

# Sentiment Analysis-CuDNNLSTM

January 18, 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 known 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 CuDNNLSTM, Embedding, \
↳Dropout, Dense
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences

# 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, 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: 18288949577461304117
, name: "/device:XLA_CPU:0"
device_type: "XLA_CPU"
```

```

memory_limit: 17179869184
locality {
}
incarnation: 17261346251242640276
physical_device_desc: "device: XLA_CPU device"
, name: "/device:XLA_GPU:0"
device_type: "XLA_GPU"
memory_limit: 17179869184
locality {
}
incarnation: 11985354752871157150
physical_device_desc: "device: XLA_GPU device"
, name: "/device:GPU:0"
device_type: "GPU"
memory_limit: 1259942707
locality {
  bus_id: 1
  links {
  }
}
incarnation: 14915131882960895272
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 \
0  570306133677760513             neutral                1.0000
1  570301130888122368             positive                0.3486
2  570301083672813571             neutral                0.6837
3  570301031407624196             negative                1.0000
4  570300817074462722             negative                1.0000

      negativereason  negativereason_confidence      airline \
0              NaN                NaN  Virgin America
1              NaN                0.0000  Virgin America
2              NaN                NaN    Virgin America
3    Bad Flight                0.7033  Virgin America
4    Can't Tell                1.0000  Virgin America

      airline_sentiment_gold      name  negativereason_gold  retweet_count \
0              NaN      cairdin                NaN                0
1              NaN      jnardino                NaN                0
2              NaN  yvonnalynn                NaN                0
3              NaN      jnardino                NaN                0
4              NaN      jnardino                NaN                0

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

      tweet_created  tweet_location      user_timezone
0  2015-02-24 11:35:52 -0800                NaN  Eastern Time (US & Canada)
1  2015-02-24 11:15:59 -0800                NaN  Pacific Time (US & Canada)
2  2015-02-24 11:15:48 -0800      Lets Play  Central Time (US & Canada)
```

```

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...

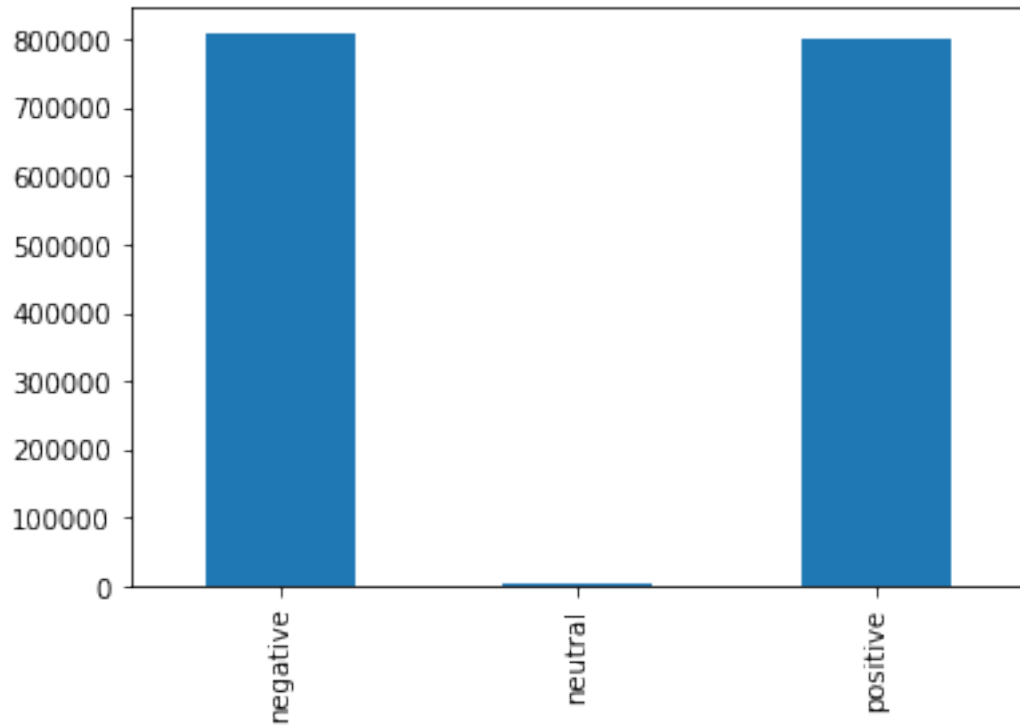
```

[1614640 rows x 2 columns]

### 3.0.2 Data exploration

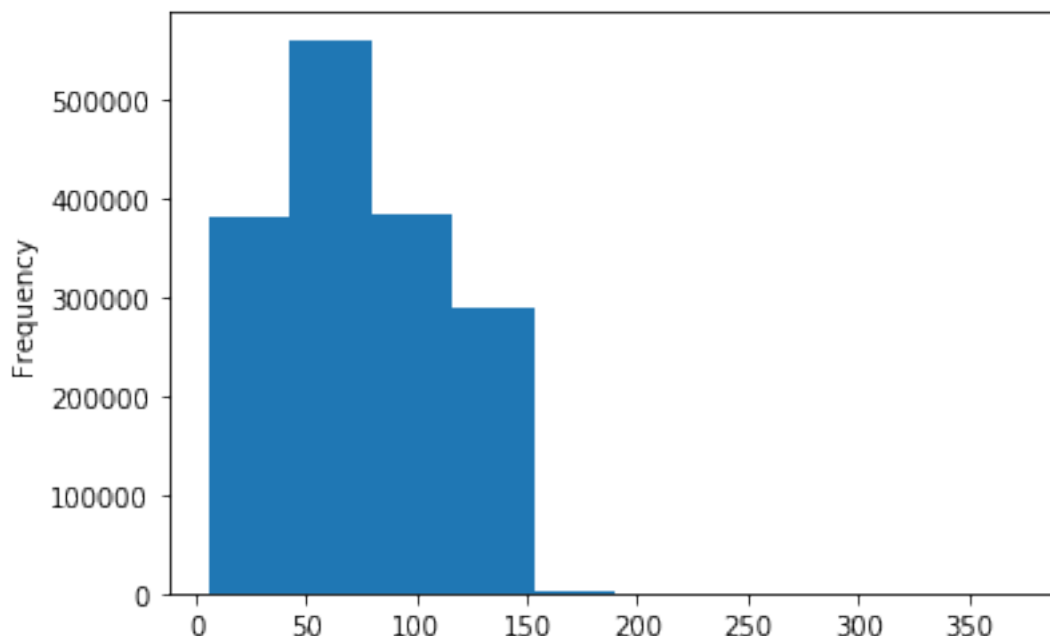
```
[12]: df['sentiment'].value_counts().sort_index().plot.bar()
```

