https://www.kaggle.com/datatattle/covid-19-nlp-text-classification

Sentiment Analysis with Covid-19 Tweets

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In [ ]:

```
##########Load the kaggle api token##########
!pip install --upgrade --force-reinstall --no-deps kaggle
!pip install transformers
!mkdir -p ~/.kaggle
!cp kaggle.json ~/.kaggle/
!chmod 600 /root/.kaggle/kaggle.json
!kaggle datasets download -d datatattle/covid-19-nlp-text-classification
!unzip covid-19-nlp-text-classification
```

In [2]:

```
### Libraries ###
import re
import numpy as np
import pandas as pd
import nltk
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
from wordcloud import WordCloud
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from keras.models import Sequential
from keras.layers import Dense,LSTM,Embedding,Input,GlobalMaxPool1D,Bidirectional,GRU
from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
from keras.callbacks import EarlyStopping,ReduceLROnPlateau
from transformers import TFBertModel
from transformers import AdamW,get_linear_schedule_with_warmup
from transformers import BertTokenizer
from torch.utils.data import TensorDataset
import tensorflow as tf
from torch.utils.data import RandomSampler,DataLoader
from tqdm.notebook import tqdm



import seaborn as sns
import matplotlib.pylab as plt
from plotly.subplots import make_subplots
import plotly.graph_objects as go

nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
```

Out[2]:

```
True
```

0.Loading Data

In [3]:

```
train=pd.read_csv("Corona_NLP_train.csv",encoding='latin1')
```

```
test=pd.read_csv("Corona_NLP_test.csv",encoding='latin1')


train['OriginalTweet']=train['OriginalTweet'].astype(str)
train['Sentiment']=train['Sentiment'].astype(str)
test['OriginalTweet']=test['OriginalTweet'].astype(str)
test['Sentiment']=test['Sentiment'].astype(str)

df=pd.concat([train,test])
df['OriginalTweet']=df['OriginalTweet'].astype(str)
df['Sentiment']=df['Sentiment'].astype(str)
df.head()
```

Out[3]:

	UserName	ScreenName	Location	TweetAt	OriginalTweet	Sentiment
0	**3799**	**48751**	**London**	**16-03-2020**	**@MeNyrbie @Phil_Gahan @Chrisitv https://t.co/i...**	**Neutral**
1	**3800**	**48752**	**UK**	**16-03-2020**	**advice Talk to your neighbours family to excha...**	**Positive**
2	**3801**	**48753**	**Vagabonds**	**16-03-2020**	**Coronavirus Australia: Woolworths to give elde...**	**Positive**
3	**3802**	**48754**	**NaN**	**16-03-2020**	**My food stock is not the only one which is emp...**	**Positive**
4	**3803**	**48755**	**NaN**	**16-03-2020**	**Me, ready to go at supermarket during the #COV...**	**Extremely Negative**

In [4]:

```
train.shape, test.shape, df.shape
```

Out[4]:

```
((41157, 6), (3798, 6), (44955, 6))
```

In [4]:

```
#Missing Values
df.isnull().sum()
```

Out[4]:

```
UserName            0
ScreenName          0
Location         9424
TweetAt             0
OriginalTweet       0
Sentiment           0
dtype: int64
```

In [5]:

```
#Sentiment Distribution
print(df.Sentiment.unique())
print(df.Sentiment.value_counts())
```

```
['Neutral' 'Positive' 'Extremely Negative' 'Negative' 'Extremely Positive']
Positive              12369
Negative              10958
Neutral                8332
Extremely Positive     7223
Extremely Negative     6073
Name: Sentiment, dtype: int64
```

In [6]:

```
# We will copy the text in another column so that the original text is also there for com
parison
df['text'] = df.OriginalTweet
df["text"] = df["text"].astype(str)

train['text'] = train.OriginalTweet
train["text"] = train["text"].astype(str)
```

```
test['text'] = test.OriginalTweet
test["text"] = test["text"].astype(str)

# Data has 5 classes, let's convert them to 3
def classes_def(x):
    if x ==  "Extremely Positive":
        return "positive"
    elif x == "Extremely Negative":
        return "negative"
    elif x == "Negative":
        return "negative"
    elif x ==  "Positive":
        return "positive"
    else:
        return "neutral"

df['sentiment']=df['Sentiment'].apply(lambda x:classes_def(x))
train['sentiment']=train['Sentiment'].apply(lambda x:classes_def(x))
test['sentiment']=test['Sentiment'].apply(lambda x:classes_def(x))

round(df.sentiment.value_counts(normalize= True),2)
```

Out[6]:

```
positive    0.44
negative    0.38
neutral     0.19
Name: sentiment, dtype: float64
```

1. EDA Analysis

In [7]:

