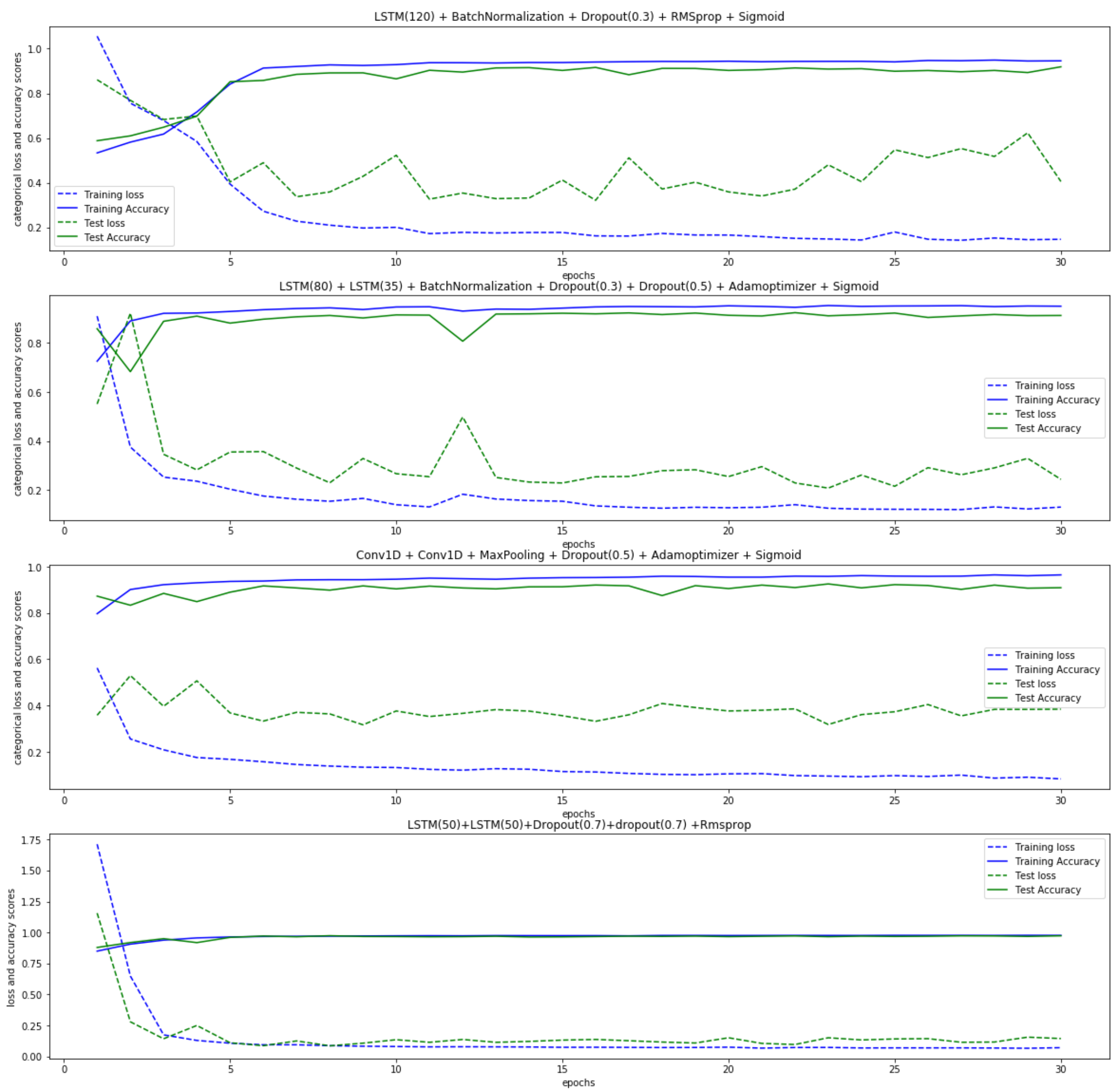
```
model_final = savetofile(model,'model_final')
history_final = savetofile(history,'history_final')
```

