In [ ]:

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# This ipython notebook shows how to train a GRU-based RNN classifier on IMDB dataset
# using global pre-trained word vectors and achieve 92.075% test accuracy
```

In [ ]:

```
# Titan X Pascal (Driver Version: 375.26)
# Keras Version: 1.2.2
# Theano Version: 0.9.0rc1 (cuda backend)
```

In [ ]:

```
"""
TO GET DATA EXECUTE THE FOLLOWING SHELL SCRIPT
# this script is based on https://github.com/mesnilgr/iclr15/blob/master/scripts/data.sh

wget http://ai.stanford.edu/~amaas/data/sentiment/aclImdb_v1.tar.gz
tar -xvf aclImdb_v1.tar.gz

for j in train/pos train/neg test/pos test/neg train/unsup; do
  for i in `ls aclImdb/$j`; do cat aclImdb/$j/$i >> temp; awk 'BEGIN{print;}' >> temp; done
  mv temp aclImdb/$j/norm.txt
done

mkdir data
mv aclImdb/train/pos/norm.txt data/full-train-pos.txt
mv aclImdb/train/neg/norm.txt data/full-train-neg.txt
mv aclImdb/test/pos/norm.txt data/test-pos.txt
mv aclImdb/test/neg/norm.txt data/test-neg.txt

cd data
head -n 10000 full-train-pos.txt > small-train-pos.txt
head -n 10000 full-train-neg.txt > small-train-neg.txt
tail -n 2500 full-train-pos.txt > valid-pos.txt
tail -n 2500 full-train-neg.txt > valid-neg.txt
cd ..

rm -r aclImdb
rm aclImdb_v1.tar.gz
"""
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In [ ]:

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In [1]:

```
%matplotlib inline
import matplotlib.pyplot as plt

import os
os.environ["THEANO_FLAGS"] = "mode=FAST_RUN,device=gpu0,floatX=float32"

import numpy as np
np.random.seed(2525)  # for reproducibility

import re
import time
from gensim.models import Word2Vec

from keras.models import Sequential
from keras.layers.core import Dense, Dropout, Activation
from keras.layers.embeddings import Embedding
from keras.layers.recurrent import GRU
from keras.utils.generic_utils import Progbar

from sklearn.metrics import precision_recall_fscore_support as score
```

```
Using Theano backend.
WARNING (theano.sandbox.cuda): The cuda backend is deprecated and will be removed in the next release (v0.10).  Pleas
e switch to the gpuarray backend. You can get more information about how to switch at this URL:
 https://github.com/Theano/Theano/wiki/Converting-to-the-new-gpu-back-end%28gpuarray%29

Using gpu device 0: TITAN X (Pascal) (CNMeM is enabled with initial size: 95.0% of memory, cuDNN 5005)
```

In [2]:

```
# ********************************************************************************************************************
# ************** 1. LOADING WORD VECTORS AND PREPARING EMBEDDING MATRIX ************************************************
# ********************************************************************************************************************
starttime = time.time()
# to get GoogleNews vectors visit this page https://code.google.com/archive/p/word2vec/
w2vmodel = Word2Vec.load_word2vec_format("../vectors/GoogleNews-vectors-negative300.bin", binary=True)
embedding_matrix = w2vmodel.syn0
# adding padding vector
embedding_matrix = np.insert(embedding_matrix, 0, np.zeros(300), axis=0) # pad index = 0
# adding unknown vector as averaged sum of 100 most rear word vectors based on from word2vec vocad
unk_vec = w2vmodel.syn0[-100:].sum(axis=0)/100
embedding_matrix = np.insert(embedding_matrix, 1, unk_vec, axis=0)  # unk index = 1
print("embedding_matrix: "+str(embedding_matrix.shape)+" "+str(embedding_matrix.dtype))

print ("Took %ds" % (time.time() - starttime))
```

```
embedding_matrix: (3000002, 300) float32
Took 26s
```

In [3]:

```
# ********************************************************************************************************************
# ************** 2. LOADING AND PREPROCESSING DATA *********************************************************************
# ********************************************************************************************************************
starttime = time.time()

maxlen = 500 #max num of words in sample

def preproc(line):
    # 1. removing stopwords
    line = " ".join([word for word in line.split(" ") if word.lower() not in ["a","to","of","and"]])
    # 2. removing HTML tags
    line = re.sub(r'<[^>]+>', ' ', line)
    # 3. removing URLs
    line = re.sub(r'(https?:\/\/(?:www\.|(?!www))[^\s\.]+\.[^\s]{2,}|www\.[^\s]+\.[^\s]{2,})', ' ', line)
    # 4. removing all non-alphabetic/numerical chars except \s and -
    line = re.sub(r'[^a-zA-Z0-9-\s]', ' ', line)
    # 5. replacing numbers with #
    line = re.sub(r'\d', '#', line)
    # 6. converting words into word ids
    def word2id(word):
        try: return w2vmodel.vocab[word].index+2;
        except: return 1 # unkown word id
    line = [word2id(word) for word in line.split()[-maxlen:]]
    # 7. adding pad vector (pad word id = 0)
    line += [0]*(maxlen-len(line))

    return line

def load_imdb(filename):
    x,y = [],[]
    # loading negative and positive samples
    for yi,fnsuffix in enumerate(["-neg.txt","-pos.txt"]):
        with open("data/"+filename+fnsuffix, "r") as txtfile:
            for line in txtfile:
                x.append(preproc(line))
                y.append(yi)

    return np.array(x,dtype="int32"),np.array(y,dtype="int32")

#x_train,y_train = load_imdb("small-train")
#x_val,y_val = load_imdb("valid")
x_train,y_train = load_imdb("full-train")
x_test,y_test   = load_imdb("test")
print("x_train:"+str(x_train.shape))
print("x_test:"+str(x_test.shape))

print ("Took %ds" % (time.time() - starttime))
```

```
x_train:(25000, 500)
x_test:(25000, 500)
Took 103s
```

In [4]:

```
# ********************************************************************************************************************
# ************** 3. BUILDING RNN ***************************************************************************************
# ********************************************************************************************************************
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```
starttime = time.time()

model = Sequential()
model.add(Embedding(embedding_matrix.shape[0],
                    embedding_matrix.shape[1],
                    weights=[embedding_matrix],
                    input_length=maxlen,
                    trainable=False,
                    mask_zero=True,
                    dropout=0.2))
model.add(GRU(output_dim=64,name="layer01",return_sequences=True,dropout_W=0.22,dropout_U=0.22))
model.add(GRU(output_dim=64,name="layer02",return_sequences=True,dropout_W=0.22,dropout_U=0.22))
model.add(GRU(output_dim=64,name="layer03",return_sequences=True,dropout_W=0.22,dropout_U=0.22))
model.add(GRU(output_dim=64,name="layer04",return_sequences=True,dropout_W=0.22,dropout_U=0.22))
model.add(GRU(output_dim=64,name="layer05",return_sequences=False,dropout_W=0.22,dropout_U=0.22))
model.add(Dense(output_dim=1,name="layer06",activation="sigmoid"))
#model.load_weights("imdb_rnnw2v_140epoch",by_name=True)
model.compile(loss="binary_crossentropy", optimizer="adam",metrics=['accuracy'])
model.summary()

print ("Took %ds" % (time.time() - starttime))
```

```
____________________________________________________________________________________________________
Layer (type)                     Output Shape          Param #     Connected to
====================================================================================================
embedding_1 (Embedding)          (None, 500, 300)      900000600   embedding_input_1[0][0]
____________________________________________________________________________________________________
layer01 (GRU)                    (None, 500, 64)       70080       embedding_1[0][0]
____________________________________________________________________________________________________
layer02 (GRU)                    (None, 500, 64)       24768       layer01[0][0]
____________________________________________________________________________________________________
layer03 (GRU)                    (None, 500, 64)       24768       layer02[0][0]
____________________________________________________________________________________________________
layer04 (GRU)                    (None, 500, 64)       24768       layer03[0][0]
____________________________________________________________________________________________________
layer05 (GRU)                    (None, 64)            24768       layer04[0][0]
____________________________________________________________________________________________________
layer06 (Dense)                  (None, 1)             65          layer05[0][0]
====================================================================================================
Total params: 900,169,817
Trainable params: 169,217
Non-trainable params: 900,000,600
____________________________________________________________________________________________________
Took 12s
```

In [5]:

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# to free memory before training
del embedding_matrix
del w2vmodel
```

In [6]:

```
# ********************************************************************************************************************
# ************** 4. FINAL TRAINING ***********************************************************************************
# ********************************************************************************************************************
starttime = time.time()

def train(x_train,y_train,x_val=np.array([]),y_val=np.array([]),
          nb_epoch=100,save=True,plotMetrics=True):

    history = {"loss":[],"acc":[],"val_loss":[],"val_acc":[]}

    x_slice_size = 500 # batch_size
    nb_batch = len(x_train)/x_slice_size+(0 if len(x_train)%x_slice_size == 0 else 1)

    print('Train on %d samples, validate on %d samples' % (x_train.shape[0], x_val.shape[0]))

    for epoch in range(nb_epoch):

        print("Epoch "+str(epoch+1)+"/"+str(nb_epoch))
        pbar = Progbar(len(x_train))

        shuffledIndices = np.arange(len(x_train))
        np.random.shuffle(shuffledIndices)
        x_train = np.array([x_train[i] for i in shuffledIndices])
        y_train = np.array([y_train[i] for i in shuffledIndices])

        for batch in range(nb_batch):
```

```
        for batch in range(nb_batch):
            start = batch*x_slice_size
            stop  = batch*x_slice_size+x_slice_size
            train = model.train_on_batch(x_train[start:stop], y_train[start:stop])
            pbar.update(stop,[("loss",train[0]),("acc",train[1])], force=True)

        history["loss"].append(pbar.sum_values["loss"][0]/float(pbar.sum_values["loss"][1]))
        history["acc"].append(pbar.sum_values["acc"][0]/float(pbar.sum_values["acc"][1]))

        if len(x_val):
            val = model.evaluate(x_val, y_val, verbose=1,batch_size=1000)
            history["val_loss"].append(val[0])
            history["val_acc"].append(val[1])
            print("validation: " + str(val))

    name = "imdb_rnnw2v_"+str(nb_epoch)+"epoch"

    if save:
        tmpmodel = Sequential()
        for layer in model.layers[1:]:
            tmpmodel.add(layer)
        tmpmodel.save_weights(name,overwrite=False)
        print("Saved as "+name)

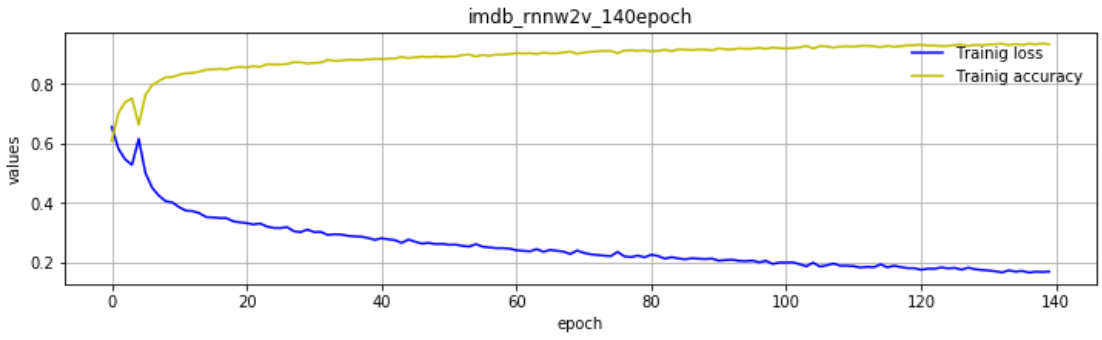
    if plotMetrics:
        plt.figure(figsize=(12, 3))
        plt.plot(history['loss'],"b",label='Trainig loss')
        plt.plot(history['acc'],"y",label='Trainig accuracy')
        if len(x_val):
            plt.plot(history['val_loss'],"g",label='Validation loss')
            plt.plot(history['val_acc'],"r",label='Validation accuracy')
        plt.ylabel('values')
        plt.xlabel('epoch')
        plt.title(name)
        plt.grid(True)
        leg = plt.legend(loc=1,fancybox=True)
        leg.get_frame().set_alpha(0.0)
        plt.show()

    print("Done!")

train(x_train,y_train,nb_epoch=140)

print ("Took %ds" % (time.time() - starttime))
```

```
Train on 25000 samples, validate on 0 samples
Epoch 1/140
25000/25000 [==============================] - 146s - loss: 0.6555 - acc: 0.6088
...
Epoch 140/140
25000/25000 [==============================] - 113s - loss: 0.1696 - acc: 0.9335
Saved as imdb_rnnw2v_140epoch
```




```
Done!
Took 15964s
```

In [7]:

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# ********************************************************************************************************************************
# ************** 5. EVALUATION ***************************************************************************************************
# ********************************************************************************************************************************
print(model.evaluate(x_test,y_test,batch_size=1000))

# F1 score
predictions = model.predict(x_test,batch_size=1000, verbose=1)
p = (predictions[:,0]>=0.5).astype(int)
precision, recall, fscore, support = score(y_test, p)
precision = np.around(precision*100,decimals=2)
```

```
recall = np.around(recall*100,decimals=2)
fscore = np.around(fscore*100,decimals=2)
print("labels    :[ neg    pos]")
print("precision :"+str(precision))
print("recall    :"+str(recall))
print("fscore    :"+str(fscore))
print("-"*25)
print("fscore.mean: "+str(fscore.mean()))
print("test distribution :"+str(support))
```

```
25000/25000 [==============================] - 15s
[0.20878124713897706, 0.92075999736785885]
25000/25000 [==============================] - 15s
labels    :[ neg    pos]
precision :[ 92.11  92.04]
recall    :[ 92.03  92.12]
fscore    :[ 92.07  92.08]
-------------------------
fscore.mean: 92.075
test distribution :[12500 12500]
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In [7]:

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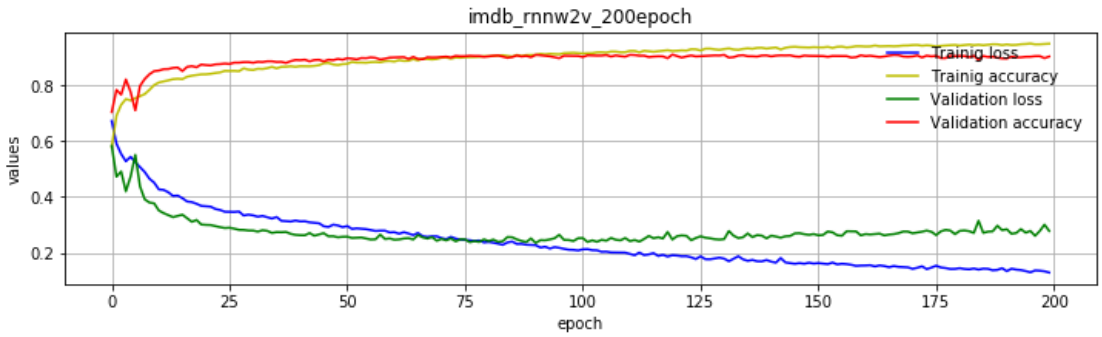
# if you want to tune parameters yourself use "small-train" and "valid" datasets
# to avoid testset overfitting
# x_train,y_train = load_imdb("small-train")
# x_val,y_val = load_imdb("valid")

starttime = time.time()

train(x_train,y_train,x_val,y_val,nb_epoch=200)

print ("Took %ds" % (time.time() - starttime))
```

```
Train on 20000 samples, validate on 5000 samples
Epoch 1/200
20000/20000 [==============================] - 124s - loss: 0.6721 - acc: 0.5798
5000/5000 [==============================] - 3s
validation: [0.58315455913543701, 0.70420000553131101]
...
Epoch 200/200
20000/20000 [==============================] - 92s - loss: 0.1292 - acc: 0.9490
5000/5000 [==============================] - 3s
validation: [0.27798883616924286, 0.90319999456405642]
Saved as imdb_rnnw2v_200epoch
```




```
Done!
Took 19260s
```

In [ ]:

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