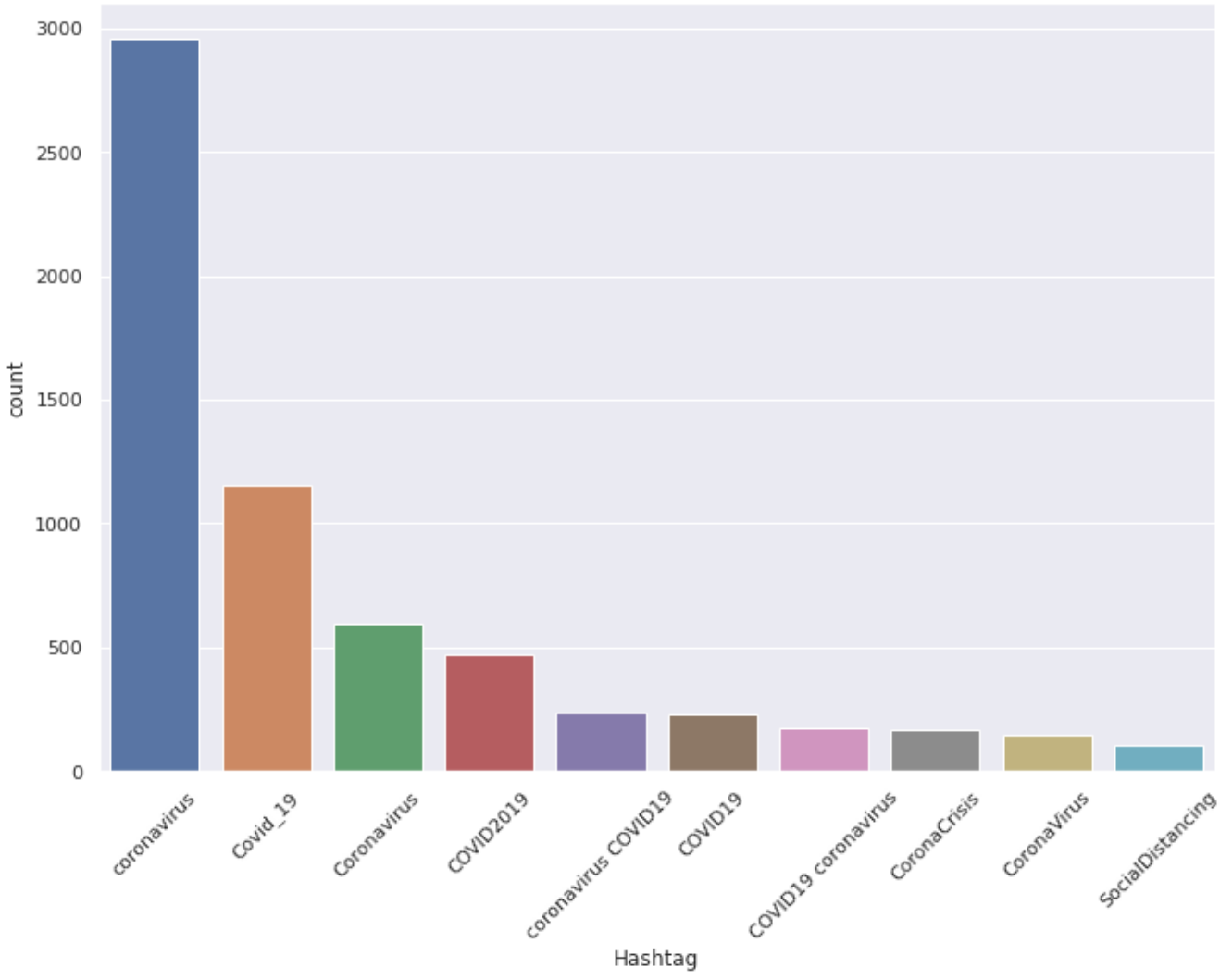
```
fig=make_subplots(1,2,subplot_titles=('Train set','Test set'))
x=train.sentiment.value_counts()
fig.add_trace(go.Bar(x=x.index,y=x.values,
                     marker_color=['#17C37B','#F92969','#FACA0C'],name='train'),row=1,co
l=1)
x=test.sentiment.value_counts()
fig.add_trace(go.Bar(x=x.index,y=x.values,
                     marker_color=['#17C37B','#F92969','#FACA0C'],name='test'),row=1,col
=2)
```

In [8]:

```
def find_hash(text):
    line=re.findall(r'(?<=#)\w+',text)
    return " ".join(line)

sns.set(rc={'figure.figsize':(11.7,8.27)})
df['hash']=df['text'].apply(lambda x:find_hash(x))
temp=df['hash'].value_counts()[:][1:11]
temp= temp.to_frame().reset_index().rename(columns={'index':'Hashtag','hash':'count'})
sns.barplot(x="Hashtag",y="count", data = temp)
plt.xticks(rotation=45)
```

Out[8]:

```
(array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9]),
 <a list of 10 Text major ticklabel objects>)
```