Section 4: Plotting the error and accuracy

In [0]:

```
import pickle
import matplotlib.pyplot as plt
%matplotlib inline
#plotting for all the models

x = list(range(1,epochs+1))

plt.figure(figsize  = (20,20))
plt.subplot(4,1,1)
plt.title('LSTM(120) + BatchNormalization + Dropout(0.3) + RMSprop + Sigmoid'
#plt.grid()
plt.plot(x,openfromfile("history_1").history['loss'],'b--',label = 'Training 
plt.plot(x,openfromfile("history_1").history['acc'],'b',label = 'Training Acc
plt.plot(x,openfromfile("history_1").history['val_loss'],'g--',label = 'Test 
plt.plot(x,openfromfile("history_1").history['val_acc'],'g',label = 'Test Acc
plt.xlabel('epochs')
plt.ylabel('categorical loss and accuracy scores')
plt.legend(loc = 'best')
print('\n\n')




plt.subplot(4,1,2)
plt.title('LSTM(80) + LSTM(35) + BatchNormalization + Dropout(0.3) + Dropout(
#plt.grid()
plt.plot(x,openfromfile("history_lstm2").history['loss'],'b--',label = 'Train
plt.plot(x,openfromfile("history_lstm2").history['acc'],'b',label = 'Training
plt.plot(x,openfromfile("history_lstm2").history['val_loss'],'g--',label = 'T
plt.plot(x,openfromfile("history_lstm2").history['val_acc'],'g',label = 'Test
plt.xlabel('epochs')
plt.ylabel('categorical loss and accuracy scores')
plt.legend(loc = 'best')
print('\n\n')



#cnn
plt.subplot(4,1,3)
plt.title('Conv1D + Conv1D + MaxPooling + Dropout(0.5) + Adamoptimizer + Sigm
#plt.grid()
plt.plot(x,openfromfile("history_cnn").history['loss'],'b--',label = 'Trainin
plt.plot(x,openfromfile("history_cnn").history['acc'],'b',label = 'Training A
plt.plot(x,openfromfile("history_cnn").history['val_loss'],'g--',label = 'Tes
plt.plot(x,openfromfile("history_cnn").history['val_acc'],'g',label = 'Test A
plt.xlabel('epochs')
plt.ylabel('categorical loss and accuracy scores')
plt.legend(loc = 'best')
print('\n\n')
#plt.show()

#
plt.subplot(4,1,4)
plt.title('LSTM(50)+LSTM(50)+Dropout(0.7)+dropout(0.7) +Rmsprop',size = 12)
plt.plot(x,openfromfile("history_final").history['loss'],'b--',label = 'Train
plt.plot(x,openfromfile("history_final").history['acc'],'b',label = 'Training
```

```
plt.plot(x,openfromfile("history_final").history['val_loss'],'g--',label = 'T
plt.plot(x,openfromfile("history_final").history['val_acc'],'g',label = 'Test
plt.xlabel('epochs')
plt.ylabel('loss and accuracy scores')
plt.legend(loc = 'best')
plt.show()

```



Conclusion

In [0]:

```
# Conclusio
from prettytable import PrettyTable
table = PrettyTable()

table.field_names = ['Architecture','optimizer','loss','test accuracy']
table.add_row(['LSTM(32) + Dropout(0.3) + BatchNormaliztion','RMSprop','categ
table.add_row(['LSTM(80) + Dropout(0.2) + LSTM(50) + Dropout(0.4)','Adam','ca
table.add_row(['Conv1D + Conv1D + MaxPooling + Dropout(0.5)',"Adam",'categori
table.add_row(['LSTM(100)+LSTM(50)+Dropout(0.7)+Dropout(0.7)','Rmsprop','biar
print(table)
```

```
+----------------------------------------------------+----------+--------------
-------------+---------------+
|                    Architecture                    | optimizer |           lo
ss           | test accuracy |
+----------------------------------------------------+----------+--------------
-------------+---------------+
|    LSTM(32) + Dropout(0.3) + BatchNormaliztion    |  RMSprop  | categorical c
ross entropy |     0.905     |
| LSTM(80) + Dropout(0.2) + LSTM(50) + Dropout(0.4) |    Adam   | categorical c
ross entropy |     0.9121    |
|    Conv1D + Conv1D + MaxPooling + Dropout(0.5)    |    Adam   | categorical c
ross entropy |     0.9091    |
|    LSTM(100)+LSTM(50)+Dropout(0.7)+Dropout(0.7)   |  Rmsprop  |    bianry cro
ss entropy   |     0.9682    |
+----------------------------------------------------+----------+--------------
-------------+---------------+
```

This project is to build a model that predicts the human activities such as Walking, Walking_Upstairs, Walking_Downstairs, Sitting, Standing or Laying.

This dataset is collected from 30 persons(referred as subjects in this dataset), performing different activities with a smartphone to their waists. The data is recorded with the help of sensors (accelerometer and Gyroscope) in that smartphone. This experiment was video recorded to label the data manually.

The startegy we employed for classification with help of deep learning models is we implemented 4 different models,3 with LSTM units and 1 with Conv1d.We tried hyper parameter tuing with hyperas also .

