HAR_LSTM

June 25, 2019

```
In [0]: # Importing Libraries
```

```
In [1]: from google.colab import drive
        drive.mount('HAR_Dataset',force_remount=True)

        rootpath="HAR_Dataset/My Drive"
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6b

Enter your authorization code:
ůůůůůůůůůů
Mounted at HAR_Dataset
```

```
In [0]: import pandas as pd
        import numpy as np
```

```
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',
        }

        # Utility function to print the confusion matrix
        def confusion_matrix(Y_true, Y_pred):
            Y_true = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_true, axis=1)])
            Y_pred = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_pred, axis=1)])

            return pd.crosstab(Y_true, Y_pred, rownames=['True'], colnames=['Pred'])
```

0.0.1 Data

```
In [0]: # Data directory
        DATADIR = 'UCI_HAR_Dataset'
```

In [0]:
```
# 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"
]
```

In [0]:
```
# 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'HAR_Dataset/My Drive/UCI_HAR_Dataset/{subset}/Inertial Signals/{sig
        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 signals)
    return np.transpose(signals_data, (1, 2, 0))
```

In [0]:
```
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_dummies.html)
    """
    filename = f'HAR_Dataset/My Drive/UCI_HAR_Dataset/{subset}/y_{subset}.txt'
    y = _read_csv(filename)[0]

    return pd.get_dummies(y).as_matrix()
```

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

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

In [11]:
```
# Import Keras
from keras import backend as K
sess = tf.Session(graph=tf.get_default_graph(), config=session_conf)
K.set_session(sess)
```

```
Using TensorFlow backend.
```

In [0]:
```
# Importing libraries
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers.core import Dense, Dropout
```

In [0]:
```
# Initializing parameters

epochs = 30

batch_size = 16


n_hidden = 32
```

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

In [15]:
```
# Loading the train and test data
X_train, X_test, Y_train, Y_test = load_data()
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:11: FutureWarning: Method .as_matri
  # This is added back by InteractiveShellApp.init_path()
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:12: FutureWarning: Method .as_matri
  if sys.path[0] == '':
```

```
In [16]: timesteps = len(X_train[0])
         input_dim = len(X_train[0][0])
         n_classes = _count_classes(Y_train)

         print(timesteps)
         print(input_dim)
         print(len(X_train))
```

```
128
9
7352
```

