In [ ]:

```
# Importing Libraries
```

In [6]:

```
!wget --header="Host: doc-04-8s-docs.googleusercontent.com" --header="User-Agent: Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/71.0.3578.98 Safari/537.36" --header="Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/apng,*/*;q=0.8" --header="Accept-Language: en-GB,en-US;q=0.9,en;q=0.8" --header="Referer: https://drive.google.com/" --header="Cookie: AUTH_ucu55st84n9vmnrguf06csv12kkku9tn_nonce=8c5pco6po95mg" --header="Connection: keep-alive" "https://doc-04-8s-docs.googleusercontent.com/docs/securesc/6qasdsvtcepj72nj3126fhrlbctlsaju/eefs3cvrbm4u1ju1gt9mistifrov2g2e/1548136800000/06629147635963609455/12370343985631133257/118toouH8ifByKJHmmowyjOjGyir-YAvi?e=download&nonce=8c5pco6po95mg&user=12370343985631133257&hash=ue43mlk075cdbk64ucdojcp3urk3ujmj" -O "HumanActivityRecognition.zip" -c
```

```
--2019-01-22 07:30:42--  https://doc-04-8s-docs.googleusercontent.com/docs/securesc/6qasdsvtcepj72nj3126fhrlbctlsaju/eefs3cvrbm4u1ju1gt9mistifrov2g2e/1548136800000/06629147635963609455/12370343985631133257/118toouH8ifByKJHmmowyjOjGyir-YAvi?e=download&nonce=8c5pco6po95mg&user=12370343985631133257&hash=ue43mlk075cdbk64ucdojcp3urk3ujmj
Resolving doc-04-8s-docs.googleusercontent.com (doc-04-8s-docs.googleusercontent.com)... 74.125.141.132, 2607:f8b0:400c:c06::84
Connecting to doc-04-8s-docs.googleusercontent.com (doc-04-8s-docs.googleusercontent.com)|74.125.141.132|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: unspecified [application/zip]
Saving to: ‘HumanActivityRecognition.zip’

HumanActivityRecogn     [     <=>            ]  85.62M  58.7MB/s
in 1.5s

2019-01-22 07:30:44 (58.7 MB/s) - ‘HumanActivityRecognition.zip’ saved [89781419]
```

In [7]:

```
!unzip HumanActivityRecognition.zip
```

```
Archive:  HumanActivityRecognition.zip
   creating: HAR/
  inflating: HAR/.DS_Store
   creating: __MACOSX/
   creating: __MACOSX/HAR/
  inflating: __MACOSX/HAR/._.DS_Store
   creating: HAR/.ipynb_checkpoints/
  inflating: HAR/.ipynb_checkpoints/HAR_EDA-checkpoint.ipynb
  inflating: HAR/.ipynb_checkpoints/HAR_LSTM-checkpoint.ipynb
  inflating: HAR/.ipynb_checkpoints/HAR_LSTM_1-checkpoint.ipynb
  inflating: HAR/.ipynb_checkpoints/HAR_PREDICTION_MODELS-checkpoin
t.ipynb
  inflating: HAR/HAR_EDA.ipynb
  inflating: __MACOSX/HAR/._HAR_EDA.ipynb
  inflating: HAR/HAR_LSTM.ipynb
  inflating: __MACOSX/HAR/._HAR_LSTM.ipynb
  inflating: HAR/HAR_PREDICTION_MODELS.ipynb
  inflating: __MACOSX/HAR/._HAR_PREDICTION_MODELS.ipynb
  inflating: HAR/t-sne_perp_10_iter_1000.png
  inflating: __MACOSX/HAR/._t-sne_perp_10_iter_1000.png
  inflating: HAR/t-sne_perp_20_iter_1000.png
  inflating: __MACOSX/HAR/._t-sne_perp_20_iter_1000.png
  inflating: HAR/t-sne_perp_2_iter_1000.png
  inflating: __MACOSX/HAR/._t-sne_perp_2_iter_1000.png
  inflating: HAR/t-sne_perp_50_iter_1000.png
  inflating: __MACOSX/HAR/._t-sne_perp_50_iter_1000.png
  inflating: HAR/t-sne_perp_5_iter_1000.png
  inflating: __MACOSX/HAR/._t-sne_perp_5_iter_1000.png
   creating: HAR/UCI_HAR_Dataset/
  inflating: HAR/UCI_HAR_Dataset/.DS_Store
   creating: __MACOSX/HAR/UCI_HAR_Dataset/
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/._.DS_Store
  inflating: HAR/UCI_HAR_Dataset/_DS_Store
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/.__DS_Store
  inflating: HAR/UCI_HAR_Dataset/activity_labels.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/._activity_labels.txt
   creating: HAR/UCI_HAR_Dataset/csv_files/
  inflating: HAR/UCI_HAR_Dataset/csv_files/test.csv
   creating: __MACOSX/HAR/UCI_HAR_Dataset/csv_files/
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/csv_files/._test.csv
  inflating: HAR/UCI_HAR_Dataset/csv_files/train.csv
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/csv_files/._train.csv
  inflating: HAR/UCI_HAR_Dataset/features.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/._features.txt
  inflating: HAR/UCI_HAR_Dataset/features_info.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/._features_info.txt
  inflating: HAR/UCI_HAR_Dataset/README.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/._README.txt
   creating: HAR/UCI_HAR_Dataset/test/
   creating: HAR/UCI_HAR_Dataset/test/Inertial Signals/
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/body_acc_x_te
st.txt
   creating: __MACOSX/HAR/UCI_HAR_Dataset/test/
   creating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._bo
dy_acc_x_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/body_acc_y_te
st.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._bo
dy_acc_y_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/body_acc_z_te
```

```
st.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._bo
dy_acc_z_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/body_gyro_x_t
est.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._bo
dy_gyro_x_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/body_gyro_y_t
est.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._bo
dy_gyro_y_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/body_gyro_z_t
est.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._bo
dy_gyro_z_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/total_acc_x_t
est.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._to
tal_acc_x_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/total_acc_y_t
est.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._to
tal_acc_y_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/Inertial Signals/total_acc_z_t
est.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/Inertial Signals/._to
tal_acc_z_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/subject_test.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/._subject_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/X_test.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/._X_test.txt
  inflating: HAR/UCI_HAR_Dataset/test/y_test.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/test/._y_test.txt
   creating: HAR/UCI_HAR_Dataset/train/
  inflating: HAR/UCI_HAR_Dataset/train/.DS_Store
   creating: __MACOSX/HAR/UCI_HAR_Dataset/train/
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/._.DS_Store
   creating: HAR/UCI_HAR_Dataset/train/Inertial Signals/
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/body_acc_x_t
rain.txt
   creating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._b
ody_acc_x_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/body_acc_y_t
rain.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._b
ody_acc_y_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/body_acc_z_t
rain.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._b
ody_acc_z_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/body_gyro_x_
train.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._b
ody_gyro_x_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/body_gyro_y_
train.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._b
ody_gyro_y_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/body_gyro_z_
train.txt
```

```
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._b
ody_gyro_z_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/total_acc_x_
train.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._t
otal_acc_x_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/total_acc_y_
train.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._t
otal_acc_y_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/Inertial Signals/total_acc_z_
train.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/Inertial Signals/._t
otal_acc_z_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/subject_train.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/._subject_train.txt

  inflating: HAR/UCI_HAR_Dataset/train/X_train.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/._X_train.txt
  inflating: HAR/UCI_HAR_Dataset/train/y_train.txt
  inflating: __MACOSX/HAR/UCI_HAR_Dataset/train/._y_train.txt
```

