Sentiment_Analysis-binary-classification-BRNN-CuDNNGRU-Batchnormalization-AttentionLayer

January 25, 2020

1 Sentiment Analysis with an RNN

Run in Google Colab

View source on GitHub

http://www.polyvista.com/blog/wp-content/uploads/2015/06/sentiment-customer-exp-large.png

1.1 What is Sentiment Analysis?

Sentiment Analysis also know as opinion mining refers to the identification, extraction and study of sentiment states by using natural language processing, text analysis, computational linguistics and biometrics.

1.2 Sentiment Analysis with an Recurrent Neural Network

We will use a RNN for sentiment analysis because we care for the sequence in the data.

1.2.1 Imports

[1]:
```
import re
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt

from tensorflow.keras.models import Sequential, load_model
from tensorflow.compat.v1.keras.layers import CuDNNGRU, Embedding,␣
 ↪Dropout,Dense, Bidirectional, BatchNormalization
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.optimizers import RMSprop, Adamax , Adam

from attention.layers import AttentionLayer
```

```
# import keras
# from keras.models import Sequential, load_model
# from keras.layers import Dense, Embedding, Dropout
# from keras.preprocessing.text import Tokenizer
# from keras.preprocessing.sequence import pad_sequences
import tensorflow as tf
from tensorflow.python.client import device_lib
```

[2]:
```
from tensorflow.compat.v1 import ConfigProto
from tensorflow.compat.v1 import InteractiveSession

config = ConfigProto()
config.gpu_options.per_process_gpu_memory_fraction = 0.6
config.gpu_options.allow_growth = True
session = InteractiveSession(config=config)
```

[3]:
```
from IPython.core.interactiveshell import InteractiveShell
InteractiveShell.ast_node_interactivity = "all" #This is for multiple print␣
↪statements per cell
```

[4]:
```
value = tf.test.is_gpu_available(
    cuda_only=False,
    min_cuda_compute_capability=None
)
print ('***If TF can access GPU: ***\n\n',value) # MUST RETURN True IF IT CAN!!
```

```
WARNING:tensorflow:From <ipython-input-4-cb50da41978a>:3: is_gpu_available (from
tensorflow.python.framework.test_util) is deprecated and will be removed in a
future version.
Instructions for updating:
Use `tf.config.list_physical_devices('GPU')` instead.
***If TF can access GPU: ***

 True
```

[5]:
```
value = tf.config.list_physical_devices('GPU')
print(value)
```

```
[PhysicalDevice(name='/physical_device:GPU:0', device_type='GPU')]
```

[6]:
```
print(device_lib.list_local_devices())
```

```
[name: "/device:CPU:0"
device_type: "CPU"
memory_limit: 268435456
locality {
}
```

```
incarnation: 2368276500846877943
, name: "/device:XLA_CPU:0"
device_type: "XLA_CPU"
memory_limit: 17179869184
locality {
}
incarnation: 9578334301403701677
physical_device_desc: "device: XLA_CPU device"
, name: "/device:XLA_GPU:0"
device_type: "XLA_GPU"
memory_limit: 17179869184
locality {
}
incarnation: 6022337804536179636
physical_device_desc: "device: XLA_GPU device"
, name: "/device:GPU:0"
device_type: "GPU"
memory_limit: 1259942707
locality {
  bus_id: 1
  links {
  }
}
incarnation: 11815328610390041577
physical_device_desc: "device: 0, name: GeForce MX150, pci bus id: 0000:02:00.0,
compute capability: 6.1"
]
```

[7]:
```
tf.debugging.set_log_device_placement(True)
```

[8]:
```
 tf
print("Num GPUs Available: ", len(tf.config.experimental.
 ↪list_physical_devices('GPU')))
```

[8]:
```
<module 'tensorflow' from '/home/erolerten/anaconda3/envs/venv-
tensorflow/lib/python3.7/site-packages/tensorflow/__init__.py'>

Num GPUs Available:  1
```