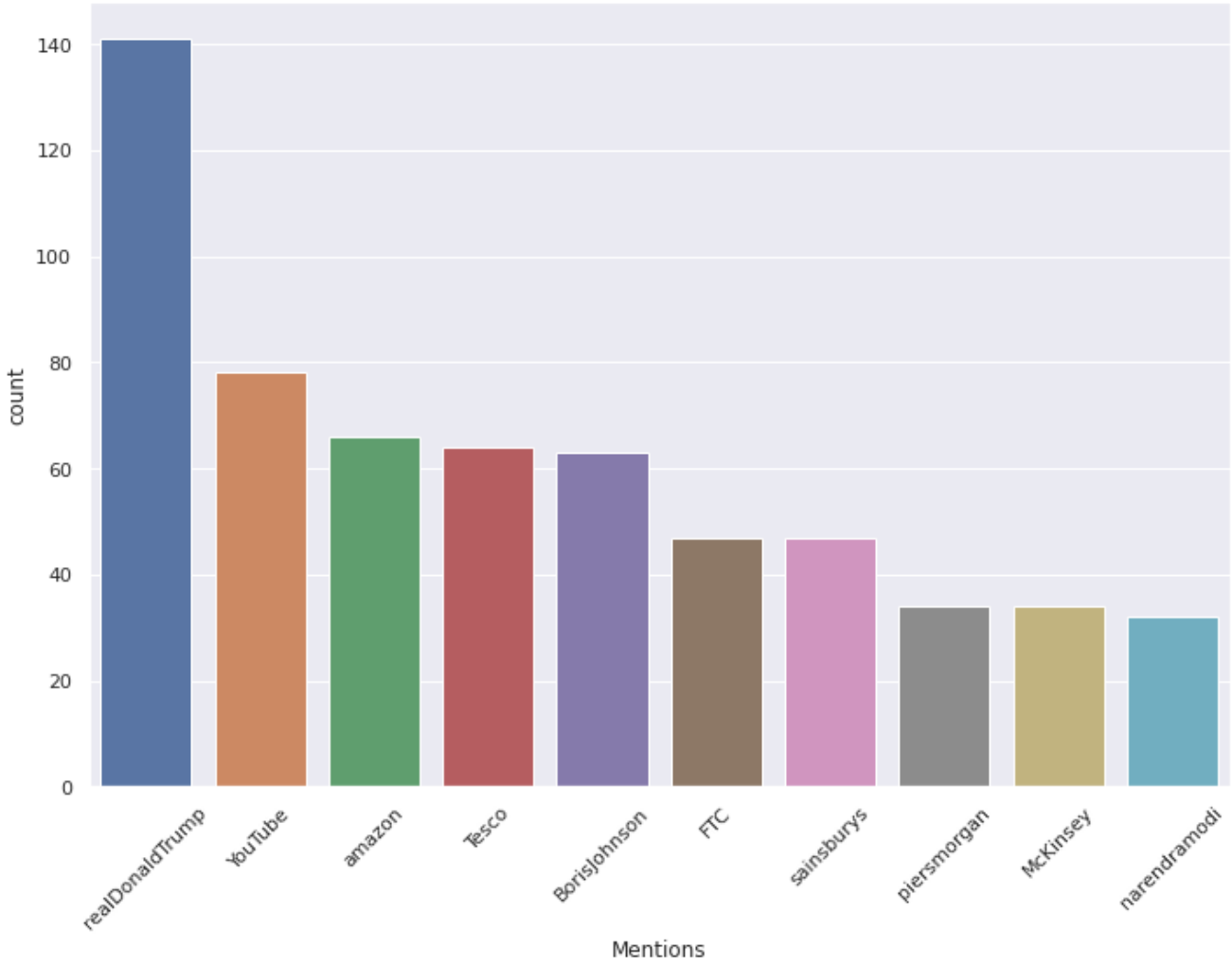


In [9]:

```
def mentions(text):
    line=re.findall(r'(?<=@)\w+',text)
    return " ".join(line)
df['mentions']=df['text'].apply(lambda x:mentions(x))

temp=df['mentions'].value_counts()[:][1:11]
temp =temp.to_frame().reset_index().rename(columns={'index':'Mentions','mentions':'count
'})

sns.barplot(x="Mentions",y="count", data = temp)
plt.xticks(rotation=45)
```

Out[9]:

```
(array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9]),
 <a list of 10 Text major ticklabel objects>)
```



2.Preprocessing

In [10]:

```
STOPWORDS = set(stopwords.words('english'))

#Remove Urls and HTML links
def remove_urls(text):
    url_remove = re.compile(r'https?://\S+|www\.\S+')
    return url_remove.sub(r'', text)

def remove_html(text):
    html=re.compile(r'<.*?>')
    return html.sub(r'',text)

# Lower casing
def lower(text):
    low_text= text.lower()
    return low_text

# Number removal
def remove_num(text):
    remove= re.sub(r'\d+', '', text)
    return remove

#Remove stopwords & Punctuations
def punct_remove(text):
    punct = re.sub(r"[^\w\s\d]","", text)
    return punct

def remove_stopwords(text):
```

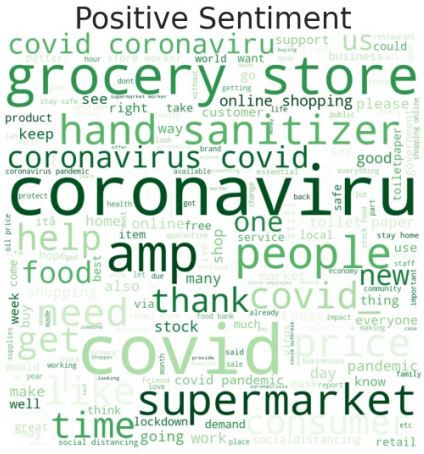
```
    return " ".join([word for word in str(text).split() if word not in STOPWORDS])

#Remove mentions and hashtags
def remove_mention(x):
    text=re.sub(r'@\w+','',x)
    return text

def remove_hash(x):
    text=re.sub(r'#\w+','',x)
    return text

#Remove extra white space left while removing stuff
def remove_space(text):
    space_remove = re.sub(r"\s+"," ",text).strip()
    return space_remove

df['text_new']=df['text'].apply(lambda x:remove_urls(x))
df['text']=df['text_new'].apply(lambda x:remove_html(x))
df['text_new']=df['text'].apply(lambda x:lower(x))
df['text']=df['text_new'].apply(lambda x:remove_num(x))
df['text_new']=df['text'].apply(lambda x:punct_remove(x))
df['text']=df['text_new'].apply(lambda x:remove_stopwords(x))
df['text_new']=df['text'].apply(lambda x:remove_mention(x))
df['text']=df['text_new'].apply(lambda x:remove_hash(x))
df['text_new']=df['text'].apply(lambda x:remove_space(x))
df = df.drop(columns=['text_new'])
```