1 Assignment A) Hypertuning Num of Hidden Units

```
In [0]: hidden_Neurons_List=[8,16,32,64,128]

        hidden_Neurons_Accuracy=[]

        for n_hidden in hidden_Neurons_List:
          model=Sequential()

          model.add(LSTM(n_hidden,input_shape=(timesteps,input_dim)))

          model.add(Dropout(0.5))

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

          model.summary()

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

          model.fit(X_train,
                    Y_train,
                    batch_size=batch_size,
                    validation_data=(X_test, Y_test),
                    epochs=epochs)



          score = model.evaluate(X_test, Y_test)
```

```
hidden_Neurons_Accuracy.append(score)
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_11 (LSTM)               (None, 8)                 576
_________________________________________________________________
dropout_11 (Dropout)         (None, 8)                 0
_________________________________________________________________
dense_11 (Dense)             (None, 6)                 54
=================================================================
Total params: 630
Trainable params: 630
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 32s 4ms/step - loss: 1.5955 - acc: 0.3632 - val_los
Epoch 2/30
7352/7352 [==============================] - 30s 4ms/step - loss: 1.3659 - acc: 0.4550 - val_los
Epoch 3/30
7352/7352 [==============================] - 30s 4ms/step - loss: 1.2118 - acc: 0.4886 - val_los
Epoch 4/30
7352/7352 [==============================] - 30s 4ms/step - loss: 1.0938 - acc: 0.5291 - val_los
Epoch 5/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.9912 - acc: 0.5642 - val_los
Epoch 6/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.9305 - acc: 0.5809 - val_los
Epoch 7/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8942 - acc: 0.5838 - val_los
Epoch 8/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8780 - acc: 0.5903 - val_los
Epoch 9/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8793 - acc: 0.5926 - val_los
Epoch 10/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8699 - acc: 0.6002 - val_los
Epoch 11/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.8410 - acc: 0.6042 - val_los
Epoch 12/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8768 - acc: 0.5898 - val_los
Epoch 13/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.9041 - acc: 0.5709 - val_los
Epoch 14/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8725 - acc: 0.5997 - val_los
```

```
Epoch 15/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8794 - acc: 0.5838 - val_los
Epoch 16/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8170 - acc: 0.6055 - val_los
Epoch 17/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8236 - acc: 0.6107 - val_los
Epoch 18/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.7993 - acc: 0.6160 - val_los
Epoch 19/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8132 - acc: 0.6137 - val_los
Epoch 20/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.7903 - acc: 0.6182 - val_los
Epoch 21/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8168 - acc: 0.6096 - val_los
Epoch 22/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8677 - acc: 0.5887 - val_los
Epoch 23/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.9627 - acc: 0.5664 - val_los
Epoch 24/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8747 - acc: 0.5849 - val_los
Epoch 25/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8360 - acc: 0.5979 - val_los
Epoch 26/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8268 - acc: 0.6027 - val_los
Epoch 27/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8024 - acc: 0.6113 - val_los
Epoch 28/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.8014 - acc: 0.6119 - val_los
Epoch 29/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.7988 - acc: 0.6103 - val_los
Epoch 30/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.7801 - acc: 0.6163 - val_los
2947/2947 [==============================] - 1s 310us/step
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_12 (LSTM)               (None, 16)                1664
_________________________________________________________________
dropout_12 (Dropout)         (None, 16)                0
_________________________________________________________________
dense_12 (Dense)             (None, 6)                 102
=================================================================
Total params: 1,766
Trainable params: 1,766
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
```

```
7352/7352 [==============================] - 33s 5ms/step - loss: 1.4487 - acc: 0.3957 - val_los
Epoch 2/30
7352/7352 [==============================] - 31s 4ms/step - loss: 1.1780 - acc: 0.4678 - val_los
Epoch 3/30
7352/7352 [==============================] - 32s 4ms/step - loss: 1.1275 - acc: 0.4739 - val_los
Epoch 4/30
7352/7352 [==============================] - 32s 4ms/step - loss: 1.0714 - acc: 0.4884 - val_los
Epoch 5/30
7352/7352 [==============================] - 32s 4ms/step - loss: 1.0013 - acc: 0.5394 - val_los
Epoch 6/30
7352/7352 [==============================] - 32s 4ms/step - loss: 0.8838 - acc: 0.6175 - val_los
Epoch 7/30
7352/7352 [==============================] - 32s 4ms/step - loss: 0.8260 - acc: 0.6488 - val_los
Epoch 8/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.7483 - acc: 0.6778 - val_los
Epoch 9/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.7194 - acc: 0.6812 - val_los
Epoch 10/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.6657 - acc: 0.7163 - val_los
Epoch 11/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.6537 - acc: 0.7145 - val_los
Epoch 12/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.6750 - acc: 0.7187 - val_los
Epoch 13/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.6330 - acc: 0.7295 - val_los
Epoch 14/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.6436 - acc: 0.7382 - val_los
Epoch 15/30
7352/7352 [==============================] - 32s 4ms/step - loss: 0.6338 - acc: 0.7533 - val_los
Epoch 16/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.5908 - acc: 0.7652 - val_los
Epoch 17/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.5812 - acc: 0.7595 - val_los
Epoch 18/30
7352/7352 [==============================] - 32s 4ms/step - loss: 0.5537 - acc: 0.7677 - val_los
Epoch 19/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.5465 - acc: 0.7777 - val_los
Epoch 20/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.5127 - acc: 0.7926 - val_los
Epoch 21/30
7352/7352 [==============================] - 32s 4ms/step - loss: 0.4995 - acc: 0.8292 - val_los
Epoch 22/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.5634 - acc: 0.8281 - val_los
Epoch 23/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.4479 - acc: 0.8602 - val_los
Epoch 24/30
7352/7352 [==============================] - 32s 4ms/step - loss: 0.4057 - acc: 0.8803 - val_los
Epoch 25/30
```

```
7352/7352 [==============================] - 31s 4ms/step - loss: 0.3659 - acc: 0.8920 - val_los
Epoch 26/30
7352/7352 [==============================] - 32s 4ms/step - loss: 0.3439 - acc: 0.8984 - val_los
Epoch 27/30
7352/7352 [==============================] - 32s 4ms/step - loss: 0.3343 - acc: 0.8981 - val_los
Epoch 28/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.3665 - acc: 0.8915 - val_los
Epoch 29/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.3177 - acc: 0.9087 - val_los
Epoch 30/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.2947 - acc: 0.9087 - val_los
2947/2947 [==============================] - 1s 330us/step
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_13 (LSTM)               (None, 32)                5376
_________________________________________________________________
dropout_13 (Dropout)         (None, 32)                0
_________________________________________________________________
dense_13 (Dense)             (None, 6)                 198
=================================================================
Total params: 5,574
Trainable params: 5,574
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 35s 5ms/step - loss: 1.3670 - acc: 0.4244 - val_los
Epoch 2/30
7352/7352 [==============================] - 34s 5ms/step - loss: 1.0645 - acc: 0.5434 - val_los
Epoch 3/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.8503 - acc: 0.6468 - val_los
Epoch 4/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.7632 - acc: 0.6723 - val_los
Epoch 5/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.6299 - acc: 0.7274 - val_los
Epoch 6/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.5365 - acc: 0.7724 - val_los
Epoch 7/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.4865 - acc: 0.7878 - val_los
Epoch 8/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.4402 - acc: 0.7976 - val_los
Epoch 9/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.4274 - acc: 0.8067 - val_los