Finally we were able to get best accuracy of 0.96

In [0]:

```
#3 Classification of static and dynamic activities
```

Classifiation of static and dynamic activities

so we will be classifiying the activities in two parts,first is Dynamic activities and second are static activities using the divide and conqueor based approach

In [0]:

```
## Classification dynamic activities
```

In [0]:
```
! pip install hyperas
```

```
Collecting hyperas
  Downloading https://files.pythonhosted.org/packages/04/34/87ad6ffb42df9c1fa
9c4c906f65813d42ad70d68c66af4ffff048c228cd4/hyperas-0.4.1-py3-none-any.whl (h
ttps://files.pythonhosted.org/packages/04/34/87ad6ffb42df9c1fa9c4c906f65813d4
2ad70d68c66af4ffff048c228cd4/hyperas-0.4.1-py3-none-any.whl)
Requirement already satisfied: jupyter in /usr/local/lib/python3.6/dist-packa
ges (from hyperas) (1.0.0)
Requirement already satisfied: keras in /usr/local/lib/python3.6/dist-package
s (from hyperas) (2.2.5)
Requirement already satisfied: nbconvert in /usr/local/lib/python3.6/dist-pac
kages (from hyperas) (5.6.1)
Requirement already satisfied: entrypoints in /usr/local/lib/python3.6/dist-p
ackages (from hyperas) (0.3)
Requirement already satisfied: nbformat in /usr/local/lib/python3.6/dist-pack
ages (from hyperas) (5.0.3)
Requirement already satisfied: hyperopt in /usr/local/lib/python3.6/dist-pack
ages (from hyperas) (0.1.2)
Requirement already satisfied: jupyter-console in /usr/local/lib/python3.6/di
st-packages (from jupyter->hyperas) (5.2.0)
Requirement already satisfied: ipykernel in /usr/local/lib/python3.6/dist-pac
kages (from jupyter->hyperas) (4.6.1)
Requirement already satisfied: notebook in /usr/local/lib/python3.6/dist-pack
ages (from jupyter->hyperas) (5.2.2)
Requirement already satisfied: qtconsole in /usr/local/lib/python3.6/dist-pac
kages (from jupyter->hyperas) (4.6.0)
Requirement already satisfied: ipywidgets in /usr/local/lib/python3.6/dist-pa
ckages (from jupyter->hyperas) (7.5.1)
Requirement already satisfied: keras-preprocessing>=1.1.0 in /usr/local/lib/p
ython3.6/dist-packages (from keras->hyperas) (1.1.0)
Requirement already satisfied: pyyaml in /usr/local/lib/python3.6/dist-packag
es (from keras->hyperas) (3.13)
Requirement already satisfied: h5py in /usr/local/lib/python3.6/dist-packages
(from keras->hyperas) (2.8.0)
Requirement already satisfied: keras-applications>=1.0.8 in /usr/local/lib/py
thon3.6/dist-packages (from keras->hyperas) (1.0.8)
Requirement already satisfied: six>=1.9.0 in /usr/local/lib/python3.6/dist-pa
ckages (from keras->hyperas) (1.12.0)
Requirement already satisfied: scipy>=0.14 in /usr/local/lib/python3.6/dist-p
ackages (from keras->hyperas) (1.4.1)
Requirement already satisfied: numpy>=1.9.1 in /usr/local/lib/python3.6/dist-
packages (from keras->hyperas) (1.17.5)
Requirement already satisfied: defusedxml in /usr/local/lib/python3.6/dist-pa
ckages (from nbconvert->hyperas) (0.6.0)
Requirement already satisfied: jinja2>=2.4 in /usr/local/lib/python3.6/dist-p
ackages (from nbconvert->hyperas) (2.10.3)
Requirement already satisfied: traitlets>=4.2 in /usr/local/lib/python3.6/dis
t-packages (from nbconvert->hyperas) (4.3.3)
Requirement already satisfied: mistune<2,>=0.8.1 in /usr/local/lib/python3.6/
dist-packages (from nbconvert->hyperas) (0.8.4)
Requirement already satisfied: testpath in /usr/local/lib/python3.6/dist-pack
ages (from nbconvert->hyperas) (0.4.4)
Requirement already satisfied: jupyter-core in /usr/local/lib/python3.6/dist-
packages (from nbconvert->hyperas) (4.6.1)
Requirement already satisfied: pandocfilters>=1.4.1 in /usr/local/lib/python
```

```