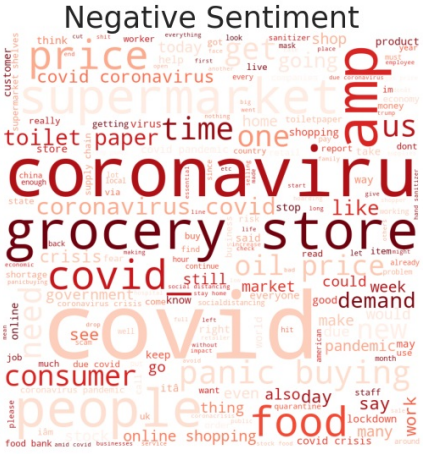
3.Wordcloud

In [11]:

```
fig, (ax1, ax2, ax3) = plt.subplots(1, 3, figsize=[30, 15])

df_pos = df[df["sentiment"]=="positive"]
df_neg = df[df["sentiment"]=="negative"]
df_neu = df[df["sentiment"]=="neutral"]

comment_words = ''
stopwords = set(STOPWORDS)

for val in df_pos.text:

    # typecaste each val to string
    val = str(val)

    # split the value
    tokens = val.split()

    # Converts each token into lowercase
    for i in range(len(tokens)):
        tokens[i] = tokens[i].lower()

    comment_words += " ".join(tokens)+" "


wordcloud1 = WordCloud(width = 800, height = 800,
                background_color ='white',
                colormap="Greens",
                stopwords = stopwords,
                min_font_size = 10).generate(comment_words)

ax1.imshow(wordcloud1)
ax1.axis('off')
ax1.set_title('Positive Sentiment',fontsize=35);

comment_words = ''

for val in df_neg.text:

    # typecaste each val to string
```

```
    val = str(val)

    # split the value
    tokens = val.split()

    # Converts each token into lowercase
    for i in range(len(tokens)):
        tokens[i] = tokens[i].lower()

    comment_words += " ".join(tokens)+" "



wordcloud2 = WordCloud(width = 800, height = 800,
                background_color ='white',
                colormap="Reds",
                stopwords = stopwords,
                min_font_size = 10).generate(comment_words)
ax2.imshow(wordcloud2)
ax2.axis('off')
ax2.set_title('Negative Sentiment',fontsize=35);



comment_words = ''
for val in df_neu.text:

    # typecaste each val to string
    val = str(val)

    # split the value
    tokens = val.split()

    # Converts each token into lowercase
    for i in range(len(tokens)):
        tokens[i] = tokens[i].lower()

    comment_words += " ".join(tokens)+" "

wordcloud3 = WordCloud(width = 800, height = 800,
                background_color ='white',
                colormap="Greys",
                stopwords = stopwords,
                min_font_size = 10).generate(comment_words)
ax3.imshow(wordcloud3)
ax3.axis('off')
ax3.set_title('Neutal Sentiment',fontsize=35);
```





4.Models

In [12]:

```
df['labelled_sentiment'] = LabelEncoder().fit_transform(df.sentiment)
```

```
xtrain, xvalid, ytrain, yvalid = train_test_split(df.text, df.labelled_sentiment,
                                                  stratify=df.labelled_sentiment,
                                                  random_state=42,
                                                  test_size=0.2, shuffle=True)
```

In [13]:

```
class Lemmatizer(object):
    def __init__(self):
        self.lemmatizer = WordNetLemmatizer()
    def __call__(self, sentence):
        sentence=re.sub('(https?:\/\/)?([\da-z\.-]+)\.([a-z\.]{2,6})([\/\w \.-]*)',' ',s
entence)
        sentence=re.sub('[^0-9a-z]',' ',sentence)
        return [self.lemmatizer.lemmatize(word) for word in sentence.split() if len(word
)>1]

# using keras tokenizer here
token = Tokenizer(num_words=None)
max_len = 60

token=Tokenizer(num_words=None,oov_token=Lemmatizer())
token.fit_on_texts(xtrain)
train_x = token.texts_to_sequences(xtrain)
train_x_padded = pad_sequences(train_x ,maxlen=max_len, padding='post', truncating='post
')
test_x = token.texts_to_sequences(xvalid)
test_x_padded = pad_sequences(test_x, maxlen=max_len, padding='post', truncating='post')
```

1.LSTM

In [34]:

```
embedding_dimension=32
v=len(token.word_index)
num_epoch=20
size_batch=64

early_stop=EarlyStopping(monitor='val_accuracy',patience=1)
reduceLR=ReduceLROnPlateau(monitor='val_accuracy',patience=1)

model=Sequential()
model.add(Input(shape=(60,)))
model.add(Embedding(v+1,embedding_dimension))
model.add(LSTM(64,return_sequences=True))
model.add(GlobalMaxPool1D())
model.add(Dense(64))
model.add(Dense(3,activation='softmax'))
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accurac
y'])
r=model.fit(train_x_padded, ytrain, validation_split=0.2,
            epochs=num_epoch, batch_size=size_batch,
            callbacks=[reduceLR,early_stop])
```

```
WARNING:tensorflow:Please add `keras.layers.InputLayer` instead of `keras.Input` to Seque
ntial model. `keras.Input` is intended to be used by Functional model.
Epoch 1/20
450/450 [==============================] - 11s 21ms/step - loss: 0.8830 - accuracy: 0.564
2 - val_loss: 0.5023 - val_accuracy: 0.8216
Epoch 2/20
450/450 [==============================] - 9s 20ms/step - loss: 0.3485 - accuracy: 0.8870
- val_loss: 0.4946 - val_accuracy: 0.8220
Epoch 3/20
450/450 [==============================] - 9s 20ms/step - loss: 0.1934 - accuracy: 0.9424
- val_loss: 0.5965 - val_accuracy: 0.7860
```