Epoch 10/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.3714 - acc: 0.8312 - val_los
Epoch 11/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.3583 - acc: 0.8683 - val_los
```

```
Epoch 12/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.3338 - acc: 0.8924 - val_los
Epoch 13/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.2621 - acc: 0.9230 - val_los
Epoch 14/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.2387 - acc: 0.9263 - val_los
Epoch 15/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.2641 - acc: 0.9165 - val_los
Epoch 16/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.2405 - acc: 0.9189 - val_los
Epoch 17/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.2195 - acc: 0.9309 - val_los
Epoch 18/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.2089 - acc: 0.9295 - val_los
Epoch 19/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.1861 - acc: 0.9312 - val_los
Epoch 20/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.1760 - acc: 0.9387 - val_los
Epoch 21/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.1834 - acc: 0.9357 - val_los
Epoch 22/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.1873 - acc: 0.9357 - val_los
Epoch 23/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.1811 - acc: 0.9376 - val_los
Epoch 24/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.1882 - acc: 0.9391 - val_los
Epoch 25/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.1621 - acc: 0.9395 - val_los
Epoch 26/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.1590 - acc: 0.9433 - val_los
Epoch 27/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.1739 - acc: 0.9410 - val_los
Epoch 28/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.1762 - acc: 0.9448 - val_los
Epoch 29/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.1490 - acc: 0.9431 - val_los
Epoch 30/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.1680 - acc: 0.9430 - val_los
2947/2947 [==============================] - 1s 377us/step
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_14 (LSTM)               (None, 64)                18944
_________________________________________________________________
dropout_14 (Dropout)         (None, 64)                0
_________________________________________________________________
dense_14 (Dense)             (None, 6)                 390
=================================================================
```

```
Total params: 19,334
Trainable params: 19,334
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 41s 6ms/step - loss: 1.2066 - acc: 0.4890 - val_los
Epoch 2/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.9584 - acc: 0.5694 - val_los
Epoch 3/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.8011 - acc: 0.6730 - val_los
Epoch 4/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.6206 - acc: 0.7609 - val_los
Epoch 5/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.5015 - acc: 0.8267 - val_los
Epoch 6/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.4565 - acc: 0.8516 - val_los
Epoch 7/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.2895 - acc: 0.9008 - val_los
Epoch 8/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.2505 - acc: 0.9195 - val_los
Epoch 9/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.2373 - acc: 0.9298 - val_los
Epoch 10/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.2064 - acc: 0.9317 - val_los
Epoch 11/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.2192 - acc: 0.9305 - val_los
Epoch 12/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.2107 - acc: 0.9334 - val_los
Epoch 13/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1739 - acc: 0.9397 - val_los
Epoch 14/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.1773 - acc: 0.9422 - val_los
Epoch 15/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1875 - acc: 0.9411 - val_los
Epoch 16/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1709 - acc: 0.9395 - val_los
Epoch 17/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1560 - acc: 0.9433 - val_los
Epoch 18/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.1454 - acc: 0.9441 - val_los
Epoch 19/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.1786 - acc: 0.9342 - val_los
Epoch 20/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1506 - acc: 0.9471 - val_los
Epoch 21/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.1713 - acc: 0.9436 - val_los
Epoch 22/30
```

```
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1466 - acc: 0.9484 - val_los
Epoch 23/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1567 - acc: 0.9470 - val_los
Epoch 24/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1475 - acc: 0.9478 - val_los
Epoch 25/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1833 - acc: 0.9436 - val_los
Epoch 26/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.1539 - acc: 0.9445 - val_los
Epoch 27/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1573 - acc: 0.9472 - val_los
Epoch 28/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.2278 - acc: 0.9357 - val_los
Epoch 29/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1552 - acc: 0.9474 - val_los
Epoch 30/30
7352/7352 [==============================] - 39s 5ms/step - loss: 0.1520 - acc: 0.9470 - val_los
2947/2947 [==============================] - 2s 526us/step
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_15 (LSTM)               (None, 128)               70656
_________________________________________________________________
dropout_15 (Dropout)         (None, 128)               0
_________________________________________________________________
dense_15 (Dense)             (None, 6)                 774
=================================================================
Total params: 71,430
Trainable params: 71,430
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 60s 8ms/step - loss: 1.2407 - acc: 0.4478 - val_los
Epoch 2/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.9093 - acc: 0.5819 - val_los
Epoch 3/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.7344 - acc: 0.6393 - val_los
Epoch 4/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.6823 - acc: 0.6927 - val_los
Epoch 5/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.4828 - acc: 0.8158 - val_los
Epoch 6/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.3518 - acc: 0.8799 - val_los
Epoch 7/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.2519 - acc: 0.9104 - val_los
Epoch 8/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.2390 - acc: 0.9249 - val_los
```

```
Epoch 9/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1885 - acc: 0.9363 - val_los
Epoch 10/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1728 - acc: 0.9361 - val_los
Epoch 11/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1587 - acc: 0.9431 - val_los
Epoch 12/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1562 - acc: 0.9445 - val_los
Epoch 13/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1533 - acc: 0.9456 - val_los
Epoch 14/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1491 - acc: 0.9486 - val_los
Epoch 15/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1383 - acc: 0.9465 - val_los
Epoch 16/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1292 - acc: 0.9517 - val_los
Epoch 17/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1563 - acc: 0.9484 - val_los
Epoch 18/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1503 - acc: 0.9484 - val_los
Epoch 19/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1697 - acc: 0.9441 - val_los
Epoch 20/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1383 - acc: 0.9486 - val_los
Epoch 21/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1327 - acc: 0.9505 - val_los
Epoch 22/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1564 - acc: 0.9450 - val_los
Epoch 23/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1220 - acc: 0.9513 - val_los
Epoch 24/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1352 - acc: 0.9495 - val_los
Epoch 25/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1334 - acc: 0.9474 - val_los
Epoch 26/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1211 - acc: 0.9527 - val_los
Epoch 27/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1188 - acc: 0.9544 - val_los
Epoch 28/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1287 - acc: 0.9506 - val_los
Epoch 29/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1709 - acc: 0.9436 - val_los
Epoch 30/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1315 - acc: 0.9517 - val_los
2947/2947 [==============================] - 3s 943us/step
```

```
---------------------------------------------------------------------------

TypeError                                 Traceback (most recent call last)

<ipython-input-100-2acaa322236d> in <module>()
 30
 31 for i in range(len(hidden_Neurons_List)):
---> 32   print("Number of Hidden Neurons : %d, Accuracy : %d"%(hidden_Neurons_List[i],hidde
 33
 34


TypeError: %d format: a number is required, not list
```