In [43]:

```
!pip3 install hyperas
!pip3 install hyperopt
```

```
Requirement already satisfied: hyperas in ./.local/lib/python3.5/sit
e-packages
Requirement already satisfied: entrypoints in /usr/local/lib/python
3.5/dist-packages (from hyperas)
Requirement already satisfied: keras in /usr/local/lib/python3.5/dis
t-packages (from hyperas)
Requirement already satisfied: nbformat in /usr/local/lib/python3.5/
dist-packages (from hyperas)
Requirement already satisfied: jupyter in /usr/local/lib/python3.5/d
ist-packages (from hyperas)
Requirement already satisfied: hyperopt in ./.local/lib/python3.5/si
te-packages (from hyperas)
Requirement already satisfied: nbconvert in /usr/local/lib/python3.
5/dist-packages (from hyperas)
Requirement already satisfied: pyyaml in /usr/local/lib/python3.5/di
st-packages (from keras->hyperas)
Requirement already satisfied: keras-applications>=1.0.6 in /usr/loc
al/lib/python3.5/dist-packages (from keras->hyperas)
Requirement already satisfied: h5py in /usr/local/lib/python3.5/dist
-packages (from keras->hyperas)
Requirement already satisfied: keras-preprocessing>=1.0.5 in /usr/lo
cal/lib/python3.5/dist-packages (from keras->hyperas)
Requirement already satisfied: six>=1.9.0 in /usr/local/lib/python3.
5/dist-packages (from keras->hyperas)
Requirement already satisfied: scipy>=0.14 in /usr/local/lib/python
3.5/site-packages (from keras->hyperas)
Requirement already satisfied: numpy>=1.9.1 in /usr/local/lib/python
3.5/site-packages (from keras->hyperas)
Requirement already satisfied: traitlets>=4.1 in /usr/local/lib/pyth
on3.5/dist-packages (from nbformat->hyperas)
Requirement already satisfied: ipython-genutils in /usr/local/lib/py
thon3.5/dist-packages (from nbformat->hyperas)
Requirement already satisfied: jupyter-core in /usr/local/lib/python
3.5/dist-packages (from nbformat->hyperas)
Requirement already satisfied: jsonschema!=2.5.0,>=2.4 in /usr/loca
l/lib/python3.5/dist-packages (from nbformat->hyperas)
Requirement already satisfied: jupyter-console in /usr/local/lib/pyt
hon3.5/dist-packages (from jupyter->hyperas)
Requirement already satisfied: ipykernel in /usr/local/lib/python3.
5/dist-packages (from jupyter->hyperas)
Requirement already satisfied: notebook in /usr/local/lib/python3.5/
dist-packages (from jupyter->hyperas)
Requirement already satisfied: qtconsole in /usr/local/lib/python3.
5/dist-packages (from jupyter->hyperas)
Requirement already satisfied: ipywidgets in /usr/local/lib/python3.
5/dist-packages (from jupyter->hyperas)
Requirement already satisfied: future in /usr/local/lib/python3.5/di
st-packages (from hyperopt->hyperas)
Requirement already satisfied: networkx in /usr/local/lib/python3.5/
dist-packages (from hyperopt->hyperas)
Requirement already satisfied: pymongo in ./.local/lib/python3.5/sit
e-packages (from hyperopt->hyperas)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.5/di
st-packages (from nbconvert->hyperas)
Requirement already satisfied: defusedxml in /usr/local/lib/python3.
5/dist-packages (from nbconvert->hyperas)
Requirement already satisfied: pandocfilters>=1.4.1 in /usr/local/li
b/python3.5/dist-packages (from nbconvert->hyperas)
Requirement already satisfied: testpath in /usr/local/lib/python3.5/
dist-packages (from nbconvert->hyperas)
Requirement already satisfied: pygments in /usr/local/lib/python3.5/
```

```
dist-packages (from nbconvert->hyperas)
Requirement already satisfied: bleach in /usr/local/lib/python3.5/di
st-packages (from nbconvert->hyperas)
Requirement already satisfied: mistune>=0.8.1 in /usr/local/lib/pyth
on3.5/dist-packages (from nbconvert->hyperas)
Requirement already satisfied: intel-numpy in /usr/local/lib/python
3.5/dist-packages (from scipy>=0.14->keras->hyperas)
Requirement already satisfied: icc-rt in /usr/local/lib/python3.5/di
st-packages (from numpy>=1.9.1->keras->hyperas)
Requirement already satisfied: tbb4py in /usr/local/lib/python3.5/di
st-packages (from numpy>=1.9.1->keras->hyperas)
Requirement already satisfied: mkl-random in /usr/local/lib/python3.
5/dist-packages (from numpy>=1.9.1->keras->hyperas)
Requirement already satisfied: mkl-fft in /usr/local/lib/python3.5/d
ist-packages (from numpy>=1.9.1->keras->hyperas)
Requirement already satisfied: mkl in /usr/local/lib/python3.5/dist-
packages (from numpy>=1.9.1->keras->hyperas)
Requirement already satisfied: decorator in /usr/local/lib/python3.
5/dist-packages (from traitlets>=4.1->nbformat->hyperas)
Requirement already satisfied: jupyter-client in /usr/local/lib/pyth
on3.5/dist-packages (from jupyter-console->jupyter->hyperas)
Requirement already satisfied: ipython in /usr/local/lib/python3.5/d
ist-packages (from jupyter-console->jupyter->hyperas)
Requirement already satisfied: prompt-toolkit<2.1.0,>=2.0.0 in /usr/
local/lib/python3.5/dist-packages (from jupyter-console->jupyter->hy
peras)
Requirement already satisfied: tornado>=4.0 in /usr/local/lib/python
3.5/dist-packages (from ipykernel->jupyter->hyperas)
Requirement already satisfied: prometheus-client in /usr/local/lib/p
ython3.5/dist-packages (from notebook->jupyter->hyperas)
Requirement already satisfied: Send2Trash in /usr/local/lib/python3.
5/dist-packages (from notebook->jupyter->hyperas)
Requirement already satisfied: pyzmq>=17 in /usr/local/lib/python3.
5/dist-packages (from notebook->jupyter->hyperas)
Requirement already satisfied: terminado>=0.8.1 in /usr/local/lib/py
thon3.5/dist-packages (from notebook->jupyter->hyperas)
Requirement already satisfied: widgetsnbextension~=3.3.0 in /usr/loc
al/lib/python3.5/dist-packages (from ipywidgets->jupyter->hyperas)
Requirement already satisfied: MarkupSafe>=0.23 in /usr/local/lib/py
thon3.5/dist-packages (from jinja2->nbconvert->hyperas)
Requirement already satisfied: webencodings in /usr/local/lib/python
3.5/dist-packages (from bleach->nbconvert->hyperas)
Requirement already satisfied: intel-openmp in /usr/local/lib/python
3.5/dist-packages (from icc-rt->numpy>=1.9.1->keras->hyperas)
Requirement already satisfied: tbb==2019.* in /usr/local/lib/python
3.5/dist-packages (from tbb4py->numpy>=1.9.1->keras->hyperas)
Requirement already satisfied: python-dateutil>=2.1 in /usr/local/li
b/python3.5/dist-packages (from jupyter-client->jupyter-console->jup
yter->hyperas)
Requirement already satisfied: pickleshare in /usr/local/lib/python
3.5/dist-packages (from ipython->jupyter-console->jupyter->hyperas)
Requirement already satisfied: setuptools>=18.5 in /usr/local/lib/py
thon3.5/dist-packages (from ipython->jupyter-console->jupyter->hyper
as)
Requirement already satisfied: pexpect; sys_platform != "win32" in /
usr/local/lib/python3.5/dist-packages (from ipython->jupyter-console
->jupyter->hyperas)
Requirement already satisfied: backcall in /usr/local/lib/python3.5/
dist-packages (from ipython->jupyter-console->jupyter->hyperas)
Requirement already satisfied: jedi>=0.10 in /usr/local/lib/python3.
5/dist-packages (from ipython->jupyter-console->jupyter->hyperas)
```

```
Requirement already satisfied: wcwidth in /usr/local/lib/python3.5/d
ist-packages (from prompt-toolkit<2.1.0,>=2.0.0->jupyter-console->ju
pyter->hyperas)
Requirement already satisfied: ptyprocess; os_name != "nt" in /usr/l
ocal/lib/python3.5/dist-packages (from terminado>=0.8.1->notebook->j
upyter->hyperas)
Requirement already satisfied: parso>=0.3.0 in /usr/local/lib/python
3.5/dist-packages (from jedi>=0.10->ipython->jupyter-console->jupyte
r->hyperas)
Requirement already satisfied: hyperopt in ./.local/lib/python3.5/si
te-packages
Requirement already satisfied: numpy in /usr/local/lib/python3.5/sit
e-packages (from hyperopt)
Requirement already satisfied: future in /usr/local/lib/python3.5/di
st-packages (from hyperopt)
Requirement already satisfied: six in /usr/local/lib/python3.5/dist-
packages (from hyperopt)
Requirement already satisfied: scipy in /usr/local/lib/python3.5/sit
e-packages (from hyperopt)
Requirement already satisfied: networkx in /usr/local/lib/python3.5/
dist-packages (from hyperopt)
Requirement already satisfied: pymongo in ./.local/lib/python3.5/sit
e-packages (from hyperopt)
Requirement already satisfied: mkl-random in /usr/local/lib/python3.
5/dist-packages (from numpy->hyperopt)
Requirement already satisfied: mkl-fft in /usr/local/lib/python3.5/d
ist-packages (from numpy->hyperopt)
Requirement already satisfied: icc-rt in /usr/local/lib/python3.5/di
st-packages (from numpy->hyperopt)
Requirement already satisfied: mkl in /usr/local/lib/python3.5/dist-
packages (from numpy->hyperopt)
Requirement already satisfied: tbb4py in /usr/local/lib/python3.5/di
st-packages (from numpy->hyperopt)
Requirement already satisfied: intel-numpy in /usr/local/lib/python
3.5/dist-packages (from scipy->hyperopt)
Requirement already satisfied: decorator>=4.3.0 in /usr/local/lib/py
thon3.5/dist-packages (from networkx->hyperopt)
Requirement already satisfied: intel-openmp in /usr/local/lib/python
3.5/dist-packages (from icc-rt->numpy->hyperopt)
Requirement already satisfied: tbb==2019.* in /usr/local/lib/python
3.5/dist-packages (from tbb4py->numpy->hyperopt)
```

In [1]:

```
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
import numpy as np
```

In [2]:

```
# 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'])
```

Data

In [2]:

```
# Data directory
DATADIR = 'UCI_HAR_Dataset'
```

In [3]:

```
# Importing tensorflow
np.random.seed(42)
import tensorflow as tf
tf.set_random_seed(42)
```

In [4]:

```
# Configuring a session
session_conf = tf.ConfigProto(
    intra_op_parallelism_threads=1,
    inter_op_parallelism_threads=1
)
```

In [5]:

```
# 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 [6]:

```
# Importing libraries
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers.core import Dense, Dropout
```

In [7]:

```
def load_data():
    import numpy as np

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

    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_dummi
es.html)
        """
        filename = 'HAR/UCI_HAR_Dataset/' + subset+ '/y_'+ subset+'.txt'
        y = _read_csv(filename)[0]

        return pd.get_dummies(y).as_matrix()
    def load_signals(subset):
        signals_data = []

        for signal in SIGNALS:
            filename = 'HAR/UCI_HAR_Dataset/'+subset+'/Inertial Signals/'+signal
+'_'+subset+'.txt'
            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 s
ignals)
        return np.transpose(signals_data, (1, 2, 0))
    """
    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,Y_train,X_test,Y_test
```

In [8]:

```
def model(X_train, Y_train, X_test, Y_test):
    model = Sequential()
    # Configuring the parameters
    model.add(LSTM({{choice([64, 128, 256])}}, input_shape=(128, 9)))
    # Adding a dropout layer
    model.add(Dropout({{uniform(0, 1)}}))
    # Adding a dense output layer with sigmoid activation
    model.add(Dense(6, activation='sigmoid'))
    # Compiling the model
    model.compile(loss='categorical_crossentropy',
              optimizer='rmsprop',
              metrics=['accuracy'])
    # Training the model
    history = model.fit(X_train,
            Y_train,
            batch_size={{choice([16,32,64])}},
            validation_data=(X_test, Y_test),
            epochs=30)
    score, acc = model.evaluate(X_test, Y_test, verbose=0)
    print('Test accuracy:', acc)
    return {'loss': -acc, 'status': STATUS_OK, 'model': model,'history.val_loss'
:history.history['val_loss'], 'history.val_acc': history.history['val_acc'],
    'history.loss': history.history['loss'], 'history.acc': history.history['ac
c']
    }
```

In [10]:

```
from hyperas import optim
from hyperopt import tpe,Trials,STATUS_OK
```

In [11]:

```
trials = Trials()
```

In [12]:

```
best_run, best_model = optim.minimize(model=model,
                                      data=load_data,
                                      max_evals=10,
                                      algo=tpe.suggest,
                                      notebook_name='HAR_LSTM',
                                      trials=trials
                                     )
```

```
>>> Imports:
#coding=utf-8

try:
    import warnings
except:
    pass

try:
    import pandas as pd
except:
    pass

try:
    import numpy as np
except:
    pass

try:
    import tensorflow as tf
except:
    pass

try:
    from keras import backend as K
except:
    pass

try:
    from keras.models import Sequential
except:
    pass

try:
    from keras.layers import LSTM
except:
    pass

try:
    from keras.layers.core import Dense, Dropout
except:
    pass

try:
    import numpy as np
except:
    pass

try:
    from hyperas import optim
except:
    pass

try:
    from hyperopt import tpe, Trials, STATUS_OK
except:
    pass

try:
    import matplotlib.pyplot as plt
except:
```

```
    pass

try:
    from collections import defaultdict
except:
    pass
```

```
>>> Hyperas search space:
```

```
def get_space():
    return {
        'LSTM': hp.choice('LSTM', [64, 128, 256]),
        'Dropout': hp.uniform('Dropout', 0, 1),
        'batch_size': hp.choice('batch_size', [16,32,64]),
    }
```

```
>>> Data
```

```
   1:
   2: import numpy as np
   3:
   4: # Raw data signals
   5: # Signals are from Accelerometer and Gyroscope
   6: # The signals are in x,y,z directions
   7: # Sensor signals are filtered to have only body acceleration
   8: # excluding the acceleration due to gravity
   9: # Triaxial acceleration from the accelerometer is total accele
ration
  10: SIGNALS = [
  11:     "body_acc_x",
  12:     "body_acc_y",
  13:     "body_acc_z",
  14:     "body_gyro_x",
  15:     "body_gyro_y",
  16:     "body_gyro_z",
  17:     "total_acc_x",
  18:     "total_acc_y",
  19:     "total_acc_z"
  20: ]
  21: # Utility function to load the load
  22: # Utility function to read the data from csv file
  23: def _read_csv(filename):
  24:     return pd.read_csv(filename, delim_whitespace=True, header
=None)
  25:
  26: def load_y(subset):
  27:     """
  28:     The objective that we are trying to predict is a integer,
from 1 to 6,
  29:     that represents a human activity. We return a binary repre
sentation of
  30:     every sample objective as a 6 bits vector using One Hot En
coding
  31:     (https://pandas.pydata.org/pandas-docs/stable/generated/pa
ndas.get_dummies.html)
  32:     """
  33:     filename = 'HAR/UCI_HAR_Dataset/' + subset+ '/y_'+ subset
+'.txt'
  34:     y = _read_csv(filename)[0]
  35:
  36:     return pd.get_dummies(y).as_matrix()
  37: def load_signals(subset):
```

```
    signals_data = []

    for signal in SIGNALS:
        filename = 'HAR/UCI_HAR_Dataset/'+subset+'/Inertial Signals/'+signal+'_'+subset+'.txt'
        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))
"""
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')


>>> Resulting replaced keras model:

def keras_fmin_fnct(space):

    model = Sequential()
    # Configuring the parameters
    model.add(LSTM(space['LSTM'], input_shape=(128, 9)))
    # Adding a dropout layer
    model.add(Dropout(space['Dropout']))
    # Adding a dense output layer with sigmoid activation
    model.add(Dense(6, activation='sigmoid'))
    # Compiling the model
    model.compile(loss='categorical_crossentropy',
                  optimizer='rmsprop',
                  metrics=['accuracy'])
    # Training the model
    history = model.fit(X_train,
                Y_train,
                batch_size=space['batch_size'],
                validation_data=(X_test, Y_test),
                epochs=30)
    score, acc = model.evaluate(X_test, Y_test, verbose=0)
    print('Test accuracy:', acc)
    return {'loss': -acc, 'status': STATUS_OK, 'model': model,'history.val_loss':history.history['val_loss'], 'history.val_acc': history.history['val_acc'],
    'history.loss': history.history['loss'], 'history.acc': history.history['acc']
    }

Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 36s 5ms/step - loss: 1.4209 - acc: 0.3564 - val_loss: 1.4125 - val_acc: 0.4544
Epoch 2/30
7352/7352 [==============================] - 31s 4ms/step - loss: 1.
```

```
1910 - acc: 0.4708 - val_loss: 1.0844 - val_acc: 0.5324
Epoch 3/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
9676 - acc: 0.5657 - val_loss: 1.0290 - val_acc: 0.5019
Epoch 4/30
7352/7352 [==============================] - 31s 4ms/step - loss: 1.
0702 - acc: 0.5178 - val_loss: 1.0130 - val_acc: 0.5151
Epoch 5/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
8446 - acc: 0.6079 - val_loss: 1.0241 - val_acc: 0.5623
Epoch 6/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
7872 - acc: 0.6158 - val_loss: 0.9752 - val_acc: 0.5626
Epoch 7/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.
7344 - acc: 0.6364 - val_loss: 0.7688 - val_acc: 0.6318
Epoch 8/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
6956 - acc: 0.6529 - val_loss: 0.8160 - val_acc: 0.6128
Epoch 9/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.
7003 - acc: 0.6548 - val_loss: 0.7380 - val_acc: 0.6108
Epoch 10/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.
6681 - acc: 0.6625 - val_loss: 0.7031 - val_acc: 0.6244
Epoch 11/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
6966 - acc: 0.6591 - val_loss: 0.7415 - val_acc: 0.6186
Epoch 12/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
6698 - acc: 0.6692 - val_loss: 0.6666 - val_acc: 0.6301
Epoch 13/30
7352/7352 [==============================] - 28s 4ms/step - loss: 0.
6118 - acc: 0.6892 - val_loss: 0.7424 - val_acc: 0.6471
Epoch 14/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.
6177 - acc: 0.7038 - val_loss: 0.6259 - val_acc: 0.7299
Epoch 15/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
5082 - acc: 0.7886 - val_loss: 0.7070 - val_acc: 0.7109
Epoch 16/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.
4196 - acc: 0.8640 - val_loss: 0.4676 - val_acc: 0.8473
Epoch 17/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
3333 - acc: 0.8909 - val_loss: 0.3985 - val_acc: 0.8819
Epoch 18/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
2580 - acc: 0.9183 - val_loss: 0.4600 - val_acc: 0.8466
Epoch 19/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.
2347 - acc: 0.9207 - val_loss: 0.2967 - val_acc: 0.9070
Epoch 20/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.
2182 - acc: 0.9187 - val_loss: 0.2504 - val_acc: 0.9074
Epoch 21/30
7352/7352 [==============================] - 28s 4ms/step - loss: 0.
1956 - acc: 0.9291 - val_loss: 0.2840 - val_acc: 0.8945
Epoch 22/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
1905 - acc: 0.9329 - val_loss: 0.2448 - val_acc: 0.9237
```

```
Epoch 23/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.
1864 - acc: 0.9378 - val_loss: 0.2842 - val_acc: 0.8867
Epoch 24/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.
1598 - acc: 0.9408 - val_loss: 0.2925 - val_acc: 0.8877
Epoch 25/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
1653 - acc: 0.9357 - val_loss: 0.2872 - val_acc: 0.9036
Epoch 26/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.
1703 - acc: 0.9381 - val_loss: 0.3389 - val_acc: 0.9026
Epoch 27/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
1610 - acc: 0.9436 - val_loss: 0.3357 - val_acc: 0.9033
Epoch 28/30
7352/7352 [==============================] - 31s 4ms/step - loss: 0.
1429 - acc: 0.9484 - val_loss: 0.2664 - val_acc: 0.9138
Epoch 29/30
7352/7352 [==============================] - 30s 4ms/step - loss: 0.
1629 - acc: 0.9403 - val_loss: 0.3990 - val_acc: 0.8989
Epoch 30/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.
1372 - acc: 0.9446 - val_loss: 0.3375 - val_acc: 0.8968
Test accuracy: 0.8968442483881914
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 120s 16ms/step - loss:
1.3790 - acc: 0.4163 - val_loss: 1.5887 - val_acc: 0.3607
Epoch 2/30
7352/7352 [==============================] - 118s 16ms/step - loss:
1.2000 - acc: 0.5128 - val_loss: 0.9426 - val_acc: 0.5609
Epoch 3/30
7352/7352 [==============================] - 123s 17ms/step - loss:
0.9695 - acc: 0.5828 - val_loss: 0.9686 - val_acc: 0.4720
Epoch 4/30
7352/7352 [==============================] - 119s 16ms/step - loss:
0.8395 - acc: 0.6304 - val_loss: 0.8240 - val_acc: 0.5982
Epoch 5/30
7352/7352 [==============================] - 116s 16ms/step - loss:
0.9826 - acc: 0.5751 - val_loss: 1.0264 - val_acc: 0.5612
Epoch 6/30
7352/7352 [==============================] - 119s 16ms/step - loss:
0.8170 - acc: 0.6209 - val_loss: 0.7117 - val_acc: 0.6210
Epoch 7/30
7352/7352 [==============================] - 118s 16ms/step - loss:
0.7924 - acc: 0.6364 - val_loss: 0.8239 - val_acc: 0.6271
Epoch 8/30
7352/7352 [==============================] - 115s 16ms/step - loss:
0.7206 - acc: 0.6681 - val_loss: 0.7129 - val_acc: 0.6841
Epoch 9/30
7352/7352 [==============================] - 115s 16ms/step - loss:
0.6576 - acc: 0.7138 - val_loss: 0.7840 - val_acc: 0.7574
Epoch 10/30
7352/7352 [==============================] - 114s 16ms/step - loss:
0.5931 - acc: 0.8020 - val_loss: 0.6623 - val_acc: 0.8052
Epoch 11/30
7352/7352 [==============================] - 114s 16ms/step - loss:
0.4535 - acc: 0.8697 - val_loss: 0.4164 - val_acc: 0.8531
Epoch 12/30
7352/7352 [==============================] - 118s 16ms/step - loss:
```

```
0.3431 - acc: 0.8958 - val_loss: 0.3562 - val_acc: 0.8928
Epoch 13/30
7352/7352 [==============================] - 113s 15ms/step - loss:
0.3124 - acc: 0.9100 - val_loss: 0.3501 - val_acc: 0.9033
Epoch 14/30
7352/7352 [==============================] - 112s 15ms/step - loss:
0.2970 - acc: 0.9204 - val_loss: 0.4288 - val_acc: 0.8965
Epoch 15/30
7352/7352 [==============================] - 111s 15ms/step - loss:
0.3897 - acc: 0.8968 - val_loss: 0.5607 - val_acc: 0.8870
Epoch 16/30
7352/7352 [==============================] - 109s 15ms/step - loss:
0.2578 - acc: 0.9222 - val_loss: 0.5337 - val_acc: 0.9013
Epoch 17/30
7352/7352 [==============================] - 112s 15ms/step - loss:
0.2654 - acc: 0.9275 - val_loss: 0.8437 - val_acc: 0.8884
Epoch 18/30
7352/7352 [==============================] - 108s 15ms/step - loss:
0.2685 - acc: 0.9256 - val_loss: 0.5361 - val_acc: 0.9002
Epoch 19/30
7352/7352 [==============================] - 114s 16ms/step - loss:
0.2487 - acc: 0.9253 - val_loss: 0.6074 - val_acc: 0.8907
Epoch 20/30
7352/7352 [==============================] - 117s 16ms/step - loss:
0.3612 - acc: 0.8792 - val_loss: 0.5659 - val_acc: 0.8965
Epoch 21/30
7352/7352 [==============================] - 109s 15ms/step - loss:
0.2977 - acc: 0.9259 - val_loss: 0.3567 - val_acc: 0.9118
Epoch 22/30
7352/7352 [==============================] - 118s 16ms/step - loss:
0.2833 - acc: 0.9244 - val_loss: 0.2639 - val_acc: 0.9145
Epoch 23/30
7352/7352 [==============================] - 116s 16ms/step - loss:
0.2543 - acc: 0.9248 - val_loss: 0.6417 - val_acc: 0.8901
Epoch 24/30
7352/7352 [==============================] - 115s 16ms/step - loss:
0.2711 - acc: 0.9314 - val_loss: 0.3078 - val_acc: 0.9155
Epoch 25/30
7352/7352 [==============================] - 113s 15ms/step - loss:
0.4324 - acc: 0.9197 - val_loss: 2.2120 - val_acc: 0.8045
Epoch 26/30
7352/7352 [==============================] - 112s 15ms/step - loss:
0.4195 - acc: 0.9158 - val_loss: 0.4296 - val_acc: 0.9101
Epoch 27/30
7352/7352 [==============================] - 108s 15ms/step - loss:
0.2178 - acc: 0.9314 - val_loss: 0.5475 - val_acc: 0.9006
Epoch 28/30
7352/7352 [==============================] - 113s 15ms/step - loss:
0.2168 - acc: 0.9355 - val_loss: 0.5504 - val_acc: 0.9141
Epoch 29/30
7352/7352 [==============================] - 109s 15ms/step - loss:
0.4097 - acc: 0.9183 - val_loss: 0.4351 - val_acc: 0.9128
Epoch 30/30
7352/7352 [==============================] - 112s 15ms/step - loss:
0.3899 - acc: 0.9180 - val_loss: 0.6097 - val_acc: 0.8755
Test accuracy: 0.8754665761791652
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 84s 11ms/step - loss:
1.3698 - acc: 0.4022 - val_loss: 1.1994 - val_acc: 0.4740
Epoch 2/30
```

```
7352/7352 [==============================] - 80s 11ms/step - loss:
1.0903 - acc: 0.5367 - val_loss: 1.1028 - val_acc: 0.5389
Epoch 3/30
7352/7352 [==============================] - 78s 11ms/step - loss:
1.1682 - acc: 0.4849 - val_loss: 1.1305 - val_acc: 0.4893
Epoch 4/30
7352/7352 [==============================] - 80s 11ms/step - loss:
0.7807 - acc: 0.6500 - val_loss: 1.1183 - val_acc: 0.5382
Epoch 5/30
7352/7352 [==============================] - 80s 11ms/step - loss:
0.5578 - acc: 0.7782 - val_loss: 0.6309 - val_acc: 0.7418
Epoch 6/30
7352/7352 [==============================] - 79s 11ms/step - loss:
0.3260 - acc: 0.8810 - val_loss: 0.4220 - val_acc: 0.7560
Epoch 7/30
7352/7352 [==============================] - 80s 11ms/step - loss:
0.2302 - acc: 0.9163 - val_loss: 0.3320 - val_acc: 0.8996
Epoch 8/30
7352/7352 [==============================] - 81s 11ms/step - loss:
0.1998 - acc: 0.9256 - val_loss: 0.2501 - val_acc: 0.9094
Epoch 9/30
7352/7352 [==============================] - 83s 11ms/step - loss:
0.2116 - acc: 0.9255 - val_loss: 0.2443 - val_acc: 0.9080
Epoch 10/30
7352/7352 [==============================] - 81s 11ms/step - loss:
0.1678 - acc: 0.9316 - val_loss: 0.2699 - val_acc: 0.8962
Epoch 11/30
7352/7352 [==============================] - 84s 11ms/step - loss:
0.1552 - acc: 0.9416 - val_loss: 0.3336 - val_acc: 0.8738
Epoch 12/30
7352/7352 [==============================] - 85s 12ms/step - loss:
0.1482 - acc: 0.9463 - val_loss: 0.2744 - val_acc: 0.9152
Epoch 13/30
7352/7352 [==============================] - 82s 11ms/step - loss:
0.1379 - acc: 0.9463 - val_loss: 0.2906 - val_acc: 0.9216
Epoch 14/30
7352/7352 [==============================] - 83s 11ms/step - loss:
0.1436 - acc: 0.9459 - val_loss: 0.2730 - val_acc: 0.9091
Epoch 15/30
7352/7352 [==============================] - 84s 11ms/step - loss:
0.1345 - acc: 0.9487 - val_loss: 0.3552 - val_acc: 0.8863
Epoch 16/30
7352/7352 [==============================] - 84s 11ms/step - loss:
0.1323 - acc: 0.9489 - val_loss: 0.2880 - val_acc: 0.9250
Epoch 17/30
7352/7352 [==============================] - 80s 11ms/step - loss:
0.1275 - acc: 0.9490 - val_loss: 0.3459 - val_acc: 0.9141
Epoch 18/30
7352/7352 [==============================] - 84s 11ms/step - loss:
0.1359 - acc: 0.9472 - val_loss: 0.2172 - val_acc: 0.9257
Epoch 19/30
7352/7352 [==============================] - 87s 12ms/step - loss:
0.1243 - acc: 0.9508 - val_loss: 0.2902 - val_acc: 0.9199
Epoch 20/30
7352/7352 [==============================] - 89s 12ms/step - loss:
0.1297 - acc: 0.9489 - val_loss: 0.3606 - val_acc: 0.9070
Epoch 21/30
7352/7352 [==============================] - 88s 12ms/step - loss:
0.1319 - acc: 0.9487 - val_loss: 0.2641 - val_acc: 0.9220
Epoch 22/30
7352/7352 [==============================] - 87s 12ms/step - loss:
```

```
0.1300 - acc: 0.9494 - val_loss: 0.2310 - val_acc: 0.9206
Epoch 23/30
7352/7352 [==============================] - 87s 12ms/step - loss:
0.1212 - acc: 0.9504 - val_loss: 0.2364 - val_acc: 0.9267
Epoch 24/30
7352/7352 [==============================] - 84s 11ms/step - loss:
0.1228 - acc: 0.9543 - val_loss: 0.2441 - val_acc: 0.9237
Epoch 25/30
7352/7352 [==============================] - 86s 12ms/step - loss:
0.1157 - acc: 0.9540 - val_loss: 0.2284 - val_acc: 0.9260
Epoch 26/30
7352/7352 [==============================] - 86s 12ms/step - loss:
0.1283 - acc: 0.9528 - val_loss: 0.2717 - val_acc: 0.9084
Epoch 27/30
7352/7352 [==============================] - 89s 12ms/step - loss:
0.1192 - acc: 0.9518 - val_loss: 0.2112 - val_acc: 0.9237
Epoch 28/30
7352/7352 [==============================] - 91s 12ms/step - loss:
0.1225 - acc: 0.9489 - val_loss: 0.3002 - val_acc: 0.9182
Epoch 29/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.1260 - acc: 0.9533 - val_loss: 0.2390 - val_acc: 0.9253
Epoch 30/30
7352/7352 [==============================] - 92s 12ms/step - loss:
0.1142 - acc: 0.9544 - val_loss: 0.2432 - val_acc: 0.9359
Test accuracy: 0.9358669833729216
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 49s 7ms/step - loss: 1.
3008 - acc: 0.4169 - val_loss: 1.1901 - val_acc: 0.5199
Epoch 2/30
7352/7352 [==============================] - 47s 6ms/step - loss: 1.
1000 - acc: 0.4893 - val_loss: 1.1207 - val_acc: 0.4954
Epoch 3/30
7352/7352 [==============================] - 46s 6ms/step - loss: 1.
0713 - acc: 0.5245 - val_loss: 1.2818 - val_acc: 0.4992
Epoch 4/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
7811 - acc: 0.6200 - val_loss: 1.4036 - val_acc: 0.4065
Epoch 5/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
7401 - acc: 0.6364 - val_loss: 0.7953 - val_acc: 0.5962
Epoch 6/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
9408 - acc: 0.5734 - val_loss: 1.2124 - val_acc: 0.4418
Epoch 7/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.
8508 - acc: 0.5819 - val_loss: 0.8116 - val_acc: 0.6271
Epoch 8/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
6312 - acc: 0.7148 - val_loss: 0.7411 - val_acc: 0.6960
Epoch 9/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
4257 - acc: 0.8410 - val_loss: 0.3409 - val_acc: 0.8785
Epoch 10/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.
2899 - acc: 0.9004 - val_loss: 0.5336 - val_acc: 0.8246
Epoch 11/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.
2299 - acc: 0.9244 - val_loss: 0.2797 - val_acc: 0.9053
Epoch 12/30
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7352/7352 [==============================] - 46s 6ms/step - loss: 0.
1991 - acc: 0.9317 - val_loss: 0.3102 - val_acc: 0.9016
Epoch 13/30
7352/7352 [==============================] - 47s 6ms/step - loss: 0.
1989 - acc: 0.9329 - val_loss: 0.3650 - val_acc: 0.8795
Epoch 14/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.
1640 - acc: 0.9380 - val_loss: 0.2827 - val_acc: 0.9148
Epoch 15/30
7352/7352 [==============================] - 44s 6ms/step - loss: 0.
1503 - acc: 0.9416 - val_loss: 0.3698 - val_acc: 0.8996
Epoch 16/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.
1704 - acc: 0.9407 - val_loss: 0.2457 - val_acc: 0.9155
Epoch 17/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
1518 - acc: 0.9448 - val_loss: 0.3255 - val_acc: 0.8965
Epoch 18/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
1529 - acc: 0.9453 - val_loss: 0.3203 - val_acc: 0.9152
Epoch 19/30
7352/7352 [==============================] - 47s 6ms/step - loss: 0.
1468 - acc: 0.9474 - val_loss: 0.3206 - val_acc: 0.9121
Epoch 20/30
7352/7352 [==============================] - 47s 6ms/step - loss: 0.
1444 - acc: 0.9478 - val_loss: 0.3120 - val_acc: 0.9138
Epoch 21/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
1360 - acc: 0.9506 - val_loss: 0.2789 - val_acc: 0.9257
Epoch 22/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
1347 - acc: 0.9505 - val_loss: 0.6842 - val_acc: 0.8565
Epoch 23/30
7352/7352 [==============================] - 44s 6ms/step - loss: 0.
1359 - acc: 0.9487 - val_loss: 0.3316 - val_acc: 0.9182
Epoch 24/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.
1272 - acc: 0.9508 - val_loss: 0.3261 - val_acc: 0.9165
Epoch 25/30
7352/7352 [==============================] - 48s 7ms/step - loss: 0.
1271 - acc: 0.9528 - val_loss: 0.2801 - val_acc: 0.9291
Epoch 26/30
7352/7352 [==============================] - 48s 6ms/step - loss: 0.
1254 - acc: 0.9514 - val_loss: 0.2819 - val_acc: 0.9250
Epoch 27/30
7352/7352 [==============================] - 48s 7ms/step - loss: 0.
1200 - acc: 0.9538 - val_loss: 0.4392 - val_acc: 0.9108
Epoch 28/30
7352/7352 [==============================] - 48s 7ms/step - loss: 0.
1357 - acc: 0.9502 - val_loss: 0.3752 - val_acc: 0.9040
Epoch 29/30
7352/7352 [==============================] - 48s 6ms/step - loss: 0.
1215 - acc: 0.9533 - val_loss: 0.3386 - val_acc: 0.9080
Epoch 30/30
7352/7352 [==============================] - 47s 6ms/step - loss: 0.
1141 - acc: 0.9543 - val_loss: 0.3957 - val_acc: 0.9108
Test accuracy: 0.9107567017305734
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 128s 17ms/step - loss:
1.3154 - acc: 0.4287 - val_loss: 1.2448 - val_acc: 0.4645
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Epoch 2/30
7352/7352 [==============================] - 124s 17ms/step - loss:
1.1578 - acc: 0.5001 - val_loss: 0.8977 - val_acc: 0.5660
Epoch 3/30
7352/7352 [==============================] - 124s 17ms/step - loss:
0.8386 - acc: 0.6571 - val_loss: 0.7195 - val_acc: 0.7241
Epoch 4/30
7352/7352 [==============================] - 125s 17ms/step - loss:
0.4539 - acc: 0.8356 - val_loss: 0.3798 - val_acc: 0.8510
Epoch 5/30
7352/7352 [==============================] - 123s 17ms/step - loss:
0.2905 - acc: 0.8900 - val_loss: 0.4832 - val_acc: 0.8358
Epoch 6/30
7352/7352 [==============================] - 126s 17ms/step - loss:
0.2227 - acc: 0.9189 - val_loss: 0.3086 - val_acc: 0.8812
Epoch 7/30
7352/7352 [==============================] - 124s 17ms/step - loss:
0.1950 - acc: 0.9270 - val_loss: 0.3672 - val_acc: 0.9074
Epoch 8/30
7352/7352 [==============================] - 124s 17ms/step - loss:
0.1617 - acc: 0.9397 - val_loss: 0.3705 - val_acc: 0.8982
Epoch 9/30
7352/7352 [==============================] - 123s 17ms/step - loss:
0.1613 - acc: 0.9408 - val_loss: 0.2987 - val_acc: 0.9040
Epoch 10/30
7352/7352 [==============================] - 122s 17ms/step - loss:
0.1562 - acc: 0.9429 - val_loss: 0.5068 - val_acc: 0.8897
Epoch 11/30
7352/7352 [==============================] - 120s 16ms/step - loss:
0.1609 - acc: 0.9418 - val_loss: 0.4135 - val_acc: 0.8958
Epoch 12/30
7352/7352 [==============================] - 119s 16ms/step - loss:
0.2207 - acc: 0.9057 - val_loss: 0.2987 - val_acc: 0.9023
Epoch 13/30
7352/7352 [==============================] - 126s 17ms/step - loss:
0.1466 - acc: 0.9448 - val_loss: 0.3185 - val_acc: 0.9101
Epoch 14/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1486 - acc: 0.9453 - val_loss: 0.3205 - val_acc: 0.9121
Epoch 15/30
7352/7352 [==============================] - 127s 17ms/step - loss:
0.1390 - acc: 0.9483 - val_loss: 0.4126 - val_acc: 0.9131
Epoch 16/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1435 - acc: 0.9444 - val_loss: 0.3551 - val_acc: 0.9233
Epoch 17/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.1420 - acc: 0.9474 - val_loss: 0.4149 - val_acc: 0.8456
Epoch 18/30
7352/7352 [==============================] - 126s 17ms/step - loss:
0.1351 - acc: 0.9468 - val_loss: 0.3911 - val_acc: 0.9182
Epoch 19/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.1609 - acc: 0.9474 - val_loss: 0.4582 - val_acc: 0.9148
Epoch 20/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1320 - acc: 0.9491 - val_loss: 0.3044 - val_acc: 0.9301
Epoch 21/30
7352/7352 [==============================] - 126s 17ms/step - loss:
0.1231 - acc: 0.9523 - val_loss: 0.4043 - val_acc: 0.9141
Epoch 22/30
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7352/7352 [==============================] - 127s 17ms/step - loss:
0.1437 - acc: 0.9474 - val_loss: 0.4021 - val_acc: 0.9169
Epoch 23/30
7352/7352 [==============================] - 127s 17ms/step - loss:
0.1451 - acc: 0.9490 - val_loss: 0.4310 - val_acc: 0.9155
Epoch 24/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1328 - acc: 0.9471 - val_loss: 0.2989 - val_acc: 0.9233
Epoch 25/30
7352/7352 [==============================] - 129s 17ms/step - loss:
0.1450 - acc: 0.9468 - val_loss: 0.4329 - val_acc: 0.9148
Epoch 26/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1401 - acc: 0.9490 - val_loss: 0.3741 - val_acc: 0.9230
Epoch 27/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1402 - acc: 0.9489 - val_loss: 0.3374 - val_acc: 0.9267
Epoch 28/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.1493 - acc: 0.9509 - val_loss: 0.2570 - val_acc: 0.9186
Epoch 29/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.1295 - acc: 0.9517 - val_loss: 0.4193 - val_acc: 0.9158
Epoch 30/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.1539 - acc: 0.9423 - val_loss: 0.4205 - val_acc: 0.9067
Test accuracy: 0.9066847641871749
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 73s 10ms/step - loss:
1.4068 - acc: 0.3814 - val_loss: 1.3328 - val_acc: 0.4404
Epoch 2/30
7352/7352 [==============================] - 69s 9ms/step - loss: 1.
2975 - acc: 0.4369 - val_loss: 1.2833 - val_acc: 0.4299
Epoch 3/30
7352/7352 [==============================] - 69s 9ms/step - loss: 1.
2589 - acc: 0.4236 - val_loss: 1.2551 - val_acc: 0.4591
Epoch 4/30
7352/7352 [==============================] - 70s 9ms/step - loss: 0.
8914 - acc: 0.5939 - val_loss: 0.8661 - val_acc: 0.6071
Epoch 5/30
7352/7352 [==============================] - 70s 10ms/step - loss:
0.8391 - acc: 0.6300 - val_loss: 0.8848 - val_acc: 0.5870
Epoch 6/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.9193 - acc: 0.5832 - val_loss: 1.9246 - val_acc: 0.4116
Epoch 7/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.9039 - acc: 0.6088 - val_loss: 0.9329 - val_acc: 0.5623
Epoch 8/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.7931 - acc: 0.6465 - val_loss: 0.6820 - val_acc: 0.6997
Epoch 9/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.6964 - acc: 0.7054 - val_loss: 0.7448 - val_acc: 0.6905
Epoch 10/30
7352/7352 [==============================] - 72s 10ms/step - loss:
0.5899 - acc: 0.7586 - val_loss: 0.5581 - val_acc: 0.7720
Epoch 11/30
7352/7352 [==============================] - 72s 10ms/step - loss:
0.5426 - acc: 0.8022 - val_loss: 0.4151 - val_acc: 0.8534
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Epoch 12/30
7352/7352 [==============================] - 72s 10ms/step - loss:
0.4032 - acc: 0.8587 - val_loss: 0.7167 - val_acc: 0.7978
Epoch 13/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.4117 - acc: 0.8555 - val_loss: 0.3870 - val_acc: 0.8721
Epoch 14/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.2552 - acc: 0.9095 - val_loss: 0.4325 - val_acc: 0.8609
Epoch 15/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.2443 - acc: 0.9157 - val_loss: 0.4188 - val_acc: 0.8758
Epoch 16/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.2229 - acc: 0.9203 - val_loss: 0.4483 - val_acc: 0.8785
Epoch 17/30
7352/7352 [==============================] - 72s 10ms/step - loss:
0.1976 - acc: 0.9261 - val_loss: 0.5582 - val_acc: 0.8273
Epoch 18/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.1966 - acc: 0.9334 - val_loss: 0.4417 - val_acc: 0.8931
Epoch 19/30
7352/7352 [==============================] - 72s 10ms/step - loss:
0.2038 - acc: 0.9236 - val_loss: 0.3587 - val_acc: 0.8935
Epoch 20/30
7352/7352 [==============================] - 72s 10ms/step - loss:
0.1831 - acc: 0.9325 - val_loss: 1.1522 - val_acc: 0.7978
Epoch 21/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.1763 - acc: 0.9368 - val_loss: 0.5223 - val_acc: 0.8755
Epoch 22/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.1853 - acc: 0.9325 - val_loss: 0.4337 - val_acc: 0.9013
Epoch 23/30
7352/7352 [==============================] - 69s 9ms/step - loss: 0.
1629 - acc: 0.9380 - val_loss: 0.5268 - val_acc: 0.8931
Epoch 24/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.1641 - acc: 0.9436 - val_loss: 0.4764 - val_acc: 0.8870
Epoch 25/30
7352/7352 [==============================] - 72s 10ms/step - loss:
0.1486 - acc: 0.9441 - val_loss: 0.4453 - val_acc: 0.8748
Epoch 26/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.1771 - acc: 0.9416 - val_loss: 0.9084 - val_acc: 0.8191
Epoch 27/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.1483 - acc: 0.9412 - val_loss: 0.4677 - val_acc: 0.8982
Epoch 28/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.1633 - acc: 0.9440 - val_loss: 0.4241 - val_acc: 0.8992
Epoch 29/30
7352/7352 [==============================] - 71s 10ms/step - loss:
0.1317 - acc: 0.9474 - val_loss: 0.3439 - val_acc: 0.9060
Epoch 30/30
7352/7352 [==============================] - 70s 9ms/step - loss: 0.
1461 - acc: 0.9474 - val_loss: 0.4540 - val_acc: 0.8992
Test accuracy: 0.8992195453003053
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 64s 9ms/step - loss: 1.
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3240 - acc: 0.4343 - val_loss: 1.2227 - val_acc: 0.4785
Epoch 2/30
7352/7352 [==============================] - 62s 8ms/step - loss: 1.
0488 - acc: 0.5567 - val_loss: 0.9246 - val_acc: 0.5819
Epoch 3/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
8679 - acc: 0.6364 - val_loss: 0.8721 - val_acc: 0.6305
Epoch 4/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
7630 - acc: 0.6798 - val_loss: 0.8584 - val_acc: 0.6620
Epoch 5/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
7343 - acc: 0.7081 - val_loss: 0.7365 - val_acc: 0.6820
Epoch 6/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
6541 - acc: 0.7661 - val_loss: 0.7389 - val_acc: 0.7659
Epoch 7/30
7352/7352 [==============================] - 62s 8ms/step - loss: 0.
5313 - acc: 0.8207 - val_loss: 0.4731 - val_acc: 0.8476
Epoch 8/30
7352/7352 [==============================] - 59s 8ms/step - loss: 0.
4648 - acc: 0.8526 - val_loss: 0.4400 - val_acc: 0.8378
Epoch 9/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
4244 - acc: 0.8834 - val_loss: 0.5648 - val_acc: 0.8419
Epoch 10/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
3312 - acc: 0.9014 - val_loss: 0.4692 - val_acc: 0.8585
Epoch 11/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
3012 - acc: 0.9078 - val_loss: 0.3977 - val_acc: 0.8734
Epoch 12/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
3310 - acc: 0.9110 - val_loss: 0.3563 - val_acc: 0.8860
Epoch 13/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2860 - acc: 0.9131 - val_loss: 0.4326 - val_acc: 0.8809
Epoch 14/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2892 - acc: 0.9184 - val_loss: 0.3172 - val_acc: 0.8948
Epoch 15/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2535 - acc: 0.9202 - val_loss: 0.4036 - val_acc: 0.8999
Epoch 16/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2573 - acc: 0.9227 - val_loss: 0.4764 - val_acc: 0.8755
Epoch 17/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2453 - acc: 0.9287 - val_loss: 0.6415 - val_acc: 0.8863
Epoch 18/30
7352/7352 [==============================] - 60s 8ms/step - loss: 0.
2532 - acc: 0.9217 - val_loss: 0.3521 - val_acc: 0.8897
Epoch 19/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2057 - acc: 0.9368 - val_loss: 0.3870 - val_acc: 0.8707
Epoch 20/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2082 - acc: 0.9332 - val_loss: 0.3583 - val_acc: 0.9108
Epoch 21/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2115 - acc: 0.9338 - val_loss: 0.7571 - val_acc: 0.8782
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Epoch 22/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
1892 - acc: 0.9314 - val_loss: 0.5819 - val_acc: 0.8870
Epoch 23/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2053 - acc: 0.9347 - val_loss: 0.4435 - val_acc: 0.9121
Epoch 24/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2181 - acc: 0.9350 - val_loss: 0.4340 - val_acc: 0.9118
Epoch 25/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2229 - acc: 0.9362 - val_loss: 0.3305 - val_acc: 0.9101
Epoch 26/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2008 - acc: 0.9408 - val_loss: 0.4580 - val_acc: 0.8955
Epoch 27/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2664 - acc: 0.9319 - val_loss: 0.6328 - val_acc: 0.8992
Epoch 28/30
7352/7352 [==============================] - 62s 8ms/step - loss: 0.
2243 - acc: 0.9397 - val_loss: 0.8507 - val_acc: 0.8714
Epoch 29/30
7352/7352 [==============================] - 61s 8ms/step - loss: 0.
2212 - acc: 0.9363 - val_loss: 0.3582 - val_acc: 0.9111
Epoch 30/30
7352/7352 [==============================] - 60s 8ms/step - loss: 0.
1751 - acc: 0.9430 - val_loss: 0.4272 - val_acc: 0.9019
Test accuracy: 0.9019341703427214
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 36s 5ms/step - loss: 1.
3341 - acc: 0.4143 - val_loss: 1.3362 - val_acc: 0.3570
Epoch 2/30
7352/7352 [==============================] - 33s 5ms/step - loss: 1.
2000 - acc: 0.4474 - val_loss: 1.3525 - val_acc: 0.3760
Epoch 3/30
7352/7352 [==============================] - 34s 5ms/step - loss: 1.
1536 - acc: 0.4755 - val_loss: 0.9473 - val_acc: 0.6020
Epoch 4/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
9045 - acc: 0.5871 - val_loss: 0.8491 - val_acc: 0.6003
Epoch 5/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
7889 - acc: 0.6518 - val_loss: 0.7489 - val_acc: 0.6549
Epoch 6/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.
7957 - acc: 0.6654 - val_loss: 0.7173 - val_acc: 0.7180
Epoch 7/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.
5563 - acc: 0.7905 - val_loss: 0.5978 - val_acc: 0.7638
Epoch 8/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.
4408 - acc: 0.8439 - val_loss: 0.4464 - val_acc: 0.8371
Epoch 9/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
3431 - acc: 0.8787 - val_loss: 0.3729 - val_acc: 0.8666
Epoch 10/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
2753 - acc: 0.9041 - val_loss: 0.4682 - val_acc: 0.8205
Epoch 11/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
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2191 - acc: 0.9196 - val_loss: 0.4380 - val_acc: 0.8663
Epoch 12/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
2124 - acc: 0.9196 - val_loss: 0.3059 - val_acc: 0.8941
Epoch 13/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1865 - acc: 0.9283 - val_loss: 0.2709 - val_acc: 0.9016
Epoch 14/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
2055 - acc: 0.9279 - val_loss: 0.2660 - val_acc: 0.8951
Epoch 15/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1726 - acc: 0.9306 - val_loss: 0.2695 - val_acc: 0.9067
Epoch 16/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1609 - acc: 0.9399 - val_loss: 0.2304 - val_acc: 0.9074
Epoch 17/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
2322 - acc: 0.9316 - val_loss: 0.2630 - val_acc: 0.9040
Epoch 18/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.
1574 - acc: 0.9406 - val_loss: 0.2288 - val_acc: 0.9135
Epoch 19/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.
1749 - acc: 0.9388 - val_loss: 0.2646 - val_acc: 0.8968
Epoch 20/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.
1546 - acc: 0.9358 - val_loss: 0.2586 - val_acc: 0.9108
Epoch 21/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.
1505 - acc: 0.9421 - val_loss: 0.2522 - val_acc: 0.8951
Epoch 22/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.
1414 - acc: 0.9433 - val_loss: 0.2839 - val_acc: 0.9050
Epoch 23/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1401 - acc: 0.9444 - val_loss: 0.2427 - val_acc: 0.9067
Epoch 24/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.
1264 - acc: 0.9499 - val_loss: 0.3614 - val_acc: 0.8951
Epoch 25/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1226 - acc: 0.9499 - val_loss: 0.3367 - val_acc: 0.8996
Epoch 26/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1355 - acc: 0.9490 - val_loss: 0.2775 - val_acc: 0.9084
Epoch 27/30
7352/7352 [==============================] - 33s 4ms/step - loss: 0.
1266 - acc: 0.9513 - val_loss: 0.2273 - val_acc: 0.9209
Epoch 28/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.
1250 - acc: 0.9504 - val_loss: 0.2206 - val_acc: 0.9328
Epoch 29/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1257 - acc: 0.9470 - val_loss: 0.2694 - val_acc: 0.9206
Epoch 30/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1226 - acc: 0.9487 - val_loss: 0.2492 - val_acc: 0.9213
Test accuracy: 0.9212758737699356
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
```

```
7352/7352 [==============================] - 133s 18ms/step - loss:
1.4584 - acc: 0.3760 - val_loss: 1.4380 - val_acc: 0.3990
Epoch 2/30
7352/7352 [==============================] - 126s 17ms/step - loss:
1.1045 - acc: 0.5184 - val_loss: 0.8487 - val_acc: 0.6237
Epoch 3/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.9701 - acc: 0.5918 - val_loss: 0.7451 - val_acc: 0.6759
Epoch 4/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.6769 - acc: 0.7251 - val_loss: 0.6333 - val_acc: 0.7492
Epoch 5/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.4460 - acc: 0.8473 - val_loss: 0.3466 - val_acc: 0.8700
Epoch 6/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.3325 - acc: 0.8965 - val_loss: 1.6093 - val_acc: 0.6888
Epoch 7/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.2486 - acc: 0.9157 - val_loss: 0.3690 - val_acc: 0.8975
Epoch 8/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.2108 - acc: 0.9260 - val_loss: 0.2507 - val_acc: 0.9145
Epoch 9/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.1831 - acc: 0.9358 - val_loss: 0.2937 - val_acc: 0.9145
Epoch 10/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.1855 - acc: 0.9335 - val_loss: 0.2236 - val_acc: 0.9172
Epoch 11/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.1729 - acc: 0.9362 - val_loss: 0.3270 - val_acc: 0.9033
Epoch 12/30
7352/7352 [==============================] - 131s 18ms/step - loss:
0.1939 - acc: 0.9384 - val_loss: 0.3628 - val_acc: 0.8914
Epoch 13/30
7352/7352 [==============================] - 131s 18ms/step - loss:
0.1650 - acc: 0.9425 - val_loss: 0.2515 - val_acc: 0.9196
Epoch 14/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.1612 - acc: 0.9441 - val_loss: 0.2220 - val_acc: 0.9226
Epoch 15/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.1473 - acc: 0.9455 - val_loss: 0.2666 - val_acc: 0.9209
Epoch 16/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1552 - acc: 0.9422 - val_loss: 0.2500 - val_acc: 0.9043
Epoch 17/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.1641 - acc: 0.9404 - val_loss: 0.4475 - val_acc: 0.9182
Epoch 18/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.1610 - acc: 0.9453 - val_loss: 0.4994 - val_acc: 0.8636
Epoch 19/30
7352/7352 [==============================] - 129s 18ms/step - loss:
0.1530 - acc: 0.9465 - val_loss: 0.3641 - val_acc: 0.9101
Epoch 20/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.1390 - acc: 0.9464 - val_loss: 0.2430 - val_acc: 0.9291
Epoch 21/30
7352/7352 [==============================] - 130s 18ms/step - loss:
```

```
0.1493 - acc: 0.9478 - val_loss: 0.3947 - val_acc: 0.9067
Epoch 22/30
7352/7352 [==============================] - 130s 18ms/step - loss:
0.1491 - acc: 0.9446 - val_loss: 0.3425 - val_acc: 0.9128
Epoch 23/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1735 - acc: 0.9418 - val_loss: 0.3824 - val_acc: 0.9063
Epoch 24/30
7352/7352 [==============================] - 125s 17ms/step - loss:
0.1471 - acc: 0.9489 - val_loss: 0.2361 - val_acc: 0.9243
Epoch 25/30
7352/7352 [==============================] - 125s 17ms/step - loss:
0.1464 - acc: 0.9445 - val_loss: 0.4671 - val_acc: 0.9080
Epoch 26/30
7352/7352 [==============================] - 125s 17ms/step - loss:
0.1644 - acc: 0.9442 - val_loss: 0.6430 - val_acc: 0.8955
Epoch 27/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1412 - acc: 0.9467 - val_loss: 0.2782 - val_acc: 0.9399
Epoch 28/30
7352/7352 [==============================] - 127s 17ms/step - loss:
0.1347 - acc: 0.9499 - val_loss: 0.4034 - val_acc: 0.9087
Epoch 29/30
7352/7352 [==============================] - 127s 17ms/step - loss:
0.1309 - acc: 0.9510 - val_loss: 0.3121 - val_acc: 0.9091
Epoch 30/30
7352/7352 [==============================] - 128s 17ms/step - loss:
0.1410 - acc: 0.9483 - val_loss: 0.2925 - val_acc: 0.9294
Test accuracy: 0.9294197488971836
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 37s 5ms/step - loss: 1.
2342 - acc: 0.4706 - val_loss: 1.3749 - val_acc: 0.4316
Epoch 2/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
8904 - acc: 0.5949 - val_loss: 0.8673 - val_acc: 0.5640
Epoch 3/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
8502 - acc: 0.6265 - val_loss: 0.9527 - val_acc: 0.6159
Epoch 4/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
6851 - acc: 0.7223 - val_loss: 0.8160 - val_acc: 0.6542
Epoch 5/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
5706 - acc: 0.7654 - val_loss: 0.5959 - val_acc: 0.7628
Epoch 6/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
4837 - acc: 0.8154 - val_loss: 0.4920 - val_acc: 0.8351
Epoch 7/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
4048 - acc: 0.8575 - val_loss: 0.5652 - val_acc: 0.8018
Epoch 8/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
2959 - acc: 0.8996 - val_loss: 0.4047 - val_acc: 0.8741
Epoch 9/30
7352/7352 [==============================] - 33s 5ms/step - loss: 0.
2485 - acc: 0.9131 - val_loss: 0.4794 - val_acc: 0.8649
Epoch 10/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
2406 - acc: 0.9174 - val_loss: 0.3802 - val_acc: 0.8541
Epoch 11/30
```

```
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1973 - acc: 0.9289 - val_loss: 0.3074 - val_acc: 0.8985
Epoch 12/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1830 - acc: 0.9347 - val_loss: 0.3364 - val_acc: 0.8982
Epoch 13/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1681 - acc: 0.9376 - val_loss: 0.2768 - val_acc: 0.9091
Epoch 14/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1654 - acc: 0.9408 - val_loss: 0.2903 - val_acc: 0.9067
Epoch 15/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1532 - acc: 0.9387 - val_loss: 0.2796 - val_acc: 0.9030
Epoch 16/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.
1544 - acc: 0.9436 - val_loss: 0.2680 - val_acc: 0.9186
Epoch 17/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.
1497 - acc: 0.9441 - val_loss: 0.2810 - val_acc: 0.9148
Epoch 18/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.
1412 - acc: 0.9478 - val_loss: 0.2536 - val_acc: 0.9138
Epoch 19/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.
1385 - acc: 0.9497 - val_loss: 0.2782 - val_acc: 0.9189
Epoch 20/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.
1388 - acc: 0.9499 - val_loss: 0.2757 - val_acc: 0.9138
Epoch 21/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1381 - acc: 0.9482 - val_loss: 0.2572 - val_acc: 0.9084
Epoch 22/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1376 - acc: 0.9489 - val_loss: 0.3220 - val_acc: 0.9070
Epoch 23/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.
1259 - acc: 0.9484 - val_loss: 0.3722 - val_acc: 0.9104
Epoch 24/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.
1350 - acc: 0.9505 - val_loss: 0.2632 - val_acc: 0.9138
Epoch 25/30
7352/7352 [==============================] - 35s 5ms/step - loss: 0.
1262 - acc: 0.9509 - val_loss: 0.3359 - val_acc: 0.9084
Epoch 26/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1389 - acc: 0.9479 - val_loss: 0.2769 - val_acc: 0.9114
Epoch 27/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1261 - acc: 0.9533 - val_loss: 0.3538 - val_acc: 0.9033
Epoch 28/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1248 - acc: 0.9513 - val_loss: 0.3200 - val_acc: 0.9036
Epoch 29/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1295 - acc: 0.9494 - val_loss: 0.3320 - val_acc: 0.9158
Epoch 30/30
7352/7352 [==============================] - 34s 5ms/step - loss: 0.
1235 - acc: 0.9517 - val_loss: 0.3404 - val_acc: 0.9050
Test accuracy: 0.9049881235154394
```

In [14]:

```
X_train, Y_train, X_test, Y_test = load_data()
print("Evalutation of best performing model:")
print(best_model.evaluate(X_test, Y_test))
print("Best performing model chosen hyper-parameters:")
print(best_run)
```

```
Evalutation of best performing model:
2947/2947 [==============================] - 8s 3ms/step
[0.24316548304311456, 0.9358669833729216]
Best performing model chosen hyper-parameters:
{'LSTM': 2, 'Dropout': 0.288662535902546, 'batch_size': 1}
```

In [16]:

```
model = Sequential()
# Configuring the parameters
model.add(LSTM(256, input_shape=(128, 9)))
# Adding a dropout layer
model.add(Dropout(0.288662535902546))
# Adding a dense output layer with sigmoid activation
model.add(Dense(6, activation='sigmoid'))
# Compiling the model
model.compile(loss='categorical_crossentropy',
          optimizer='rmsprop',
          metrics=['accuracy'])
# Training the model
history = model.fit(X_train,
        Y_train,
        batch_size=32,
        validation_data=(X_test, Y_test),
        epochs=30)
score, acc = model.evaluate(X_test, Y_test, verbose=0)
print('Test accuracy:', acc)
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 96s 13ms/step - loss:
1.3417 - acc: 0.4068 - val_loss: 1.1853 - val_acc: 0.5243
Epoch 2/30
7352/7352 [==============================] - 93s 13ms/step - loss:
1.1744 - acc: 0.4770 - val_loss: 1.1168 - val_acc: 0.4700
Epoch 3/30
7352/7352 [==============================] - 92s 13ms/step - loss:
1.0587 - acc: 0.5163 - val_loss: 0.9571 - val_acc: 0.5222
Epoch 4/30
7352/7352 [==============================] - 92s 12ms/step - loss:
0.7292 - acc: 0.6752 - val_loss: 0.9916 - val_acc: 0.5996
Epoch 5/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.6078 - acc: 0.7599 - val_loss: 0.5368 - val_acc: 0.7767
Epoch 6/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.4263 - acc: 0.8441 - val_loss: 0.3994 - val_acc: 0.8656
Epoch 7/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.2956 - acc: 0.8993 - val_loss: 0.2945 - val_acc: 0.8907
Epoch 8/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.2548 - acc: 0.9075 - val_loss: 0.3646 - val_acc: 0.8816
Epoch 9/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.2054 - acc: 0.9255 - val_loss: 0.3065 - val_acc: 0.8873
Epoch 10/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.1790 - acc: 0.9331 - val_loss: 0.3470 - val_acc: 0.8958
Epoch 11/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.1700 - acc: 0.9378 - val_loss: 0.3698 - val_acc: 0.8870
Epoch 12/30
7352/7352 [==============================] - 92s 12ms/step - loss:
0.1709 - acc: 0.9336 - val_loss: 0.4295 - val_acc: 0.8901
Epoch 13/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.1510 - acc: 0.9427 - val_loss: 0.3111 - val_acc: 0.9111
Epoch 14/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.1611 - acc: 0.9426 - val_loss: 0.2664 - val_acc: 0.9084
Epoch 15/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.1426 - acc: 0.9480 - val_loss: 0.3880 - val_acc: 0.8941
Epoch 16/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.1254 - acc: 0.9517 - val_loss: 0.4313 - val_acc: 0.8955
Epoch 17/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.1490 - acc: 0.9419 - val_loss: 0.4394 - val_acc: 0.8992
Epoch 18/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.1238 - acc: 0.9494 - val_loss: 0.5041 - val_acc: 0.8968
Epoch 19/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.1294 - acc: 0.9508 - val_loss: 0.3452 - val_acc: 0.9094
Epoch 20/30
7352/7352 [==============================] - 93s 13ms/step - loss:
0.1301 - acc: 0.9489 - val_loss: 0.3721 - val_acc: 0.9060
```

```
Epoch 21/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.1280 - acc: 0.9495 - val_loss: 0.2238 - val_acc: 0.9304
Epoch 22/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.1261 - acc: 0.9491 - val_loss: 0.3413 - val_acc: 0.9135
Epoch 23/30
7352/7352 [==============================] - 91s 12ms/step - loss:
0.1283 - acc: 0.9501 - val_loss: 0.2854 - val_acc: 0.9108
Epoch 24/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.1196 - acc: 0.9533 - val_loss: 0.3144 - val_acc: 0.9114
Epoch 25/30
7352/7352 [==============================] - 92s 12ms/step - loss:
0.1156 - acc: 0.9529 - val_loss: 0.2865 - val_acc: 0.9111
Epoch 26/30
7352/7352 [==============================] - 92s 12ms/step - loss:
0.1294 - acc: 0.9517 - val_loss: 0.2388 - val_acc: 0.9186
Epoch 27/30
7352/7352 [==============================] - 91s 12ms/step - loss:
0.1226 - acc: 0.9509 - val_loss: 0.2108 - val_acc: 0.9213
Epoch 28/30
7352/7352 [==============================] - 92s 13ms/step - loss:
0.1196 - acc: 0.9536 - val_loss: 0.3917 - val_acc: 0.9060
Epoch 29/30
7352/7352 [==============================] - 92s 12ms/step - loss:
0.1198 - acc: 0.9531 - val_loss: 0.3241 - val_acc: 0.9094
Epoch 30/30
7352/7352 [==============================] - 91s 12ms/step - loss:
0.1189 - acc: 0.9524 - val_loss: 0.2353 - val_acc: 0.9260
Test accuracy: 0.9260264675941635
```

In [22]:

```
import matplotlib.pyplot as plt
```

In [26]:

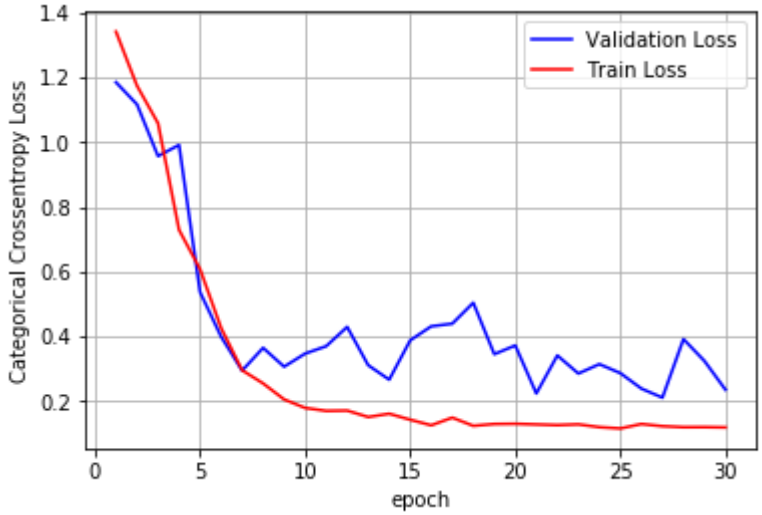
```
def plt_dynamic(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation Loss")
    ax.plot(x, ty, 'r', label="Train Loss")
    plt.legend()
    plt.grid()
    fig.canvas.draw()
```

In [27]:

```
fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Categorical Crossentropy Loss')

# list of epoch numbers
x = list(range(1,31))


vy = history.history['val_loss']
ty = history.history['loss']
plt_dynamic(x, vy, ty, ax)
```



Steps

1. Hyperas is used for hyperparmater tuning.
2. Number of Epoch =30
3. model() function contains the model for hyperparameter tuning.
4. load_data() is used for loading the data.
5. for LSTM I used values 64, 128, 256
6. for Dropouts , I take value from uniform distribution of 0 and 1 and apply on each model
7. for batch size , I used values 16,32,64
8. After hyperparameter tuning, I got no of LSTM-256,0.288662535902546-dropout rate, 32-batch size as the best values.
9. With these values, I train the model and got the test accuracy of 92.6%
10. Train and validaton loss is also plotted for the best model.

Summary

LSTM	Dropout	Batch size	Accuracy
256	0.29	32	92.6

In [ ]:

```
```