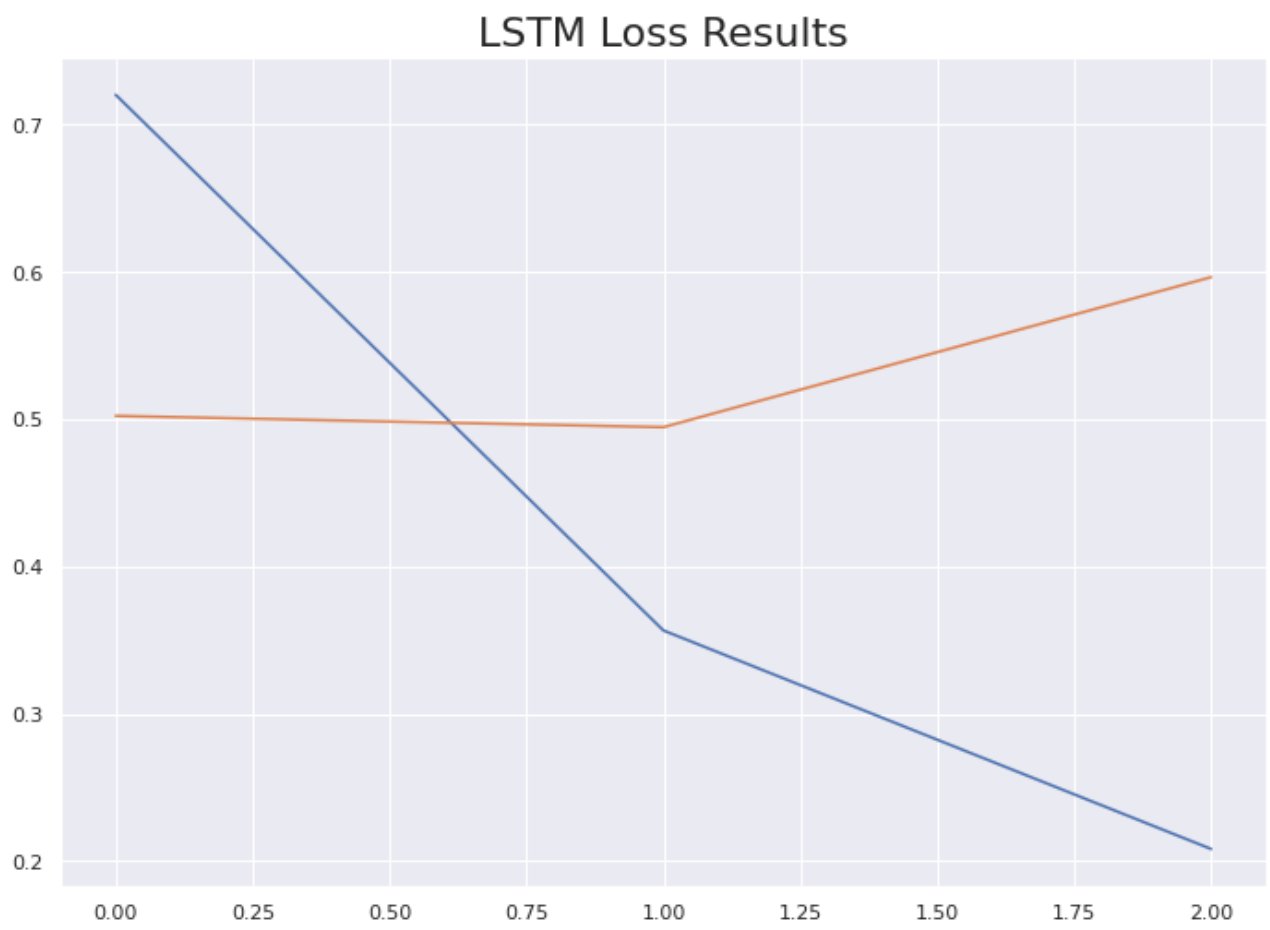
In [36]:

```
plt.plot(r.history['loss'])
```

```
plt.plot(r.history['val_loss'])
plt.title('LSTM Loss Results',fontdict={'size':'22'})
plt.plot()
```

Out[36]:

```
[]
```



In [37]:

```
ypred = model.predict(test_x_padded)
ypred = [np.argmax(i) for i in ypred]
```

In [38]:

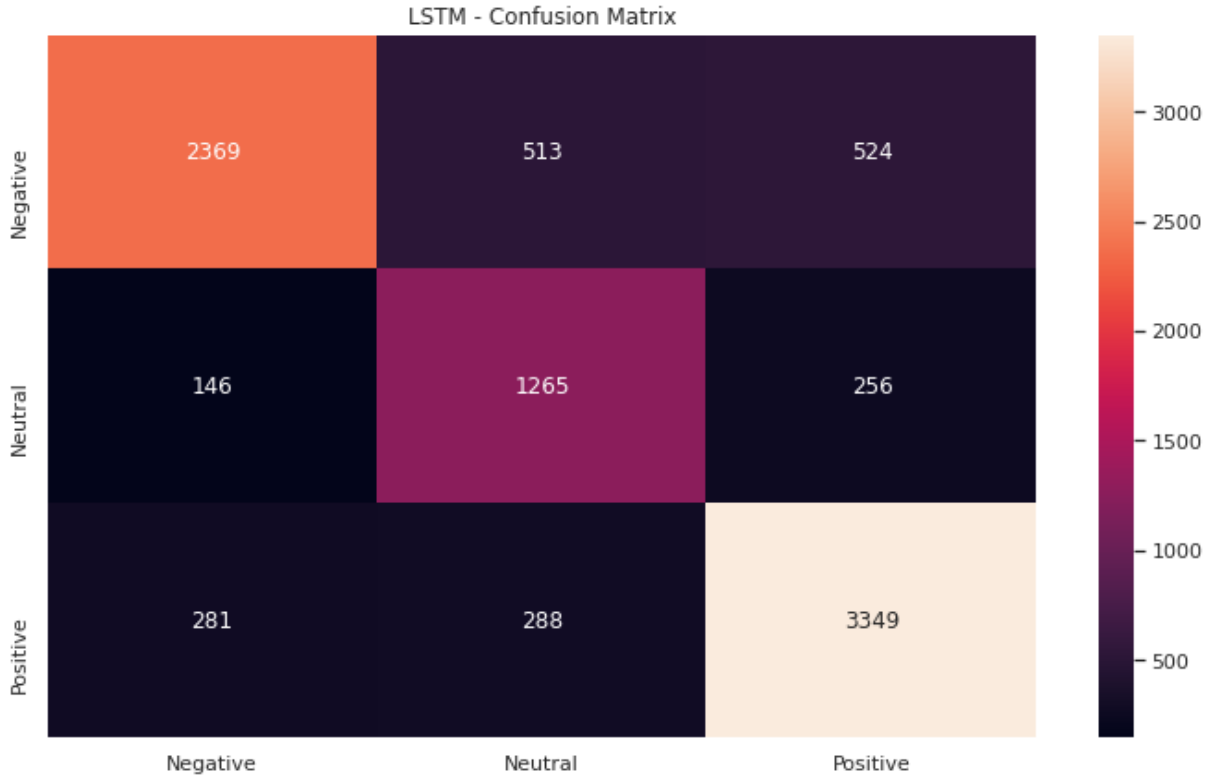
```
print(classification_report(yvalid,ypred,target_names=['Negative', 'Neutral', 'Positive'
]))
```

```
              precision    recall  f1-score   support

    Negative       0.85      0.70      0.76      3406
     Neutral       0.61      0.76      0.68      1667
    Positive       0.81      0.85      0.83      3918

    accuracy                           0.78      8991
   macro avg       0.76      0.77      0.76      8991
weighted avg       0.79      0.78      0.78      8991
```

In [39]:

```
labels = ['Negative', 'Neutral', 'Positive']
conf = confusion_matrix(yvalid, ypred)
cm = pd.DataFrame(
    conf, index = [i for i in labels],
    columns = [i for i in labels]
)

plt.figure(figsize = (12,7))
sns.heatmap(cm, annot=True, fmt="d")
plt.title("LSTM - Confusion Matrix")
```

```
plt.show()
```



2. GRU

In [40]:

```
num_epoch=20
size_batch=64

model = Sequential()
model.add(Input(shape=(60,)))
model.add(Embedding(v+1,embedding_dimension))
model.add(GRU(64,return_sequences=True))
model.add(GlobalMaxPool1D())
model.add(Dense(64))
model.add(Dense(3,activation='softmax'))
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accurac
y'])
model.summary()
r=model.fit(train_x_padded, ytrain, validation_split=0.2,
            epochs=num_epoch, batch_size=size_batch,
            callbacks=[reduceLR,early_stop])
```

```
WARNING:tensorflow:Please add `keras.layers.InputLayer` instead of `keras.Input` to Seque
ntial model. `keras.Input` is intended to be used by Functional model.
Model: "sequential_7"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_7 (Embedding)      (None, 60, 32)            1731360
_________________________________________________________________
gru_1 (GRU)                  (None, 60, 64)            18816
_________________________________________________________________
global_max_pooling1d_7 (Glob (None, 64)                0
_________________________________________________________________
dense_14 (Dense)             (None, 64)                4160
_________________________________________________________________
dense_15 (Dense)             (None, 3)                 195
=================================================================
Total params: 1,754,531
Trainable params: 1,754,531
Non-trainable params: 0
_________________________________________________________________
Epoch 1/20
```

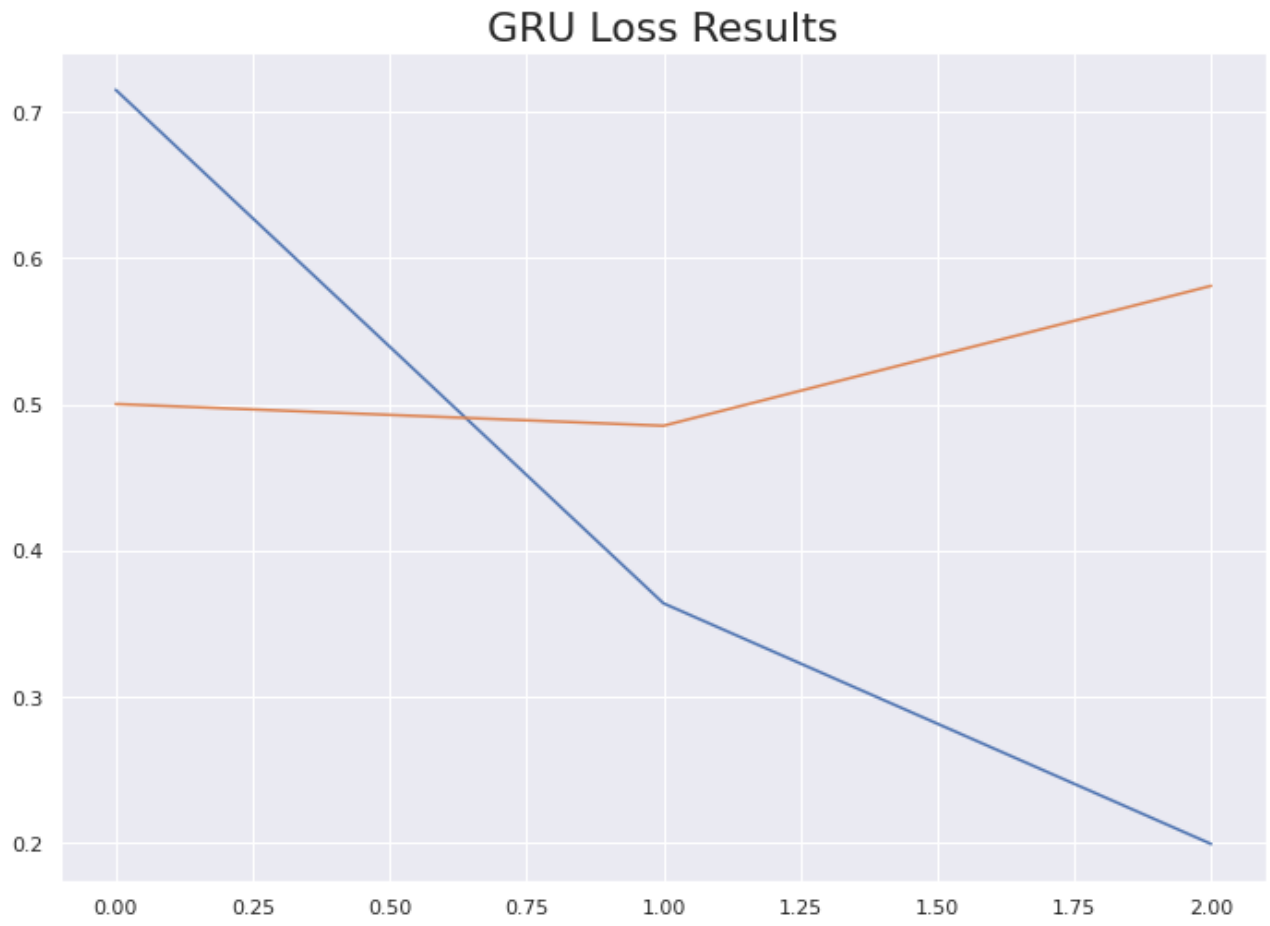
```
450/450 [==============================] - 11s 22ms/step - loss: 0.8792 - accuracy: 0.565
3 - val_loss: 0.5004 - val_accuracy: 0.8184
Epoch 2/20
450/450 [==============================] - 9s 20ms/step - loss: 0.3623 - accuracy: 0.8825
- val_loss: 0.4855 - val_accuracy: 0.8257
Epoch 3/20
450/450 [==============================] - 9s 21ms/step - loss: 0.1859 - accuracy: 0.9415
- val_loss: 0.5812 - val_accuracy: 0.8077
```