In [0]:
```python
print(hidden_Neurons_List)
print("...........")
print(hidden_Neurons_Accuracy)
```

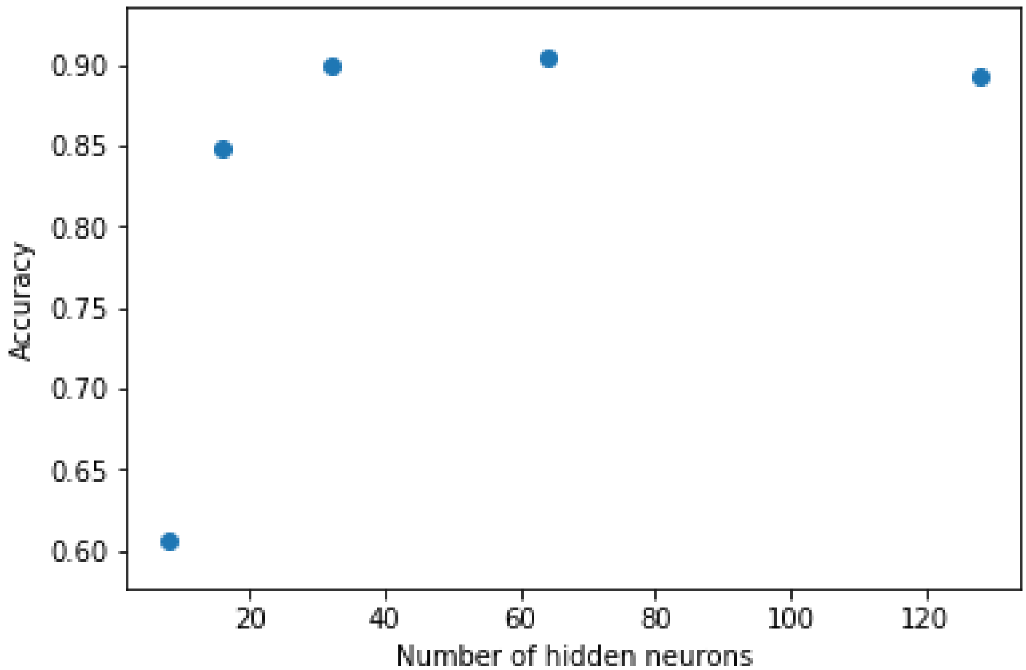
```
[8, 16, 32, 64, 128]
...
[[0.7497640215505128, 0.6067186969799796], [0.5063654349498706, 0.8486596538853071], [0.44709858
```

In [0]:
```python
max_acc=0
y=[]
for i in range(len(hidden_Neurons_List)):
  if hidden_Neurons_Accuracy[i][1]>max_acc:
    max_acc=hidden_Neurons_Accuracy[i][1]

    best_n_hidden=hidden_Neurons_List[i]

  y.append(hidden_Neurons_Accuracy[i][1])
  print("Number of Hidden Neurons : %d, Accuracy : %f"%(hidden_Neurons_List[i],hidden_Ne
```

```
Number of Hidden Neurons : 8, Accuracy : 0.606719
Number of Hidden Neurons : 16, Accuracy : 0.848660
Number of Hidden Neurons : 32, Accuracy : 0.899220
Number of Hidden Neurons : 64, Accuracy : 0.904988
Number of Hidden Neurons : 128, Accuracy : 0.892094
```

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


x = hidden_Neurons_List
```

```
plt.scatter(x, y)
plt.xlabel('Number of hidden neurons')
plt.ylabel('Accuracy')
plt.show()
```




```
In [0]: print("The best value of number of hidden neurons is %d"%best_n_hidden)
```

```
The best value of number of hidden neurons is 64
```

2 Assignment B) Hypertuning Dropout Rate

```
In [0]:
```

```
In [0]: dropout_List=[0.1,0.3,0.5,0.7,0.9]

        dropout_Accuracy=[]

        for dropout in dropout_List:
          model=Sequential()

          model.add(LSTM(best_n_hidden,input_shape=(timesteps,input_dim)))
```

```
    model.add(Dropout(dropout))

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

    model.summary()

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

    model.fit(X_train,
              Y_train,
              batch_size=batch_size,
              validation_data=(X_test, Y_test),
              epochs=epochs)



    score = model.evaluate(X_test, Y_test)

    dropout_Accuracy.append(score)
```

```
WARNING: Logging before flag parsing goes to stderr.
W0617 05:37:13.891773 140504591730560 deprecation_wrapper.py:119] From /usr/local/lib/python3.6/

W0617 05:37:13.895210 140504591730560 deprecation_wrapper.py:119] From /usr/local/lib/python3.6/

W0617 05:37:13.906264 140504591730560 deprecation_wrapper.py:119] From /usr/local/lib/python3.6/

W0617 05:37:14.170121 140504591730560 deprecation_wrapper.py:119] From /usr/local/lib/python3.6/

W0617 05:37:14.182163 140504591730560 deprecation.py:506] From /usr/local/lib/python3.6/dist-pac
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
W0617 05:37:14.214296 140504591730560 deprecation_wrapper.py:119] From /usr/local/lib/python3.6/

W0617 05:37:14.237277 140504591730560 deprecation_wrapper.py:119] From /usr/local/lib/python3.6/

W0617 05:37:14.389814 140504591730560 deprecation.py:323] From /usr/local/lib/python3.6/dist-pac
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where


_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 64)                18944
```

```
_________________________________________________________________
dropout_1 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 390
=================================================================
Total params: 19,334
Trainable params: 19,334
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 37s 5ms/step - loss: 1.2624 - acc: 0.4302 - val_los
Epoch 2/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.9102 - acc: 0.5945 - val_los
Epoch 3/30
7352/7352 [==============================] - 36s 5ms/step - loss: 0.6894 - acc: 0.7201 - val_los
Epoch 4/30
7352/7352 [==============================] - 36s 5ms/step - loss: 0.6155 - acc: 0.7780 - val_los
Epoch 5/30
7352/7352 [==============================] - 36s 5ms/step - loss: 0.4409 - acc: 0.8474 - val_los
Epoch 6/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.3038 - acc: 0.8988 - val_los
Epoch 7/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.2346 - acc: 0.9174 - val_los
Epoch 8/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1999 - acc: 0.9291 - val_los
Epoch 9/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1781 - acc: 0.9366 - val_los
Epoch 10/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1564 - acc: 0.9369 - val_los
Epoch 11/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1501 - acc: 0.9438 - val_los
Epoch 12/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1606 - acc: 0.9419 - val_los
Epoch 13/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1453 - acc: 0.9429 - val_los
Epoch 14/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1542 - acc: 0.9453 - val_los
Epoch 15/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1489 - acc: 0.9426 - val_los
Epoch 16/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1412 - acc: 0.9468 - val_los
Epoch 17/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1386 - acc: 0.9464 - val_los
Epoch 18/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1273 - acc: 0.9476 - val_los
Epoch 19/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1273 - acc: 0.9505 - val_los
```