```
[12]: <matplotlib.axes._subplots.AxesSubplot at 0x7f5ee1536bd0>
```



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

```
[13]: <matplotlib.axes._subplots.AxesSubplot at 0x7f5ee159cb90>
```



### 3.0.3 Preprocessing

```
[14]: # data['text'] = data['text'].str.replace('@VirginAmerica', '')
# data.head()
df = df.sample(frac=1).reset_index(drop=True)
df
```

```
[14]:
```

	sentiment	text
0	positive	Be happy and enjoy the moment of now
1	positive	@daisyclover1938 lol... I thought you were tuc...
2	positive	@frankieurwin http://twitpic.com/6ges9 - Very ...
3	positive	Oh forgot finished 8th net 300.00 not good but...
4	positive	im yours and suddenly your mine...brighter tha...
...	...	...
1614635	positive	Awe thanks punkin ~TaME~
1614636	negative	@sofiesunshine me too bless her!
1614637	positive	@LeoHandmade 2 pairs of earrings! That is wond...
1614638	positive	@DonnieWahlberg I am working and cannot wait f...
1614639	negative	Running wild in WeHo x leaving on wednesday fo...

[1614640 rows x 2 columns]

```
[15]: 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()
```

```
[15]: 0          be happy and enjoy the moment of now
      1    @daisyclover1938 lol... i thought you were tuc...
      2    @frankieurwin http://twitpic.com/6ges9 - very ...
      3    oh forgot finished 8th net 300.00 not good but...
      4    im yours and suddenly your mine...brighter tha...
      ...
      1614635          awe thanks punkin ~tame~
      1614636          @sofiesunshine me too  bless her!
      1614637    @leohandmade 2 pairs of earrings! that is wond...
      1614638    @donniewahlberg i am working and cannot wait f...
      1614639    running wild in weho x leaving on wednesday fo...
      Name: text, Length: 1614640, dtype: object
```

```
[15]: 0          Be happy and enjoy the moment of now
      1    daisyclover1938 lol I thought you were tucked ...
      2    frankieurwin httpwtitpiccom6ges9  Very stylin ...
      3    Oh forgot finished 8th net 30000 not good but ...
      4    im yours and suddenly your minebrighter than t...
      Name: text, dtype: object
```

```
[16]: df['sentiment']
```

```
[16]: 0          positive
      1          positive
      2          positive
      3          positive
      4          positive
      ...
      1614635    positive
      1614636    negative
      1614637    positive
      1614638    positive
      1614639    negative
      Name: sentiment, Length: 1614640, dtype: object
```