3.6/dist-packages (from nbconvert->hyperas) (1.4.2)
Requirement already satisfied: pygments in /usr/local/lib/python3.6/dist-pack
ages (from nbconvert->hyperas) (2.1.3)
Requirement already satisfied: bleach in /usr/local/lib/python3.6/dist-packag
es (from nbconvert->hyperas) (3.1.0)
Requirement already satisfied: ipython-genutils in /usr/local/lib/python3.6/d
ist-packages (from nbformat->hyperas) (0.2.0)
Requirement already satisfied: jsonschema!=2.5.0,>=2.4 in /usr/local/lib/pyth
on3.6/dist-packages (from nbformat->hyperas) (2.6.0)
Requirement already satisfied: tqdm in /usr/local/lib/python3.6/dist-packages
(from hyperopt->hyperas) (4.28.1)
Requirement already satisfied: future in /usr/local/lib/python3.6/dist-packag
es (from hyperopt->hyperas) (0.16.0)
Requirement already satisfied: pymongo in /usr/local/lib/python3.6/dist-packa
ges (from hyperopt->hyperas) (3.10.0)
Requirement already satisfied: networkx in /usr/local/lib/python3.6/dist-pack
ages (from hyperopt->hyperas) (2.4)
Requirement already satisfied: jupyter-client in /usr/local/lib/python3.6/dis
t-packages (from jupyter-console->jupyter->hyperas) (5.3.4)
Requirement already satisfied: ipython in /usr/local/lib/python3.6/dist-packa
ges (from jupyter-console->jupyter->hyperas) (5.5.0)
Requirement already satisfied: prompt-toolkit<2.0.0,>=1.0.0 in /usr/local/li
b/python3.6/dist-packages (from jupyter-console->jupyter->hyperas) (1.0.18)
Requirement already satisfied: tornado>=4.0 in /usr/local/lib/python3.6/dist-
packages (from ipykernel->jupyter->hyperas) (4.5.3)
Requirement already satisfied: terminado>=0.3.3; sys_platform != "win32" in /
usr/local/lib/python3.6/dist-packages (from notebook->jupyter->hyperas) (0.8.
3)
Requirement already satisfied: widgetsnbextension~=3.5.0 in /usr/local/lib/py
thon3.6/dist-packages (from ipywidgets->jupyter->hyperas) (3.5.1)
Requirement already satisfied: MarkupSafe>=0.23 in /usr/local/lib/python3.6/d
ist-packages (from jinja2>=2.4->nbconvert->hyperas) (1.1.1)
Requirement already satisfied: decorator in /usr/local/lib/python3.6/dist-pac
kages (from traitlets>=4.2->nbconvert->hyperas) (4.4.1)
Requirement already satisfied: webencodings in /usr/local/lib/python3.6/dist-
packages (from bleach->nbconvert->hyperas) (0.5.1)
Requirement already satisfied: pyzmq>=13 in /usr/local/lib/python3.6/dist-pac
kages (from jupyter-client->jupyter-console->jupyter->hyperas) (17.0.0)
Requirement already satisfied: python-dateutil>=2.1 in /usr/local/lib/python
3.6/dist-packages (from jupyter-client->jupyter-console->jupyter->hyperas)
 (2.6.1)
Requirement already satisfied: pickleshare in /usr/local/lib/python3.6/dist-p
ackages (from ipython->jupyter-console->jupyter->hyperas) (0.7.5)
Requirement already satisfied: simplegeneric>0.8 in /usr/local/lib/python3.6/
dist-packages (from ipython->jupyter-console->jupyter->hyperas) (0.8.1)
Requirement already satisfied: setuptools>=18.5 in /usr/local/lib/python3.6/d
ist-packages (from ipython->jupyter-console->jupyter->hyperas) (42.0.2)
Requirement already satisfied: pexpect; sys_platform != "win32" in /usr/loca
l/lib/python3.6/dist-packages (from ipython->jupyter-console->jupyter->hypera
s) (4.7.0)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.6/dist-packa
ges (from prompt-toolkit<2.0.0,>=1.0.0->jupyter-console->jupyter->hyperas)
 (0.1.8)
Requirement already satisfied: ptyprocess; os_name != "nt" in /usr/local/lib/
python3.6/dist-packages (from terminado>=0.3.3; sys_platform != "win32"->note
book->jupyter->hyperas) (0.6.0)
```

```
Installing collected packages: hyperas
Successfully installed hyperas-0.4.1
```

In [0]:

```
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers.core import Dense, Dropout
from hyperopt import Trials, STATUS_OK, tpe
from hyperas import optim
from hyperas.distributions import choice, uniform
warnings.simplefilter("ignore")
```

In [0]:

```
#saving data for loading it later in hyperas for hyper-parameter tuning
savetofile(X_train,'train')
savetofile(X_test,'test')
savetofile(Y_train,'train_y')
savetofile(Y_test,'test_y')
```

In [0]:

```
def data():
    x_train = pickle.load(open('train'+".p",'rb'))
    y_train = pickle.load(open('train_y'+".p",'rb'))
    x_test =  pickle.load(open("test"+".p",'rb'))
    y_test =  pickle.load(open("test_y"+".p",'rb'))
    return x_train, y_train, x_test, y_test
```

In [0]:

```
#we tried the hyperparameter tuning but it is not working in this case as som
#this is the code I tried to implement gethering from multiple sources
#following source helped me to tune the parameters - https://towardsdatascien
"""
def create_model(x_train, y_train, x_test, y_test):

    epochs = 8
    batch_size = 32
    timesteps = x_train.shape[1]
    input_dim = len(x_train[0][0])
    n_classes = 6

    model = Sequential()

    model.add(LSTM(64, return_sequences = True, input_shape = (timesteps, inp
    model.add(Dropout({{uniform(0, 1)}}))

    model.add(LSTM({{choice([32, 16])}}))
    model.add(Dropout({{uniform(0, 1)}}))

    model.add(Dense(n_classes, activation='sigmoid'))

    print(model.summary())

    model.compile(loss='categorical_crossentropy', metrics=['accuracy'], opti

    result = model.fit(x_train, y_train, batch_size = batch_size, epochs=epoc

    validation_acc = np.amax(result.history['val_acc'])

    print('Best validation acc of epoch:', validation_acc)

    return {'loss': -validation_acc, 'status': STATUS_OK, 'model': model}
    """
```

In [0]:

```
"""
import warnings
warnings.filterwarnings('ignore')
best_run, best_model = optim.minimize(model=create_model, data=data, algo=tpe
x_train, y_train, x_test, y_test = data()

score = best_model.evaluate(x_test, y_test)

print('---------------------')
print('|      Accuracy      |')
print('---------------------')
acc = np.round((score[1]*100), 2)
print(str(acc)+"%\n")

print('----------------------------------')
print('|      Best Hyper-Parameters      |')
print('----------------------------------')
print(best_run)
print("\n\n")

true_labels = [np.argmax(i)+1 for i in y_test]
predicted_probs = best_model.predict(x_test)
predicted_labels = [np.argmax(i)+1 for i in predicted_probs]
print_confusionMatrix(true_labels, predicted_labels)
"""
```

```
    260     def exhaust(self):
    261         n_done = len(self.trials)
--> 262         self.run(self.max_evals - n_done, block_until_done=self.async
hronous)
    263         self.trials.refresh()
    264         return self

/usr/local/lib/python3.6/dist-packages/hyperopt/fmin.py in run(self, N, block
_until_done)
    225                 else:
    226                     # -- loop over trials and do the jobs directl
y
--> 227                     self.serial_evaluate()
    228
    229                 try:

/usr/local/lib/python3.6/dist-packages/hyperopt/fmin.py in serial_evaluate(se
lf, N)
    139             ctrl = base.Ctrl(self.trials, current_trial=trial)
    140             try:
```

Classifying the activities in Static and Dynamic and then combinig both the models using divide and conquer based approach

In [0]:
```
#initializing the session
tf.set_random_seed(0)
session_conf = tf.ConfigProto(intra_op_parallelism_threads=1,
                              inter_op_parallelism_threads=1)


```

2 class classification

In [0]:
```
## Classifying data as 2 class dynamic vs static
##data preparation

def load_y(subset):
        """
        The objective that we are trying to predict is a integer, from 1 to 6
        that represents a human activity. We return a binary representation o
        every sample objective as a 6 bits vector using One Hot Encoding
        """
        filename = f'drive/My Drive/UCI_HAR_Dataset/{subset}/y_{subset}.txt'
        y = _read_csv(filename)[0]
        y[y<=3] = 0 #for all dynamic activities
        y[y>3] = 1 #for all stattic activities
        return pd.get_dummies(y).as_matrix()#getting thee matrix

x_train,x_test = load_signals('train'), load_signals('test')
y_train,y_test = load_y('train'), load_y('test')
print(x_train.shape)
print(x_test.shape)
```

```
(7352, 2)
(2947, 2)
```

Architecture 1 with adam optimizer for classifying 2 classes

In [0]:

```python

sess = tf.Session(graph=tf.get_default_graph())
K.set_session(sess)
model_2c = Sequential()
model_2c.add(Conv1D(filters=32, kernel_size=3, activation='relu',kernel_initi
model_2c.add(Conv1D(filters=32, kernel_size=3, activation='relu',kernel_initi
model_2c.add(Dropout(0.6))
model_2c.add(MaxPooling1D(pool_size=2))
model_2c.add(Flatten())
model_2c.add(Dense(50, activation='relu'))
model_2c.add(Dense(2, activation='softmax'))
model_2c.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv1d_1 (Conv1D)            (None, 126, 32)           896       
_________________________________________________________________
conv1d_2 (Conv1D)            (None, 124, 32)           3104      
_________________________________________________________________
dropout_1 (Dropout)          (None, 124, 32)           0         
_________________________________________________________________
max_pooling1d_1 (MaxPooling1 (None, 62, 32)            0         
_________________________________________________________________
flatten_1 (Flatten)          (None, 1984)              0         
_________________________________________________________________
dense_1 (Dense)              (None, 50)                99250     
_________________________________________________________________
dense_2 (Dense)              (None, 2)                 102       
=================================================================
Total params: 103,352
Trainable params: 103,352
Non-trainable params: 0
_________________________________________________________________
```

In [0]:
```
model_2c.compile(loss='categorical_crossentropy', optimizer='adam', metrics=[
model_2c.fit(x_train,y_train, epochs=20, batch_size=16,validation_data=(x_tes
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/20
7352/7352 [==============================] - 3s 382us/step - loss: 0.0571 - ac
c: 0.9778 - val_loss: 0.0136 - val_acc: 0.9976
Epoch 2/20
7352/7352 [==============================] - 2s 337us/step - loss: 0.0033 - ac
c: 0.9992 - val_loss: 0.0169 - val_acc: 0.9932
Epoch 3/20
7352/7352 [==============================] - 3s 355us/step - loss: 9.8120e-04 -
acc: 0.9995 - val_loss: 0.0345 - val_acc: 0.9888
Epoch 4/20
7352/7352 [==============================] - 3s 358us/step - loss: 0.0012 - ac
c: 0.9997 - val_loss: 0.0192 - val_acc: 0.9936
Epoch 5/20
7352/7352 [==============================] - 2s 338us/step - loss: 5.9842e-05 -
acc: 1.0000 - val_loss: 0.0260 - val_acc: 0.9898
Epoch 6/20
7352/7352 [==============================] - 2s 331us/step - loss: 4.4741e-05 -
acc: 1.0000 - val_loss: 0.0307 - val_acc: 0.9895
Epoch 7/20
7352/7352 [==============================] - 2s 325us/step - loss: 5.2726e-05 -
acc: 1.0000 - val_loss: 0.0284 - val_acc: 0.9898
Epoch 8/20
7352/7352 [==============================] - 2s 340us/step - loss: 4.7698e-05 -
acc: 1.0000 - val_loss: 0.0292 - val_acc: 0.9895
Epoch 9/20
7352/7352 [==============================] - 3s 373us/step - loss: 4.1584e-05 -
acc: 1.0000 - val_loss: 0.0374 - val_acc: 0.9895
Epoch 10/20
7352/7352 [==============================] - 2s 315us/step - loss: 3.8117e-05 -
acc: 1.0000 - val_loss: 0.0455 - val_acc: 0.9891
Epoch 11/20
7352/7352 [==============================] - 3s 363us/step - loss: 3.5981e-05 -
acc: 1.0000 - val_loss: 0.0427 - val_acc: 0.9891
Epoch 12/20
7352/7352 [==============================] - 3s 359us/step - loss: 3.3263e-05 -
acc: 1.0000 - val_loss: 0.0432 - val_acc: 0.9891
Epoch 13/20
7352/7352 [==============================] - 3s 356us/step - loss: 3.8532e-05 -
acc: 1.0000 - val_loss: 0.0491 - val_acc: 0.9895
Epoch 14/20
7352/7352 [==============================] - 3s 345us/step - loss: 3.4566e-05 -
acc: 1.0000 - val_loss: 0.0456 - val_acc: 0.9895
Epoch 15/20
7352/7352 [==============================] - 3s 354us/step - loss: 3.3491e-05 -
acc: 1.0000 - val_loss: 0.0475 - val_acc: 0.9895
Epoch 16/20
7352/7352 [==============================] - 2s 340us/step - loss: 3.3821e-05 -
acc: 1.0000 - val_loss: 0.0412 - val_acc: 0.9898
Epoch 17/20
7352/7352 [==============================] - 3s 345us/step - loss: 3.5012e-05 -
acc: 1.0000 - val_loss: 0.0437 - val_acc: 0.9895
Epoch 18/20
```

```
7352/7352 [==============================] - 2s 321us/step - loss: 3.6307e-05 -
acc: 1.0000 - val_loss: 0.0492 - val_acc: 0.9895
Epoch 19/20
7352/7352 [==============================] - 3s 360us/step - loss: 0.0576 - ac
c: 0.9952 - val_loss: 0.1907 - val_acc: 0.9868
Epoch 20/20
7352/7352 [==============================] - 3s 364us/step - loss: 0.0952 - ac
c: 0.9937 - val_loss: 0.0144 - val_acc: 0.9990
```

Out[90]:
```
<keras.callbacks.History at 0x7feae7c11400>
```

In [0]:
```python
#saving model
model_2c.save('final_model_2c.h5')
```

Classifying the static activities

In [0]:
```python

def load_y(subset):
"""
    The objective that we are trying to predict is a integer, from 1 to 6,
    that represents a human activity. We return a binary representation of
    every sample objective as a 6 bits vector using One Hot Encoding
    (https://pandas.pydata.org/pandas-docs/stable/generated/pandas.get_dummie
        """
    filename = f'drive/My Drive/UCI_HAR_Dataset/{subset}/y_{subset}.txt'
    y = _read_csv(filename)[0]
    y_subset = y>3 #for static activities
    y = y[y_subset]
    return pd.get_dummies(y).as_matrix(),y_subset

Y_train_s,y_train_sub = load_y('train')
Y_val_s,y_test_sub = load_y('test')
X_train_s, X_val_s = load_signals('train'), load_signals('test')
X_train_s = X_train_s[y_train_sub]
X_val_s = X_val_s[y_test_sub]


```

Architecture 2 with adam optimizer

In [0]:

```
np.random.seed(0)
#tf.set_random_seed(0)
#sess = tf.Session(graph=tf.get_default_graph())
#K.set_session(sess)
model = Sequential()
model.add(Conv1D(filters=128, kernel_size=7, activation='relu',kernel_initial
model.add(Conv1D(filters=96, kernel_size=3, activation='relu',kernel_initiali
model.add(Dropout(0.7))
model.add(MaxPooling1D(pool_size=3))
model.add(Flatten())
model.add(Dense(30, activation='relu'))
model.add(Dense(3, activation='softmax'))
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv1d_3 (Conv1D)            (None, 122, 128)          8192      
_________________________________________________________________
conv1d_4 (Conv1D)            (None, 120, 96)           36960     
_________________________________________________________________
dropout_2 (Dropout)          (None, 120, 96)           0         
_________________________________________________________________
max_pooling1d_2 (MaxPooling1 (None, 40, 96)            0         
_________________________________________________________________
flatten_2 (Flatten)          (None, 3840)              0         
_________________________________________________________________
dense_3 (Dense)              (None, 30)                115230    
_________________________________________________________________
dense_4 (Dense)              (None, 3)                 93        
=================================================================
Total params: 160,475
Trainable params: 160,475
Non-trainable params: 0
_________________________________________________________________
```

In [0]:
```
import math
#adam = optimizers.Adam(lr=0.004)
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['ac
model.fit(X_train_s,Y_train_s, epochs=100, batch_size=32,validation_data=(X_v
#K.clear_session()

```

```
Train on 4067 samples, validate on 1560 samples
Epoch 1/100
4067/4067 [==============================] - 1s 292us/step - loss: 0.3541 - a
cc: 0.8785 - val_loss: 0.3553 - val_acc: 0.8814
Epoch 2/100
4067/4067 [==============================] - 1s 198us/step - loss: 0.2323 - a
cc: 0.9142 - val_loss: 0.2968 - val_acc: 0.9006
Epoch 3/100
4067/4067 [==============================] - 1s 182us/step - loss: 0.1686 - a
cc: 0.9343 - val_loss: 0.2738 - val_acc: 0.9058
Epoch 4/100
4067/4067 [==============================] - 1s 173us/step - loss: 0.2100 - a
cc: 0.9343 - val_loss: 0.2724 - val_acc: 0.9083
Epoch 5/100
4067/4067 [==============================] - 1s 185us/step - loss: 0.1412 - a
cc: 0.9452 - val_loss: 0.2368 - val_acc: 0.9192
Epoch 6/100
4067/4067 [==============================] - 1s 170us/step - loss: 0.1148 - a
cc: 0.9577 - val_loss: 0.2803 - val_acc: 0.9115
```

In [0]:
```
#saving model
model.save('final_model_static.h5')
```

Classifyinf dynamic activities

In [0]:
```
##data preparation
def load_y(subset):

    """
    The objective that we are trying to predict is a integer, from 1 to 6,
    that represents a human activity. We return a binary representation of
    every sample objective as a 6 bits vector using One Hot Encoding
    """
  filename = f'drive/My Drive/UCI_HAR_Dataset/{subset}/y_{subset}.txt'
  y = _read_csv(filename)[0]
  y_subset = y<=3 #classifying for  dynamic activities
  y = y[y_subset]
  return pd.get_dummies(y).as_matrix(),y_subset

Y_train_d,y_train_sub = load_y('train')
Y_val_d,y_test_sub = load_y('test')
X_train_d, X_val_d = load_signals('train'), load_signals('test')
X_train_d = X_train_d[y_train_sub]
X_val_d = X_val_d[y_test_sub]

```

Architecture 3 with adam optimizer

In [0]:
```
np.random.seed(0)
#tf.set_random_seed(0)
#sess = tf.Session(graph=tf.get_default_graph())
#K.set_session(sess)
model = Sequential()
model.add(Conv1D(filters=64, kernel_size=7, activation='relu',kernel_initiali
model.add(Conv1D(filters=32, kernel_size=3, activation='relu',kernel_initiali
model.add(Dropout(0.6))
model.add(MaxPooling1D(pool_size=3))
model.add(Flatten())
model.add(Dense(30, activation='relu'))
model.add(Dense(3, activation='softmax'))
model.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv1d_5 (Conv1D)            (None, 122, 64)           4096
_________________________________________________________________
conv1d_6 (Conv1D)            (None, 120, 32)           6176
_________________________________________________________________
dropout_3 (Dropout)          (None, 120, 32)           0
_________________________________________________________________
max_pooling1d_3 (MaxPooling1 (None, 40, 32)            0
_________________________________________________________________
flatten_3 (Flatten)          (None, 1280)              0
_________________________________________________________________
dense_5 (Dense)              (None, 30)                38430
_________________________________________________________________
dense_6 (Dense)              (None, 3)                 93
=================================================================
Total params: 48,795
Trainable params: 48,795
Non-trainable params: 0
_________________________________________________________________
```

In [0]:
```
import math
import keras
#adam = keras.optimizers.Adam(lr=0.004)
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['ac
model.fit(X_train_s,Y_train_s, epochs=100, batch_size=32,validation_data=(X_v
#K.clear_session()
```

```
Train on 4067 samples, validate on 1560 samples
Epoch 1/100
4067/4067 [==============================] - 1s 255us/step - loss: 0.3476 - a
cc: 0.8670 - val_loss: 0.2779 - val_acc: 0.8994
Epoch 2/100
4067/4067 [==============================] - 1s 158us/step - loss: 0.2045 - a
cc: 0.9137 - val_loss: 0.2820 - val_acc: 0.9071
Epoch 3/100
4067/4067 [==============================] - 1s 170us/step - loss: 0.1711 - a
cc: 0.9265 - val_loss: 0.2314 - val_acc: 0.9147
Epoch 4/100
4067/4067 [==============================] - 1s 199us/step - loss: 0.1420 - a
cc: 0.9383 - val_loss: 0.2294 - val_acc: 0.9083
Epoch 5/100
4067/4067 [==============================] - 1s 160us/step - loss: 0.1276 - a
cc: 0.9493 - val_loss: 0.2400 - val_acc: 0.9090
Epoch 6/100
4067/4067 [==============================] - 1s 172us/step - loss: 0.1130 - a
cc: 0.9560 - val_loss: 0.2280 - val_acc: 0.9288
```

In [0]:
```
#saving model
model.save('final_model_dynamic.h5')
```

Final model and results

In [0]:
```
#getting all the models
from keras.models import load_model
#getting the models
model_2class = load_model('final_model_2c.h5')
model_dynamic = load_model('final_model_dynamic.h5')
model_static = load_model('final_model_static.h5')
#for all the classses
class_2 = pickle.load(open('2class.p','rb'))
static = pickle.load(open('static.p','rb'))
dynamic = pickle.load(open('dynamic.p','rb'))
```

In [0]:

```
#predicting output activity
def predict_activity(X):
    ##predicting whether dynamic or static
    predict_2class = model_2class.predict(transform_data(X,scale_2class))
    Y_pred_2class =  np.argmax(predict_2class, axis=1)
    #static data filter
    X_static = X[Y_pred_2class==1]
    #dynamic data filter
    X_dynamic = X[Y_pred_2class==0]
    #predicting static activities
    predict_static = model_static.predict(transform_data(X_static,scale_stati
    predict_static = np.argmax(predict_static,axis=1)
    #adding 4 because need to get inal prediction lable as output
    predict_static = predict_static + 4
    #predicting dynamic activites
    predict_dynamic = model_dynamic.predict(transform_data(X_dynamic,scale_dy
    predict_dynamic = np.argmax(predict_dynamic,axis=1)
    #adding 1 because need to get inal prediction lable as output
    predict_dynamic = predict_dynamic + 1
    ##appending final output to one list in the same sequence of input data
    i,j = 0,0
    final_pred = []
    for mask in Y_pred_2class:
        if mask == 1:
            final_pred.append(predict_static[i])
            i = i + 1
        else:
            final_pred.append(predict_dynamic[j])
            j = j + 1
    return final_pred
```

In [0]:

```
##predicting
final_pred_val = predict_activity(X_test)
final_pred_train = predict_activity(X_train)
```

In [1]:

```
##accuracy of train and test
from sklearn.metrics import accuracy_score
print('Accuracy of train data:',accuracy_score(Y_train,final_pred_train))
print('Accuracy of validation data:',accuracy_score(Y_val,final_pred_val))
```

```
Accuracy of train data: 0.963949945593036
Accuracy of validation data: 0.9518384798099763
```

so here we finally get the best performing model with test accuracy of 0.95 and trainaccuracy of 0.96 using divide and conquer methods