```
Epoch 20/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1309 - acc: 0.9502 - val_los
Epoch 21/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1280 - acc: 0.9502 - val_los
Epoch 22/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1233 - acc: 0.9504 - val_los
Epoch 23/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1221 - acc: 0.9508 - val_los
Epoch 24/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.1172 - acc: 0.9538 - val_los
Epoch 25/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1187 - acc: 0.9531 - val_los
Epoch 26/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1161 - acc: 0.9532 - val_los
Epoch 27/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1402 - acc: 0.9521 - val_los
Epoch 28/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1163 - acc: 0.9536 - val_los
Epoch 29/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1366 - acc: 0.9486 - val_los
Epoch 30/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1231 - acc: 0.9513 - val_los
2947/2947 [==============================] - 1s 482us/step
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_2 (LSTM)                (None, 64)                18944
_________________________________________________________________
dropout_2 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_2 (Dense)              (None, 6)                 390
=================================================================
Total params: 19,334
Trainable params: 19,334
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 38s 5ms/step - loss: 1.1909 - acc: 0.4815 - val_los
Epoch 2/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.8578 - acc: 0.5934 - val_los
Epoch 3/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.7158 - acc: 0.6548 - val_los
Epoch 4/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.6563 - acc: 0.7359 - val_los
Epoch 5/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.5247 - acc: 0.8050 - val_los
Epoch 6/30
```

```
7352/7352 [==============================] - 38s 5ms/step - loss: 0.3771 - acc: 0.8769 - val_los
Epoch 7/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2673 - acc: 0.9155 - val_los
Epoch 8/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2216 - acc: 0.9222 - val_los
Epoch 9/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2169 - acc: 0.9257 - val_los
Epoch 10/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1829 - acc: 0.9355 - val_los
Epoch 11/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1814 - acc: 0.9388 - val_los
Epoch 12/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1636 - acc: 0.9419 - val_los
Epoch 13/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1737 - acc: 0.9400 - val_los
Epoch 14/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1586 - acc: 0.9449 - val_los
Epoch 15/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1422 - acc: 0.9459 - val_los
Epoch 16/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1587 - acc: 0.9467 - val_los
Epoch 17/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1336 - acc: 0.9504 - val_los
Epoch 18/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1427 - acc: 0.9490 - val_los
Epoch 19/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1423 - acc: 0.9489 - val_los
Epoch 20/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1414 - acc: 0.9493 - val_los
Epoch 21/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1332 - acc: 0.9474 - val_los
Epoch 22/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1370 - acc: 0.9480 - val_los
Epoch 23/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1298 - acc: 0.9514 - val_los
Epoch 24/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1684 - acc: 0.9387 - val_los
Epoch 25/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1460 - acc: 0.9450 - val_los
Epoch 26/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1249 - acc: 0.9497 - val_los
Epoch 27/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1340 - acc: 0.9501 - val_los
Epoch 28/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1403 - acc: 0.9471 - val_los
Epoch 29/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1313 - acc: 0.9532 - val_los
Epoch 30/30
```

```
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1223 - acc: 0.9523 - val_los
2947/2947 [==============================] - 1s 490us/step
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_3 (LSTM)                (None, 64)                18944
_________________________________________________________________
dropout_3 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_3 (Dense)              (None, 6)                 390
=================================================================
Total params: 19,334
Trainable params: 19,334
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 39s 5ms/step - loss: 1.2709 - acc: 0.4396 - val_los
Epoch 2/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.9985 - acc: 0.5336 - val_los
Epoch 3/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.8254 - acc: 0.6430 - val_los
Epoch 4/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.6177 - acc: 0.7556 - val_los
Epoch 5/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.4842 - acc: 0.8275 - val_los
Epoch 6/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.3198 - acc: 0.8998 - val_los
Epoch 7/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2715 - acc: 0.9174 - val_los
Epoch 8/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2208 - acc: 0.9251 - val_los
Epoch 9/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2100 - acc: 0.9287 - val_los
Epoch 10/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1847 - acc: 0.9397 - val_los
Epoch 11/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1697 - acc: 0.9411 - val_los
Epoch 12/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1787 - acc: 0.9380 - val_los
Epoch 13/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1637 - acc: 0.9437 - val_los
Epoch 14/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1527 - acc: 0.9416 - val_los
Epoch 15/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1626 - acc: 0.9406 - val_los
Epoch 16/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1543 - acc: 0.9442 - val_los
```

```
Epoch 17/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1458 - acc: 0.9467 - val_los
Epoch 18/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1391 - acc: 0.9505 - val_los
Epoch 19/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1359 - acc: 0.9465 - val_los
Epoch 20/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1804 - acc: 0.9445 - val_los
Epoch 21/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2048 - acc: 0.9441 - val_los
Epoch 22/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2478 - acc: 0.9264 - val_los
Epoch 23/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1511 - acc: 0.9460 - val_los
Epoch 24/30
7352/7352 [==============================] - 36s 5ms/step - loss: 0.1383 - acc: 0.9516 - val_los
Epoch 25/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1342 - acc: 0.9508 - val_los
Epoch 26/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1315 - acc: 0.9509 - val_los
Epoch 27/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1282 - acc: 0.9483 - val_los
Epoch 28/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1411 - acc: 0.9489 - val_los
Epoch 29/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1463 - acc: 0.9463 - val_los
Epoch 30/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1289 - acc: 0.9513 - val_los
2947/2947 [==============================] - 1s 494us/step
```

```
W0617 06:32:15.475296 140504591730560 nn_ops.py:4224] Large dropout rate: 0.7 (>0.5). In TensorF
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_4 (LSTM)                (None, 64)                18944
_________________________________________________________________
dropout_4 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_4 (Dense)              (None, 6)                 390
=================================================================
Total params: 19,334
Trainable params: 19,334
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
```