2 Place tensors on the CPU

3 with tf.device(‘/GPU:0’):

a = tf.constant([[1.0, 2.0, 3.0], [4.0, 5.0, 6.0]]) b = tf.constant([[1.0, 2.0], [3.0, 4.0], [5.0, 6.0]])

c = tf.matmul(a, b) print(c)

3.0.1 Loading in Dataset

[9]:
```
data1 = pd.read_csv('Tweets.csv')
data2 = pd.read_csv('stanford-tweets.csv',sep=',')
# data1 = data1.sample(frac=1).reset_index(drop=True)
# data2 = data2.sample(frac=1).reset_index(drop=True)
print(data1.shape)
print(data2.shape)

data1.head()
data2.head()
```

```
(14640, 15)
(1600000, 2)
```

[9]:

	tweet_id	airline_sentiment	airline_sentiment_confidence	negativereason	negativereason_confidence	airline	airline_sentiment_gold	name	negativereason_gold	retweet_count	text	tweet_coord	tweet_created	tweet_location	user_timezone
0	570306133677760513	neutral	1.0000	NaN	NaN	Virgin America	NaN	cairdin	NaN	0	@VirginAmerica What @dhepburn said.	NaN	2015-02-24 11:35:52 -0800	NaN	Eastern Time (US & Canada)
1	570301130888122368	positive	0.3486	NaN	0.0000	Virgin America	NaN	jnardino	NaN	0	@VirginAmerica plus you've added commercials t…	NaN	2015-02-24 11:15:59 -0800	NaN	Pacific Time (US & Canada)
2	570301083672813571	neutral	0.6837	NaN	NaN	Virgin America	NaN	yvonnalynn	NaN	0	@VirginAmerica I didn't today… Must mean I n…	NaN	2015-02-24 11:15:48 -0800	Lets Play	Central Time (US & Canada)
3	570301031407624196	negative	1.0000	Bad Flight	0.7033	Virgin America	NaN	jnardino	NaN	0	@VirginAmerica it's really aggressive to blast…	NaN			
4	570300817074462722	negative	1.0000	Can't Tell	1.0000	Virgin America	NaN	jnardino	NaN	0	@VirginAmerica and it's a really big bad thing…	NaN			

```
3  2015-02-24 11:15:36 -0800            NaN  Pacific Time (US & Canada)
4  2015-02-24 11:14:45 -0800            NaN  Pacific Time (US & Canada)
```

[9]:

	sentiment	text
0	negative	@switchfoot http://twitpic.com/2y1zl - Awww, t…
1	negative	is upset that he can't update his Facebook by …
2	negative	@Kenichan I dived many times for the ball. Man…
3	negative	my whole body feels itchy and like its on fire
4	negative	@nationwideclass no, it's not behaving at all…

Removing all columns except the airline_sentiment and text column.

[10]:
```
data1 = data1[['airline_sentiment', 'text']]
new_columns = ['sentiment','text']
data1.columns = new_columns
data1.head()
```

[10]:

	sentiment	text
0	neutral	@VirginAmerica What @dhepburn said.
1	positive	@VirginAmerica plus you've added commercials t…
2	neutral	@VirginAmerica I didn't today… Must mean I n…
3	negative	@VirginAmerica it's really aggressive to blast…
4	negative	@VirginAmerica and it's a really big bad thing…

[11]:
```
df = data1.append(data2, ignore_index = True)
print(df.shape)
df
```

```
(1614640, 2)
```

[11]:

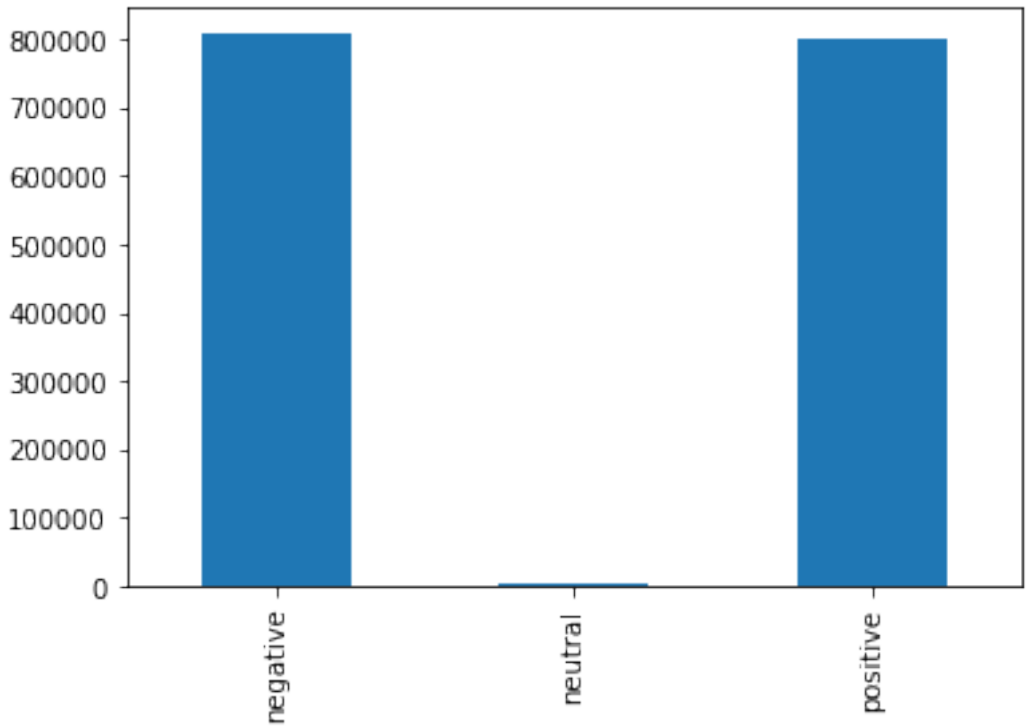
	sentiment	text
0	neutral	@VirginAmerica What @dhepburn said.
1	positive	@VirginAmerica plus you've added commercials t…
2	neutral	@VirginAmerica I didn't today… Must mean I n…
3	negative	@VirginAmerica it's really aggressive to blast…
4	negative	@VirginAmerica and it's a really big bad thing…
…	…	…
1614635	positive	Just woke up. Having no school is the best fee…
1614636	positive	TheWDB.com - Very cool to hear old Walt interv…
1614637	positive	Are you ready for your MoJo Makeover? Ask me f…
1614638	positive	Happy 38th Birthday to my boo of alll time!!! …
1614639	positive	happy #charitytuesday @theNSPCC @SparksCharity…

[1614640 rows x 2 columns]