In [42]:

```
plt.plot(r.history['loss'])
plt.plot(r.history['val_loss'])
plt.title('GRU Loss Results',fontdict={'size':'22'})
plt.plot()
```

Out[42]:

```
[]
```

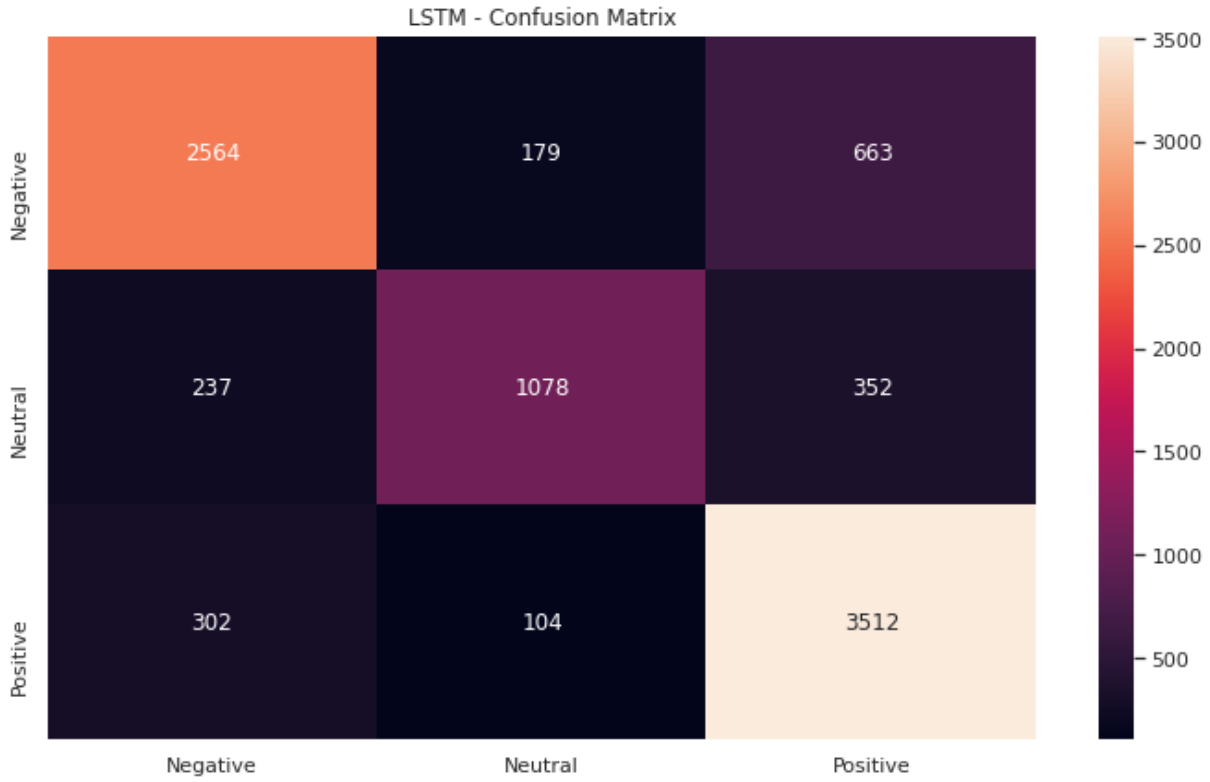


In [43]:

```
ypred = model.predict(test_x_padded)
ypred = [np.argmax(i) for i in ypred]
print(classification_report(yvalid,ypred,target_names=['Negative', 'Neutral', 'Positive'
]))
labels = ['Negative', 'Neutral', 'Positive']
conf = confusion_matrix(yvalid, ypred)
cm = pd.DataFrame(
    conf, index = [i for i in labels],
    columns = [i for i in labels]
)

plt.figure(figsize = (12,7))
sns.heatmap(cm, annot=True, fmt="d")
plt.title("LSTM - Confusion Matrix")
plt.show()
```

```
              precision    recall  f1-score   support

    Negative       0.83      0.75      0.79      3406
```

```
     Neutral       0.79      0.65      0.71      1667
    Positive       0.78      0.90      0.83      3918

    accuracy                           0.80      8991
   macro avg       0.80      0.77      0.78      8991
weighted avg       0.80      0.80      0.79      8991
```



3.Bi-Directional LSTM

In [44]:

```
num_epoch=20
size_batch=64

model = Sequential()
model.add(Input(shape=(60,)))
model.add(Embedding(v+1,embedding_dimension))
model.add(Bidirectional(LSTM(64,return_sequences=True)))
model.add(GlobalMaxPool1D())
model.add(Dense(64))
model.add(Dense(3,activation='softmax'))
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accurac
y'])
model.summary()
r=model.fit(train_x_padded, ytrain, validation_split=0.2,
            epochs=num_epoch, batch_size=size_batch,
            callbacks=[reduceLR,early_stop])
```

```
WARNING:tensorflow:Please add `keras.layers.InputLayer` instead of `keras.Input` to Seque
ntial model. `keras.Input` is intended to be used by Functional model.
Model: "sequential_8"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_8 (Embedding)      (None, 60, 32)            1731360
_________________________________________________________________
bidirectional_1 (Bidirection (None, 60, 128)           49664
_________________________________________________________________
global_max_pooling1d_8 (Glob (None, 128)               0
_________________________________________________________________
dense_16 (Dense)             (None, 64)                8256
_________________________________________________________________
dense_17 (Dense)             (None, 3)                 195
```

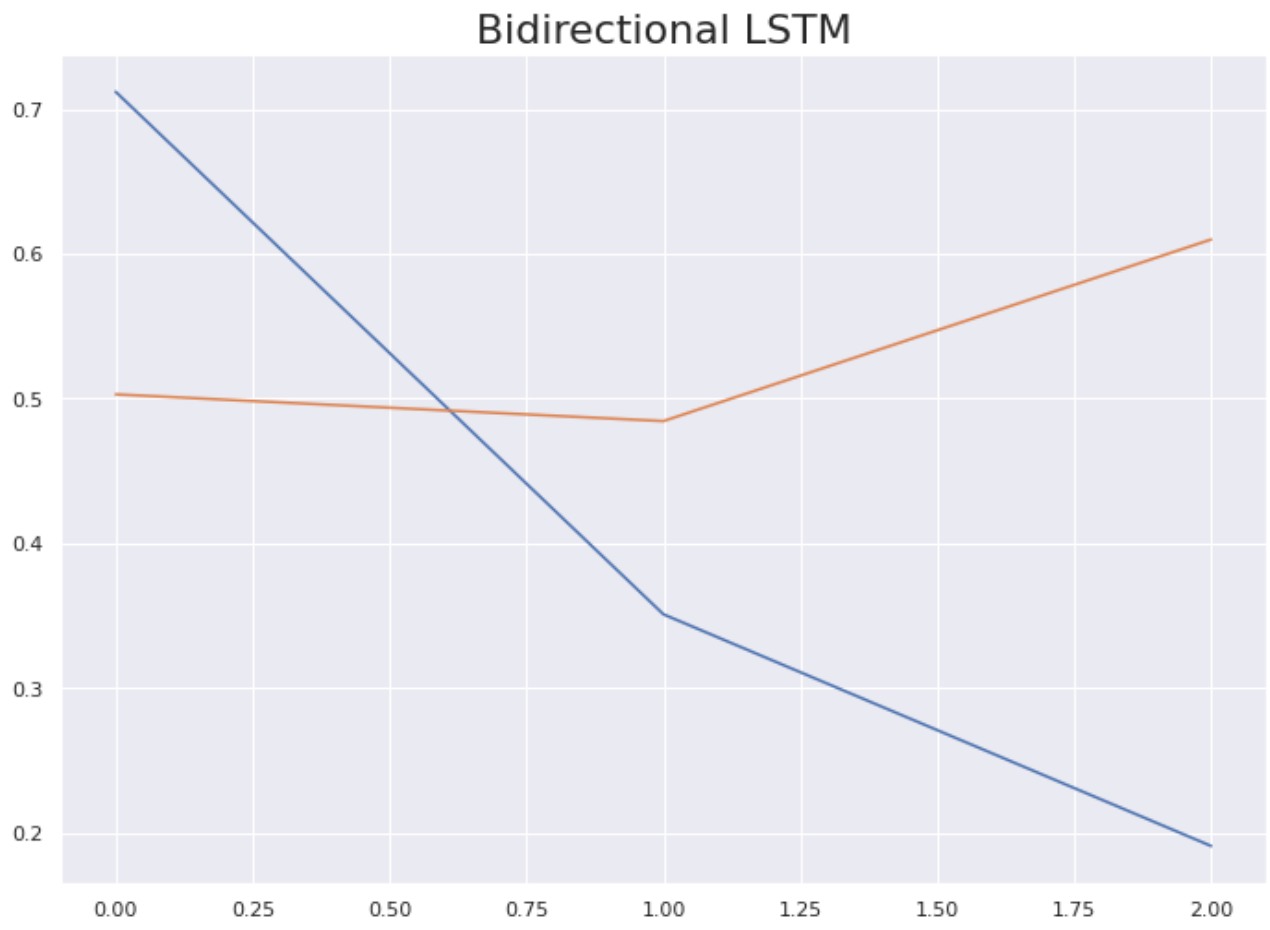
```
=================================================================
Total params: 1,789,475
Trainable params: 1,789,475
Non-trainable params: 0
_________________________________________________________________
Epoch 1/20
450/450 [==============================] - 16s 27ms/step - loss: 0.8836 - accuracy: 0.556
6 - val_loss: 0.5030 - val_accuracy: 0.8205
Epoch 2/20
450/450 [==============================] - 11s 24ms/step - loss: 0.3402 - accuracy: 0.890
5 - val_loss: 0.4845 - val_accuracy: 0.8289
Epoch 3/20
450/450 [==============================] - 11s 25ms/step - loss: 0.1760 - accuracy: 0.946
0 - val_loss: 0.6099 - val_accuracy: 0.7970
```

In [46]:

```
plt.plot(r.history['loss'])
plt.plot(r.history['val_loss'])
plt.title('Bidirectional LSTM',fontdict={'size':'22'})
plt.plot()
```

Out[46]:

```
[]
```



In [24]:

```
ypred = model.predict(test_x_padded)
ypred = [np.argmax(i) for i in ypred]
print(classification_report(yvalid,ypred,target_names=['Negative', 'Neutral', 'Positive'
]))
labels = ['Negative', 'Neutral', 'Positive']
conf = confusion_matrix(yvalid, ypred)
cm = pd.DataFrame(
    conf, index = [i for i in labels],
    columns = [i for i in labels]
)

plt.figure(figsize = (12,7))
sns.heatmap(cm, annot=True, fmt="d")
```

```
plt.title("LSTM - Confusion Matrix")
plt.show()
```

```
              precision    recall  f1-score   support

    Negative       0.80      0.83      0.81      3406
     Neutral       0.81      0.72      0.76      1667
    Positive       0.84      0.86      0.85      3918

    accuracy                           0.82      8991
   macro avg       0.82      0.80      0.81      8991
weighted avg       0.82      0.82      0.82      8991
```