```
Epoch 1/30
7352/7352 [==============================] - 39s 5ms/step - loss: 1.3130 - acc: 0.4402 - val_los
Epoch 2/30
7352/7352 [==============================] - 37s 5ms/step - loss: 1.0343 - acc: 0.5465 - val_los
Epoch 3/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.8394 - acc: 0.6143 - val_los
Epoch 4/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.7459 - acc: 0.6659 - val_los
Epoch 5/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.7040 - acc: 0.7108 - val_los
Epoch 6/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.5503 - acc: 0.8098 - val_los
Epoch 7/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.4508 - acc: 0.8615 - val_los
Epoch 8/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.3289 - acc: 0.9038 - val_los
Epoch 9/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2942 - acc: 0.9064 - val_los
Epoch 10/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2701 - acc: 0.9168 - val_los
Epoch 11/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2548 - acc: 0.9246 - val_los
Epoch 12/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.2221 - acc: 0.9291 - val_los
Epoch 13/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2188 - acc: 0.9334 - val_los
Epoch 14/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1972 - acc: 0.9369 - val_los
Epoch 15/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1874 - acc: 0.9365 - val_los
Epoch 16/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1929 - acc: 0.9374 - val_los
Epoch 17/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.2103 - acc: 0.9339 - val_los
Epoch 18/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.1873 - acc: 0.9422 - val_los
Epoch 19/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.2091 - acc: 0.9384 - val_los
Epoch 20/30
7352/7352 [==============================] - 38s 5ms/step - loss: 0.1869 - acc: 0.9422 - val_los
Epoch 21/30
7352/7352 [==============================] - 38s 5ms/step - loss: nan - acc: 0.9393 - val_loss:
Epoch 22/30
7352/7352 [==============================] - 37s 5ms/step - loss: nan - acc: 0.9463 - val_loss:
Epoch 23/30
7352/7352 [==============================] - 37s 5ms/step - loss: nan - acc: 0.9404 - val_loss:
Epoch 24/30
7352/7352 [==============================] - 36s 5ms/step - loss: nan - acc: 0.9433 - val_loss:
```

```
Epoch 25/30
7352/7352 [==============================] - 36s 5ms/step - loss: nan - acc: 0.9444 - val_loss:
Epoch 26/30
7352/7352 [==============================] - 43s 6ms/step - loss: nan - acc: 0.9412 - val_loss:
Epoch 27/30
7352/7352 [==============================] - 37s 5ms/step - loss: nan - acc: 0.9444 - val_loss:
Epoch 28/30
7352/7352 [==============================] - 38s 5ms/step - loss: nan - acc: 0.9412 - val_loss:
Epoch 29/30
7352/7352 [==============================] - 38s 5ms/step - loss: nan - acc: 0.9459 - val_loss:
Epoch 30/30
7352/7352 [==============================] - 37s 5ms/step - loss: nan - acc: 0.9425 - val_loss:
2947/2947 [==============================] - 1s 487us/step
```

```
W0617 06:51:05.217503 140504591730560 nn_ops.py:4224] Large dropout rate: 0.9 (>0.5). In TensorF
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_5 (LSTM)                (None, 64)                18944
_________________________________________________________________
dropout_5 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_5 (Dense)              (None, 6)                 390
=================================================================
Total params: 19,334
Trainable params: 19,334
Non-trainable params: 0
_________________________________________________________________
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 39s 5ms/step - loss: 1.4367 - acc: 0.3902 - val_los
Epoch 2/30
7352/7352 [==============================] - 37s 5ms/step - loss: 1.2442 - acc: 0.4649 - val_los
Epoch 3/30
7352/7352 [==============================] - 37s 5ms/step - loss: 1.1148 - acc: 0.5132 - val_los
Epoch 4/30
7352/7352 [==============================] - 37s 5ms/step - loss: 1.0714 - acc: 0.5355 - val_los
Epoch 5/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.9871 - acc: 0.5768 - val_los
Epoch 6/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.9340 - acc: 0.5944 - val_los
Epoch 7/30
7352/7352 [==============================] - 37s 5ms/step - loss: 0.8972 - acc: 0.6145 - val_los
Epoch 8/30
7352/7352 [==============================] - 37s 5ms/step - loss: 1.0225 - acc: 0.5970 - val_los
```

```
Epoch 9/30
4624/7352 [=================>...] - ETA: 12s - loss: 0.8600 - acc: 0.6122Buffered data was trunc
```

```
In [0]: print(dropout_List)
        print("...........")
        print(dropout_Accuracy)
```

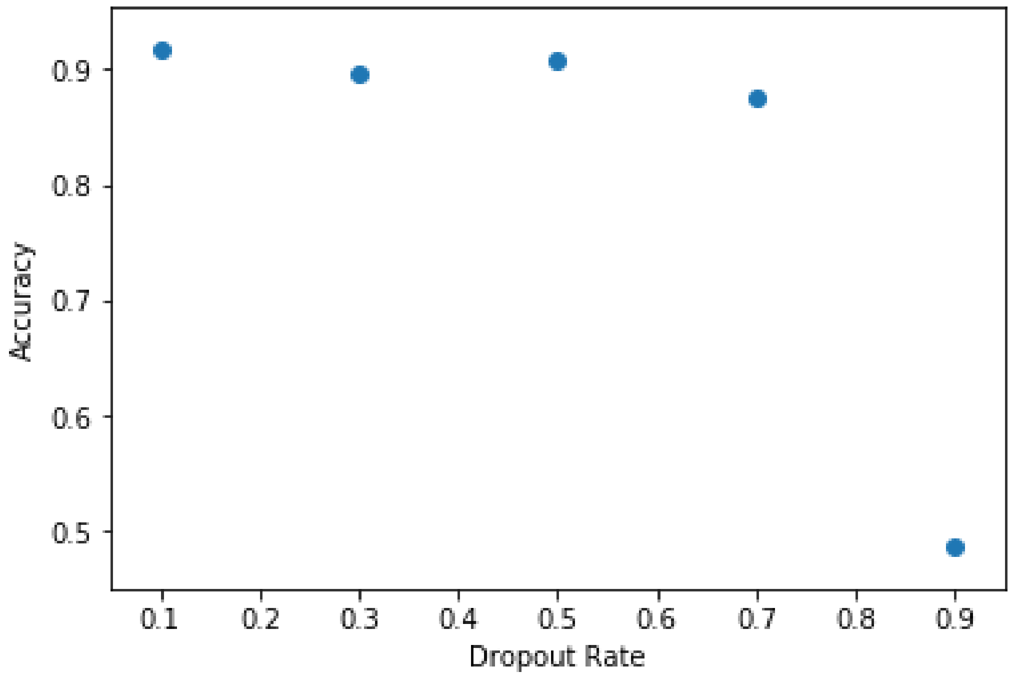
```
[0.1, 0.3, 0.5, 0.7, 0.9]
...
[[0.26970847920445745, 0.9165252799457075], [0.5416957346667051, 0.8961655921275874], [0.4099368
```