```
[17]: df
```

```
[17]:      sentiment      text
0      positive  Be happy and enjoy the moment of now
1      positive  daisyclover1938 lol I thought you were tucked ...
2      positive  frankieurwin httpwtitpiccom6ges9  Very stylin ...
3      positive  Oh forgot finished 8th net 30000 not good but ...
4      positive  im yours and suddenly your minebrighter than t...
...      ...
1614635  positive  Awe thanks punkin TaME
```



```

1614636  negative                sofiesunshine me too  bless her
1614637  positive  LeoHandmade 2 pairs of earrings That is wonder...
1614638  positive  DonnieWahlberg I am working and cannot wait fo...
1614639  negative  Running wild in WeHo x leaving on wednesday fo...

```

```
[1614640 rows x 2 columns]
```

```
[18]: # from numba import jit, cuda
```

```

[20]: tokenizer = Tokenizer(num_words=3000, 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]

```

```

[20]: array([[ 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,  0,  0, 22,
               118,  6, 367,  3, 707, 12, 28],
             [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
               0,  0,  0,  0,  0,  0, 52,  1, 242,  7, 126,
               30, 11, 141, 75, 10,  3, 1093, 56, 17,  4,  74,
               59,  9,  6, 31, 51,  2, 272],
             [ 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,  0,  0,  0, 117, 72,  7,
               126, 1091, 55,  4, 519,  7, 35],
             [ 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,  0,  0,  0,  0, 81, 461,
               370, 1828, 25, 29, 19, 56, 47],
             [ 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,  0,  0,  0,  0,  0, 13,
               999,  6, 2319, 41, 194,  3, 751]], dtype=int32)

```

### 3.0.4 Creating model

```

[21]: model = Sequential()
model.add(Embedding(3000, 256, input_length=X.shape[1]))
model.add(Dropout(0.3))
model.add(CuDNNLSTM(256, return_sequences=True))
model.add(Dropout(0.3))
model.add(CuDNNLSTM(256, return_sequences=True))
model.add(Dropout(0.3))

```

```

model.add(CuDNNLSTM(256))
model.add(Dropout(0.3))
model.add(Dense(3, activation='softmax'))

```

```

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 ConcatV2 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

```

```

[22]: model.compile(loss='categorical_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, 40, 256)	768000
dropout (Dropout)	(None, 40, 256)	0
cu_dnnlstm (CuDNNLSTM)	(None, 40, 256)	526336
dropout_1 (Dropout)	(None, 40, 256)	0
cu_dnnlstm_1 (CuDNNLSTM)	(None, 40, 256)	526336
dropout_2 (Dropout)	(None, 40, 256)	0
cu_dnnlstm_2 (CuDNNLSTM)	(None, 256)	526336
dropout_3 (Dropout)	(None, 256)	0
dense (Dense)	(None, 3)	771
Total params: 2,347,779		
Trainable params: 2,347,779		
Non-trainable params: 0		

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

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

```
[23]: [None, None, None, None, None]
```

```
[24]: 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

```
[25]: batch_size = 32
      epochs = 8

      import time
```

```

start = time.time()
model.fit(X_train, y_train, epochs=epochs, batch_size=batch_size, verbose=2)
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 1291712 samples
Epoch 1/8
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
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 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
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

```

```
[25]: <tensorflow.python.keras.callbacks.History at 0x7f5d5472a750>
```

```
[26]: model.save('sentiment_analysis-19012020.h5')
```

13

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

### 3.0.6 Testing model

```
[27]: 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_972693 in device
/job:localhost/replica:0/task:0/device:GPU:0
Be happy and enjoy the moment of now [2.0290272e-02 4.7672945e-25
9.7970974e-01] [0 0 1]
daisyclover1938 lol I thought you were tucked up in bed Thanks for the info will
have a think about it and get back to N [3.4346059e-01 4.0449539e-08
6.5653944e-01] [0 0 1]
frankieurwin http://twitpic.com/6ges9 Very stylin amp you were worried What a
handsome boy you are [9.4989961e-01 5.3679365e-14 5.0100364e-02] [1 0 0]
Oh forgot finished 8th net 30000 not good but will work [3.5080394e-01
4.9227136e-08 6.4919597e-01] [0 0 1]
im yours and suddenly your mine brighter than the sunshine [2.4183053e-01
2.9110243e-09 7.5816953e-01] [0 0 1]
```

```
[27]: [None, None, None, None, None]
```

```
[30]: 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 prediprinttns: ', 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)

```

Number of prediprinttns: 322928  
 Number of accurate predictions: 264411  
 Number of false predictions: 58517  
 Accuracy: 0.8187924243174949

```

[31]: 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)

```

Positive predictions: 157922  
 Neutral predictions: 751  
 Negative predictions: 164255  
 Real positive: 160546  
 Real neutral: 630  
 Real negative: 161752

### **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)