3.0.2 Data exploration

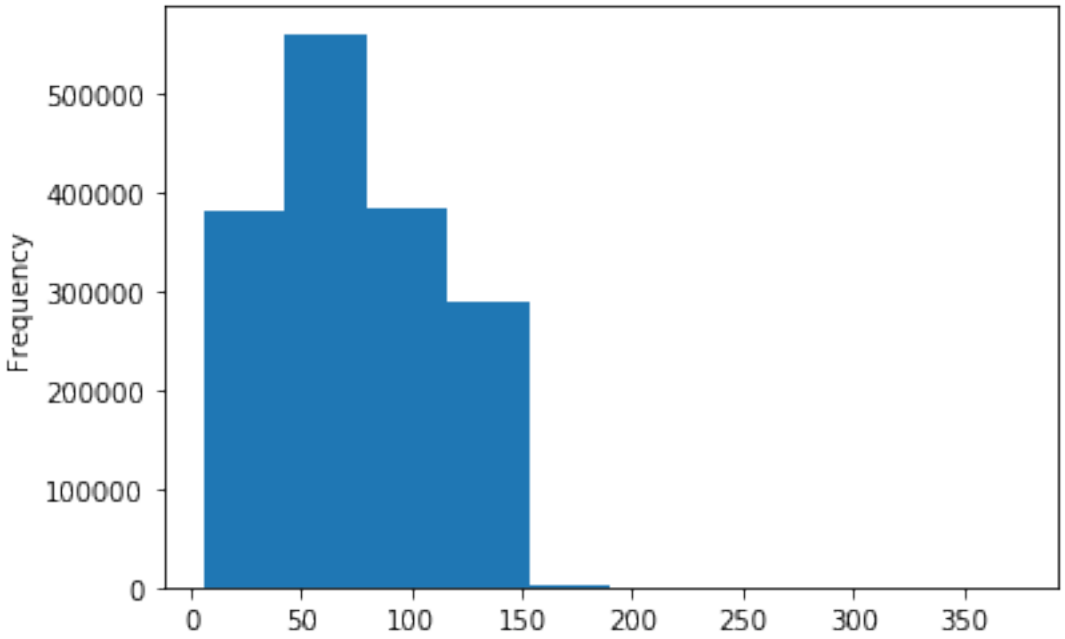
[12]:
```
df['sentiment'].value_counts().sort_index().plot.bar()
```

[12]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f72804cc590>
```



[13]:
```
df['text'].str.len().plot.hist()
```

[13]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f72747d9410>
```



3.0.3 Preprocessing

[14]:
```
# How much of Dataset to be used
frac = 0.15
```

[15]:
```
# data['text'] = data['text'].str.replace('@VirginAmerica', '')
# data.head()
df = df.sample(frac=frac).reset_index(drop=True)
df
```

[15]:

	sentiment	text
0	positive	at panera and using a #wii remote to control a…
1	positive	Hoping it doesn't rain this afternoon; round 2…
2	positive	Drinking by the pool with friends
3	positive	@ExpectToConnect i'll be sure to look forward…
4	positive	tonight has ended stupendously! free beer and…
…	…	…
242191	positive	Looking for where @vodafoneuk have already giv…
242192	negative	@macro_kiwi I miss having no real responsibili…
242193	positive	@djsky1 Haha, I was thinking that too…Like e…
242194	positive	@Wrangler253 you just have to lear the ropes!
242195	positive	I am so impatient sometimes. I probably should…

[242196 rows x 2 columns]

[16]:
```
df['text'].apply(lambda x: x.lower()) #transform text to lowercase
df['text'] = df['text'].apply(lambda x: re.sub('[^a-zA-z0-9\s]', '', x))
df['text'].head()
```

[16]:
```
0         at panera and using a #wii remote to control a…
1         hoping it doesn't rain this afternoon; round 2…
2                        drinking by the pool with friends
3         @expecttoconnect i'll be sure to  look forward…
4         tonight has ended stupendously!  free beer and…
                                 …
242191    looking for where @vodafoneuk have already giv…
242192    @macro_kiwi i miss having no real responsibili…
242193    @djsky1 haha, i was thinking that too…like e…
242194       @wrangler253  you just have to lear the ropes!
242195    i am so impatient sometimes. i probably should…
Name: text, Length: 242196, dtype: object
```

[16]:
```
0    at panera and using a wii remote to control a …
1    Hoping it doesnt rain this afternoon round 2 o…
2                   Drinking by the pool with friends
3    ExpectToConnect ill be sure to  look forward t…
4    tonight has ended stupendously  free beer and …
Name: text, dtype: object
```

[17]:
```
df['sentiment']
```

[17]:
```
0         positive
1         positive
2         positive
3         positive
4         positive
            …
242191    positive
242192    negative
242193    positive
242194    positive
242195    positive
Name: sentiment, Length: 242196, dtype: object
```

[18]:
```
df = df[df['sentiment'] != 'neutral']
```

[19]:
```
df
```

[19]:
```
       sentiment                                               text
0       positive  at panera and using a wii remote to control a …
1       positive  Hoping it doesnt rain this afternoon round 2 o…
2       positive                 Drinking by the pool with friends
```

```
3       positive  ExpectToConnect ill be sure to  look forward t…
4       positive  tonight has ended stupendously  free beer and …
…          …                                                  …
242191  positive  Looking for where vodafoneuk have already give…
242192  negative  macro_kiwi I miss having no real responsibilit…
242193  positive  djsky1 Haha I was thinking that tooLike everyo…
242194  positive       Wrangler253  you just have to lear the ropes
242195  positive  I am so impatient sometimes I probably should …

[241724 rows x 2 columns]
```

[20]:
```
vocabulary_size = 13000
```

[21]:
```
tokenizer = Tokenizer(num_words=vocabulary_size, split=" ")
tokenizer.fit_on_texts(df['text'].values)

X = tokenizer.texts_to_sequences(df['text'].values)
X = pad_sequences(X) # padding our text vector so they all have the same length
X[:5]
```

[21]:
```
array([[   0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
           0,    0,    0,    0,    0,    0,    0,    0,   22, 6499,
           6,  532,    4, 1601, 3868,    2, 1684,    4, 1979,  110,  275,
        8285,  804],
       [   0,    0,    0,    0,    0,    0,    0,    0,    0,    0,  583,
           9,  209,  255,   27,  605, 1037,   81,   12,  715,  150,   46,
           6,    1,   41,   25,   69,    4, 2752,   35,  851,  349, 2638,
        1334,   11],
       [   0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
           0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
           0,    0,    0,    0,    0,    0,    0,  770,  121,    3,  667,
          21,  193],
       [   0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
           0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
           0,    0,    0,    0,   98,   23,  194,    2,  207,  381,    2,
         536,    9],
       [   0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
           0,    0,    0,    0,    0,    0,    0,    0,    0,    0,  123,
          97, 1244,  361,  840,    6, 4285,   21,    4,   70,  257,  620,
         182,    8]], dtype=int32)
```

3.0.4 Creating model

[22]:
```
model = Sequential()
model.add(Embedding(vocabulary_size, 256, input_length=X.shape[1]))
model.add(Dropout(0.3))
model.add(Bidirectional(CuDNNGRU(256, return_sequences=True)))
model.add(Dropout(0.3))
model.add(Bidirectional(CuDNNGRU(256, return_sequences=True)))
model.add(AttentionLayer(name='attention'))
model.add(BatchNormalization())
model.add(Dense(2, activation='sigmoid'))
```

```
Executing op RandomUniform in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op Sub in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op Mul in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op Add in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op VarIsInitializedOp in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op LogicalNot in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op Assert in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op AssignVariableOp in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op RandomUniform in device
/job:localhost/replica:0/task:0/device:GPU:0
Executing op Sub in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op Mul in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op Add in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarIsInitializedOp in device
/job:localhost/replica:0/task:0/device:GPU:0
Executing op LogicalNot in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op Assert in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op AssignVariableOp in device
/job:localhost/replica:0/task:0/device:GPU:0
Executing op RandomStandardNormal in device
/job:localhost/replica:0/task:0/device:GPU:0
Executing op Qr in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op DiagPart in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op Sign in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op Transpose in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op Reshape in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op Fill in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
```

```
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
```

[23]:
```
model.compile(loss='binary_crossentropy', optimizer='adam',␣
 ↪metrics=['accuracy'])
model.summary()
```

```
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding (Embedding)        (None, 35, 256)           3328000
_________________________________________________________________
dropout (Dropout)            (None, 35, 256)           0
_________________________________________________________________
bidirectional (Bidirectional (None, 35, 512)           789504
_________________________________________________________________
dropout_1 (Dropout)          (None, 35, 512)           0
_________________________________________________________________
bidirectional_1 (Bidirection (None, 35, 512)           1182720
_________________________________________________________________
attention (AttentionLayer)   (None, 512)               263168
_________________________________________________________________
batch_normalization (BatchNo (None, 512)               2048
_________________________________________________________________
dense (Dense)                (None, 2)                 1026
=================================================================
Total params: 5,566,466
Trainable params: 5,565,442
Non-trainable params: 1,024
_________________________________________________________________
```

[24]:
```
y = pd.get_dummies(df['sentiment']).values
[print(df['sentiment'][i], y[i]) for i in range(0,5)]
```

```
positive [0 1]
positive [0 1]
positive [0 1]
positive [0 1]
positive [0 1]
```

[24]:
```
[None, None, None, None, None]
```

[25]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=0)
```

3.0.5 Training model

[26]:
```
batch_size = 32
epochs = 7
import time
from datetime import datetime
datetime = str(datetime.now())
csv_logger = tf.keras.callbacks.CSVLogger('training'+datetime+'.log')
start = time.time()
history = model.fit(X_train, y_train, epochs=epochs, batch_size=batch_size,␣
 ↪verbose=2, callbacks=[csv_logger])
end = time.time()
elapsed = end - start
print(elapsed/60," minutes")
```

```
Executing op RangeDataset in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op RepeatDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op MapDataset in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op PrefetchDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op FlatMapDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op TensorDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op RepeatDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op ZipDataset in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op ParallelMapDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op DatasetCardinality in device
/job:localhost/replica:0/task:0/device:CPU:0
Train on 193379 samples
Epoch 1/7
Executing op ModelDataset in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op AnonymousIteratorV2 in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op MakeIterator in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op AssignVariableOp in device
/job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
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Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
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Executing op LogicalNot in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op Assert in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
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Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
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Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op VarHandleOp in device /job:localhost/replica:0/task:0/device:GPU:0
Executing op __inference_distributed_function_4267 in device
/job:localhost/replica:0/task:0/device:GPU:0
193379/193379 - 407s - loss: 0.4716 - accuracy: 0.7761
Epoch 2/7
193379/193379 - 385s - loss: 0.4078 - accuracy: 0.8162
Epoch 3/7
193379/193379 - 385s - loss: 0.3702 - accuracy: 0.8371
Epoch 4/7
```

```
193379/193379 - 387s - loss: 0.3346 - accuracy: 0.8570
Epoch 5/7
193379/193379 - 395s - loss: 0.2980 - accuracy: 0.8748
Epoch 6/7
193379/193379 - 401s - loss: 0.2642 - accuracy: 0.8905
Epoch 7/7
193379/193379 - 399s - loss: 0.2367 - accuracy: 0.9024
Executing op DeleteIterator in device
/job:localhost/replica:0/task:0/device:CPU:0
45.981415983041124  minutes
```

3.0.6 Plotting Training History

[27]:
```
# print(history)
```

[28]:
```
import matplotlib.pyplot as plt

# Plot training & validation accuracy values
plt.plot(history.history['accuracy'])
# plt.plot(history.history['val_accuracy'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()

# Plot training & validation loss values
plt.plot(history.history['loss'])
# plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```

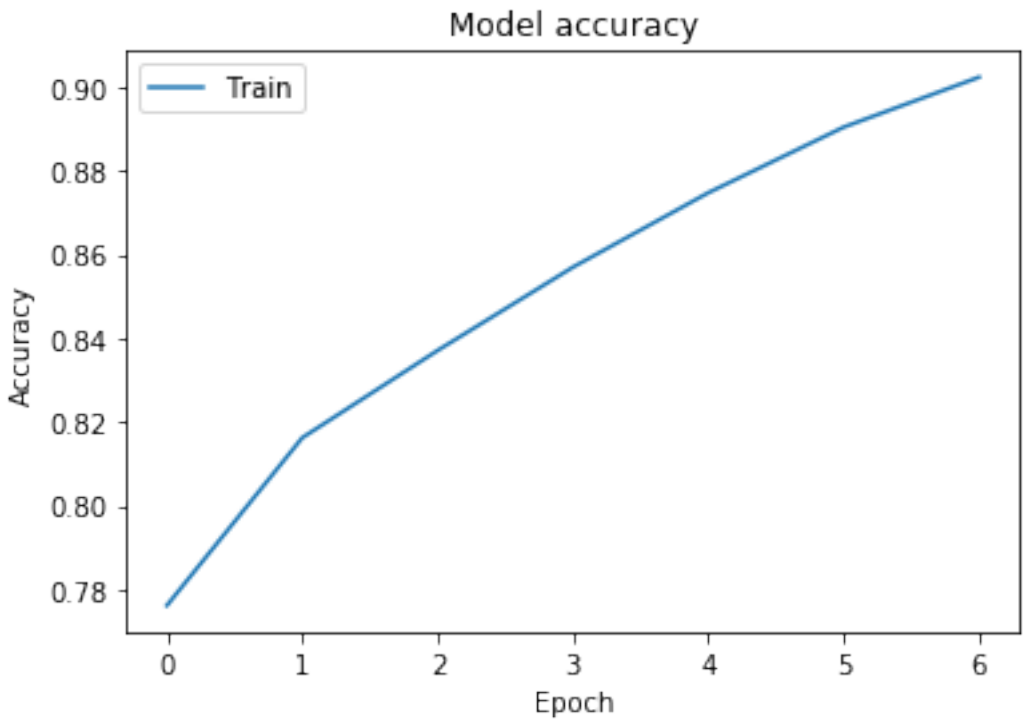
[28]:
```
[<matplotlib.lines.Line2D at 0x7f71b20dabd0>]
```

[28]:
```
Text(0.5, 1.0, 'Model accuracy')
```

[28]:
```
Text(0, 0.5, 'Accuracy')
```

[28]:
```
Text(0.5, 0, 'Epoch')
```

[28]:
```
<matplotlib.legend.Legend at 0x7f72b8e3d990>
```



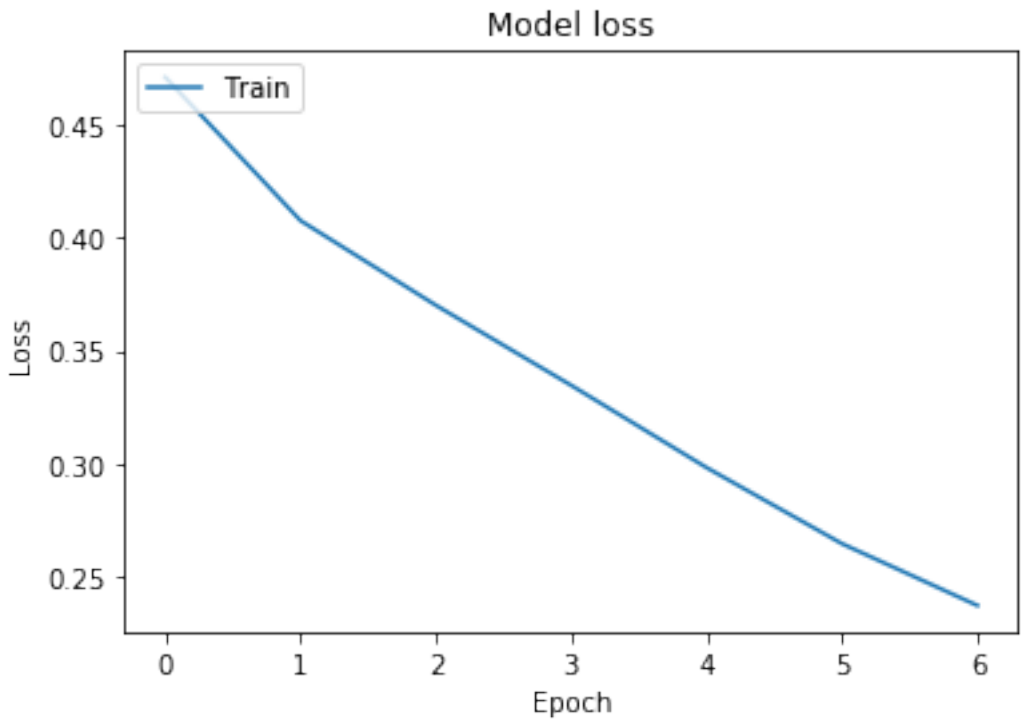
[28]: [<matplotlib.lines.Line2D at 0x7f71b20555d0>]

[28]: Text(0.5, 1.0, 'Model loss')

[28]: Text(0, 0.5, 'Loss')

[28]: Text(0.5, 0, 'Epoch')

[28]: <matplotlib.legend.Legend at 0x7f71b2037c90>



3.0.7 Testing model

[ ]:
```
predictions = model.predict(X_test)

[print(df['text'][i], predictions[i], y_test[i]) for i in range(0, 5)]
```

```
Executing op RangeDataset in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op RepeatDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op MapDataset in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op PrefetchDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op FlatMapDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op TensorDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op RepeatDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op ZipDataset in device /job:localhost/replica:0/task:0/device:CPU:0
Executing op ParallelMapDataset in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op ModelDataset in device /job:localhost/replica:0/task:0/device:CPU:0
```

```
Executing op AnonymousIteratorV2 in device
/job:localhost/replica:0/task:0/device:CPU:0
Executing op __inference_distributed_function_131781 in device
/job:localhost/replica:0/task:0/device:GPU:0
```

[ ]:
```
accurate_prediction_count, inaccurate_prediction_count = 0, 0
for i, prediction in enumerate(predictions):
    if np.argmax(prediction)==np.argmax(y_test[i]):
        accurate_prediction_count += 1
    else:
        inaccurate_prediction_count += 1

total_predictions = accurate_prediction_count + inaccurate_prediction_count
print('Number of predictions: ', total_predictions)
print('Number of accurate predictions: ', accurate_prediction_count)
print('Number of false predictions: ', inaccurate_prediction_count)
print('Accuracy: ', accurate_prediction_count/total_predictions)
```

[ ]:
```
name =␣
↪'Sentiment_Analysis-binary-classification-BRNN-CuDNNGRU-Batchnormalization-AttentionLayer-6
```

[ ]:
```
model.save(name+'.h5')
```

[ ]:
```
# pos_count, neu_count, neg_count = 0, 0, 0
# real_pos, real_neu, real_neg = 0, 0, 0
# for i, prediction in enumerate(predictions):
#     if np.argmax(prediction)==2:
#         pos_count += 1
#     elif np.argmax(prediction)==1:
#         neu_count += 1
#     else:
#         neg_count += 1

#     if np.argmax(y_test[i])==2:
#         real_pos += 1
#     elif np.argmax(y_test[i])==1:
#         real_neu += 1
#     else:
#         real_neg +=1

# print('Positive predictions:', pos_count)
# print('Neutral predictions:', neu_count)
# print('Negative predictions:', neg_count)
# print('Real positive:', real_pos)
# print('Real neutral:', real_neu)
# print('Real negative:', real_neg)
```

[ ]:
```
!jupyter nbconvert␣
↪Sentiment_Analysis-binary-classification-BRNN-CuDNNGRU-Batchnormalization-AttentionLayer.
↪ipynb --to pdf
```

3.1 Improvements we could implement

Weight classes (because data is skew)

Train more epochs

Use bigger network

Try other word number

3.2 Resources

Recurrent Neural Networks Explained (my own post and video)

Sentiment Analysis (Wikipedia)

What is the best way to do sentiment analysis with Python? (Quora)

How to Do Sentiment Analysis (Siraj Raval)