```
In [0]: print(dropout_List)
        print("...........")
        print(dropout_Accuracy)



        max_acc=0
        best_dropout=0
        y=[]
        for i in range(len(dropout_List)):
          if dropout_Accuracy[i][1]>max_acc:
            max_acc=dropout_Accuracy[i][1]
            best_dropout=dropout_List[i]
          y.append(dropout_Accuracy[i][1])
          print("Number of Hidden Neurons : %d, Accuracy : %f"%(dropout_List[i],dropout_Accuracy

        print(".........\n")
        print("The best droput value is : %f"%best_dropout)
```

```
[0.1, 0.3, 0.5, 0.7, 0.9]
...
[[0.26970847920445745, 0.9165252799457075], [0.5416957346667051, 0.8961655921275874], [0.4099368
Number of Hidden Neurons : 0, Accuracy : 0.916525
Number of Hidden Neurons : 0, Accuracy : 0.896166
Number of Hidden Neurons : 0, Accuracy : 0.908381
Number of Hidden Neurons : 0, Accuracy : 0.876485
Number of Hidden Neurons : 0, Accuracy : 0.487275
...

The best droput value is : 0.100000
```

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

```
x = dropout_List


plt.scatter(x, y)
plt.xlabel('Dropout Rate')
plt.ylabel('Accuracy')
plt.show()
```



3 Assignment C) 2 Layer LSTM and Higher dropout

```
In [0]: from keras.layers import TimeDistributed
        from keras.layers.convolutional import Conv1D
        from keras.layers.convolutional import MaxPooling1D
        from keras.layers import Flatten

        from keras.layers import BatchNormalization
```

```
In [0]: epochs = 75
        kernel_size = 1
        pool_size = 2

        dropout_rate = 0.1

        f_act = 'relu'
```

In [23]:
```
model = Sequential()
model.add(Conv1D(512, (kernel_size), input_shape=(X_train.shape[1],X_train.shape[2]), a
model.add(BatchNormalization())
model.add(MaxPooling1D(pool_size=(pool_size)))
model.add(Dropout(dropout_rate))

model.add(Conv1D(64, (kernel_size), activation=f_act, padding='same'))
model.add(BatchNormalization())
model.add(MaxPooling1D(pool_size=(pool_size)))
model.add(Dropout(dropout_rate))


model.add(Conv1D(32, (kernel_size), activation=f_act, padding='same'))
model.add(BatchNormalization())
model.add(MaxPooling1D(pool_size=(pool_size)))
model.add(Dropout(dropout_rate))

model.add(LSTM(256, return_sequences=True))
model.add(LSTM(128, return_sequences=True))
model.add(LSTM(64))


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

#model.summary()

model.compile(loss='categorical_crossentropy',optimizer='adam',metrics=['accuracy'])

model.fit(X_train,
         Y_train,
          batch_size=batch_size,
          validation_data=(X_test, Y_test),
          epochs=epochs)
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/75
7352/7352 [==============================] - 76s 10ms/step - loss: 0.6044 - acc: 0.7349 - val_lo
Epoch 2/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.2458 - acc: 0.9142 - val_lo
Epoch 3/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1767 - acc: 0.9347 - val_lo
Epoch 4/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1652 - acc: 0.9395 - val_lo
Epoch 5/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1463 - acc: 0.9402 - val_lo
Epoch 6/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1405 - acc: 0.9475 - val_lo
Epoch 7/75
```

```
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1327 - acc: 0.9470 - val_lo
Epoch 8/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1376 - acc: 0.9440 - val_lo
Epoch 9/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1231 - acc: 0.9508 - val_lo
Epoch 10/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1273 - acc: 0.9482 - val_lo
Epoch 11/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1260 - acc: 0.9490 - val_lo
Epoch 12/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1253 - acc: 0.9478 - val_lo
Epoch 13/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1237 - acc: 0.9468 - val_lo
Epoch 14/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1246 - acc: 0.9487 - val_lo
Epoch 15/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1303 - acc: 0.9474 - val_lo
Epoch 16/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1215 - acc: 0.9495 - val_lo
Epoch 17/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1140 - acc: 0.9543 - val_lo
Epoch 18/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1081 - acc: 0.9540 - val_lo
Epoch 19/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1114 - acc: 0.9559 - val_lo
Epoch 20/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1125 - acc: 0.9533 - val_lo
Epoch 21/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1108 - acc: 0.9540 - val_lo
Epoch 22/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1160 - acc: 0.9520 - val_lo
Epoch 23/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1189 - acc: 0.9494 - val_lo
Epoch 24/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1029 - acc: 0.9581 - val_lo
Epoch 25/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1085 - acc: 0.9561 - val_lo
Epoch 26/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.1045 - acc: 0.9584 - val_lo
Epoch 27/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.1038 - acc: 0.9584 - val_lo
Epoch 28/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0988 - acc: 0.9607 - val_lo
Epoch 29/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0920 - acc: 0.9634 - val_lo
Epoch 30/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0936 - acc: 0.9627 - val_lo
Epoch 31/75
```

```
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0985 - acc: 0.9601 - val_lo
Epoch 32/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0959 - acc: 0.9619 - val_lo
Epoch 33/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0933 - acc: 0.9642 - val_lo
Epoch 34/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0889 - acc: 0.9637 - val_lo
Epoch 35/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0952 - acc: 0.9635 - val_lo
Epoch 36/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0887 - acc: 0.9642 - val_lo
Epoch 37/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0908 - acc: 0.9645 - val_lo
Epoch 38/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0866 - acc: 0.9664 - val_lo
Epoch 39/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0799 - acc: 0.9682 - val_lo
Epoch 40/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0926 - acc: 0.9656 - val_lo
Epoch 41/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0804 - acc: 0.9695 - val_lo
Epoch 42/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0847 - acc: 0.9679 - val_lo
Epoch 43/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0749 - acc: 0.9721 - val_lo
Epoch 44/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0834 - acc: 0.9668 - val_lo
Epoch 45/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0744 - acc: 0.9694 - val_lo
Epoch 46/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0689 - acc: 0.9708 - val_lo
Epoch 47/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0731 - acc: 0.9723 - val_lo
Epoch 48/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0761 - acc: 0.9690 - val_lo
Epoch 49/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0659 - acc: 0.9737 - val_lo
Epoch 50/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0748 - acc: 0.9733 - val_lo
Epoch 51/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0634 - acc: 0.9739 - val_lo
Epoch 52/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0671 - acc: 0.9728 - val_lo
Epoch 53/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0681 - acc: 0.9736 - val_lo
Epoch 54/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0602 - acc: 0.9765 - val_lo
Epoch 55/75
```

```
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0579 - acc: 0.9770 - val_lo
Epoch 56/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0590 - acc: 0.9755 - val_lo
Epoch 57/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0600 - acc: 0.9765 - val_lo
Epoch 58/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0619 - acc: 0.9758 - val_lo
Epoch 59/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0594 - acc: 0.9777 - val_lo
Epoch 60/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0530 - acc: 0.9782 - val_lo
Epoch 61/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0599 - acc: 0.9765 - val_lo
Epoch 62/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0532 - acc: 0.9793 - val_lo
Epoch 63/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0473 - acc: 0.9803 - val_lo
Epoch 64/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0585 - acc: 0.9762 - val_lo
Epoch 65/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0506 - acc: 0.9804 - val_lo
Epoch 66/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0502 - acc: 0.9803 - val_lo
Epoch 67/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0483 - acc: 0.9814 - val_lo
Epoch 68/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0486 - acc: 0.9801 - val_lo
Epoch 69/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0506 - acc: 0.9804 - val_lo
Epoch 70/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0427 - acc: 0.9835 - val_lo
Epoch 71/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0418 - acc: 0.9823 - val_lo
Epoch 72/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0465 - acc: 0.9805 - val_lo
Epoch 73/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0388 - acc: 0.9835 - val_lo
Epoch 74/75
7352/7352 [==============================] - 71s 10ms/step - loss: 0.0427 - acc: 0.9833 - val_lo
Epoch 75/75
7352/7352 [==============================] - 72s 10ms/step - loss: 0.0455 - acc: 0.9811 - val_lo
2947/2947 [==============================] - 4s 1ms/step
```

In [0]:
```
#model=Sequential()

#model.add(LSTM(200,return_sequences=True,input_shape=(timesteps,input_dim)))
```

```
#model.add(LSTM(100))

#model.add(Dropout(0.8))

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

#model.summary()

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

#model.fit(X_train,
#         Y_train,
#          batch_size=batch_size,
#          validation_data=(X_test, Y_test),
#          epochs=epochs)



#score = model.evaluate(X_test, Y_test)
```

In [0]:
```
#print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
```

In [0]:

In [28]:
```
# Confusion Matrix
print(confusion_matrix(Y_test, model.predict(X_test)))
```

```
Pred                LAYING  SITTING  ...  WALKING_DOWNSTAIRS  WALKING_UPSTAIRS
True                                 ...
LAYING                 537        0  ...                   0                 0
SITTING                  5      433  ...                   0                 3
STANDING                 0       27  ...                   0                 0
WALKING                  0        0  ...                   3                 0
WALKING_DOWNSTAIRS       0        0  ...                 415                 2
WALKING_UPSTAIRS         0        0  ...                   0               442

[6 rows x 6 columns]
```

In [26]:
```
score = model.evaluate(X_test, Y_test)
```

```
2947/2947 [==============================] - 4s 1ms/step
```

In [27]:
```
print(score)
```

```
[0.1823121076857176, 0.9637048147261827]
```

4 Conclusions

In [29]:
```
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Excercise","Task","Remarks","Accuracy"]


x.add_row(["A","Hypertuning Hidden Neurons","Best value found at 64",0.904988])
x.add_row(["B","Hypertuning Dropout value","Best value found at 0.1",0.916525])
x.add_row(["C","To improve accuracy to beyond 96%","CNN + LSTM used",0.9637048147261827

print(x)
```

```
+-----------+-----------------------------------+-------------------------+--------------------+
| Excercise |                Task               |         Remarks         |      Accuracy      |
+-----------+-----------------------------------+-------------------------+--------------------+
|     A     |     Hypertuning Hidden Neurons    |  Best value found at 64 |      0.904988      |
|     B     |     Hypertuning Dropout value     | Best value found at 0.1 |      0.916525      |
|     C     | To improve accuracy to beyond 96% |      CNN + LSTM used    | 0.9637048147261827 |
+-----------+-----------------------------------+-------------------------+--------------------+
```

In [0]: