Introduction

Sentiment Analysis can be defined as the process of analyzing text data and categorizing them into Positive, Negative, or Neutral sentiments. Sentiment Analysis is used in many cases like Social Media Monitoring, Customer service, Brand Monitoring, political campaigns, etc. Analyzing customer feedback such as social media conversations, product reviews, and survey responses allows companies to understand the customer’s emotions better which is becoming more essential to meet their needs.

Tweet => "My ridiculous dog is amazing." [sentiment: positive]

With all of the tweets circulating every second it is hard to tell whether the sentiment behind a specific tweet will impact a company, or a person's, brand for being viral (positive), or devastate profit because it strikes a negative tone. **Capturing sentiment in language is important** in these times where decisions and reactions are created and updated in seconds. **But, which words actually lead to the sentiment description?** In this competition you will need to **pick out the part of the tweet (word or phrase) that reflects the sentiment** .

Business Problem

It is almost impossible to manually sort thousands of social media conversations, customer reviews, and surveys. The problem I am trying to solve here is part of this Kaggle competition. In this problem, we are given some text data along with their **sentiment(positive/negative/neutral)** and **we need to find the phrases/words that best support the sentiment.**

Data Overview

The dataset used here is from the **Kaggle competition Tweet Sentiment Extraction**. The dataset used in this competition is from phrases from Figure Eight’s Data for Everyone platform.

It consists of two data files train.csv and test.csv, where there are 27481 rows in training data and 3534 rows in test data.

List of columns in the dataset

textID: unique id for each row of data

text: this column contains text data of the tweet.

sentiment: the sentiment of the text (positive/negative/neutral)

selected_text: phrases /words from the text that best supports the sentiment

Performance Metric

The performance metric used in this problem is the word-level Jaccard score. The Jaccard Score or Jaccard Similarity is one of the statistics used in understanding the similarity between two sets.

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} = \frac{|A \cap B|}{|A| + |B| - |A \cap B|}$$

In [ ]:

```
def jaccard(str1, str2):
  ''' function takes two input strings and outputs jaccard score '''
  a = set(str(str1).lower().split())
  b = set(str(str2).lower().split())
  c = a.intersection(b)
  return float(len(c)) / (len(a) + len(b) - len(c))
```

Reading-Data

In [ ]:

```
from google.colab import files
from datetime import datetime                          # using kaggle api token
api_token = files.upload()
```

Choose File **No file selected**

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving kaggle.json to kaggle.json
```

In [ ]:

```
!mkdir ~/.kaggle
!cp kaggle.json ~/.kaggle/
```

In [ ]:

```
!kaggle competitions download -c 'tweet-sentiment-extraction'
```

```
Warning: Your Kaggle API key is readable by other users on this system! To fix this, you
can run 'chmod 600 /root/.kaggle/kaggle.json'
Warning: Looks like you're using an outdated API Version, please consider updating (serve
r 1.5.12 / client 1.5.4)
Downloading test.csv to /content
  0% 0.00/307k [00:00<?, ?B/s]
100% 307k/307k [00:00<00:00, 46.6MB/s]
Downloading sample_submission.csv to /content
  0% 0.00/41.4k [00:00<?, ?B/s]
100% 41.4k/41.4k [00:00<00:00, 42.7MB/s]
Downloading train.csv.zip to /content
  0% 0.00/1.23M [00:00<?, ?B/s]
100% 1.23M/1.23M [00:00<00:00, 83.4MB/s]
```

In [ ]:

```
!unzip train.csv.zip
```

```
Archive:  train.csv.zip
  inflating: train.csv
```

In [ ]:

```
!pip install fuzzywuzzy
```

```
Collecting fuzzywuzzy
  Downloading fuzzywuzzy-0.18.0-py2.py3-none-any.whl (18 kB)
Installing collected packages: fuzzywuzzy
Successfully installed fuzzywuzzy-0.18.0
```

In [ ]:

```
from google.colab import drive
```

```
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [ ]:

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np                                                                        #
imports ....
import tensorflow as tf
%matplotlib inline
from plotly import graph_objs as go
import plotly.express as px
import plotly.figure_factory as ff
from collections import Counter
from PIL import Image
from wordcloud import WordCloud, STOPWORDS, ImageColorGenerator
%load_ext tensorboard
import nltk
from nltk.corpus import stopwords
import string
from tqdm import tqdm
import os
import re
import spacy
import random
import warnings
warnings.filterwarnings("ignore")
from numpy import array
from numpy import asarray
from numpy import zeros
from tensorflow.keras.callbacks import ModelCheckpoint
from tensorflow.keras.callbacks import CSVLogger,EarlyStopping,ModelCheckpoint, LearningR
ateScheduler
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.models import Sequential,Model
from tensorflow.keras.layers import Activation, Dropout, Flatten, Dense, Conv2D, MaxPool
ing2D,Embedding,LSTM,Embedding,Input,Softmax,Dense,Activation,Dropout
from fuzzywuzzy import fuzz
from sklearn.preprocessing import LabelEncoder,OneHotEncoder
import time
from time import time
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

In [ ]:

```
train_df = pd.read_csv('train.csv')
test_df = pd.read_csv('test.csv')
```

In [ ]:

```
train_df.head()
```

Out[ ]:

	textID	text	selected_text	sentiment
0	cb774db0d1	I`d have responded, if I were going	I`d have responded, if I were going	neutral
1	549e992a42	Sooo SAD I will miss you here in San Diego!!!	Sooo SAD	negative
2	088c60f138	my boss is bullying me...	bullying me	negative
3	9642c003ef	what interview! leave me alone	leave me alone	negative
4	358bd9e861	Sons of ****, why couldn`t they put them on t...	Sons of ****,	negative

In [ ]:

```
test_df.head()
```

Out[ ]:

	textID	text	sentiment
0	f87dea47db	Last session of the day http://twitpic.com/67ezh	neutral
1	96d74cb729	Shanghai is also really exciting (precisely -...	positive
2	eee518ae67	Recession hit Veronique Branquinho, she has to...	negative
3	01082688c6	happy bday!	positive
4	33987a8ee5	http://twitpic.com/4w75p - I like it!!	positive

EDA

In [ ]:

```
results_jaccard=[]

for ind,row in train_df.iterrows():
    sentence1 = row.text
# jaccard score between text and selected text of train data
    sentence2 = row.selected_text

    jaccard_score = jaccard(sentence1,sentence2)
    results_jaccard.append([sentence1,sentence2,jaccard_score])
```

In [ ]:

```
jaccard = pd.DataFrame(results_jaccard,columns=["text","selected_text","jaccard_score"])
# jaccard score between text and selected text
train_df = train_df.merge(jaccard,how='outer')
train_df['Num_words_ST'] = train_df['selected_text'].apply(lambda x:len(str(x).split()))
# Number Of words in Selected Text
train_df['Num_word_text'] = train_df['text'].apply(lambda x:len(str(x).split()))
# Number Of words in main text
train_df['difference_in_words'] = train_df['Num_word_text'] - train_df['Num_words_ST']
# difference in number of words
```

In [ ]:

```
train_df.head()
```

Out[ ]:

	textID	text	selected_text	sentiment	jaccard_score	Num_words_ST	Num_word_text	difference_in_words
0	cb774db0d1	I`d have responded, if I were going	I`d have responded, if I were going	neutral	1.000000	7	7	0
1	549e992a42	Sooo SAD I will miss you here in San Diego!!!	Sooo SAD	negative	0.200000	2	10	8
2	088c60f138	my boss is bullying me...	bullying me	negative	0.166667	2	5	3
3	9642c003ef	what interview! leave me alone	leave me alone	negative	0.600000	3	5	2
		Sons of ****, why couldn`t						

	textID	text	selected_text	sentiment	jaccard_score	Num_words_ST	Num_word_text	difference_in_words
4	358bd9e861	why couldn't they put them on t...	Sons of ****	negative	0.214286	3	14	11

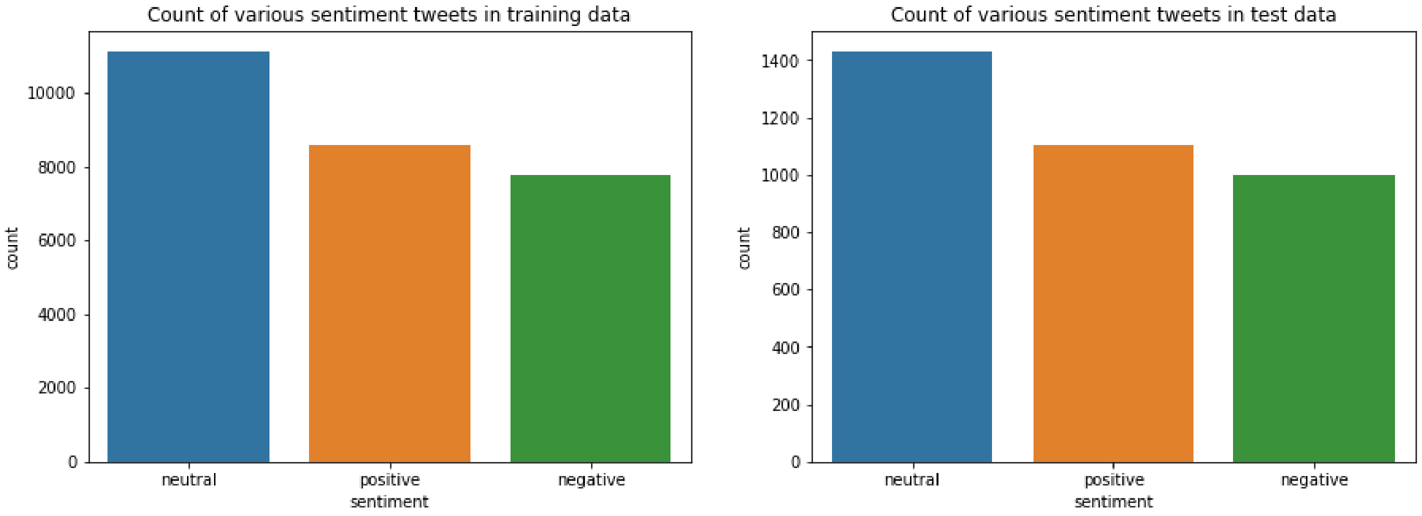
In [ ]:

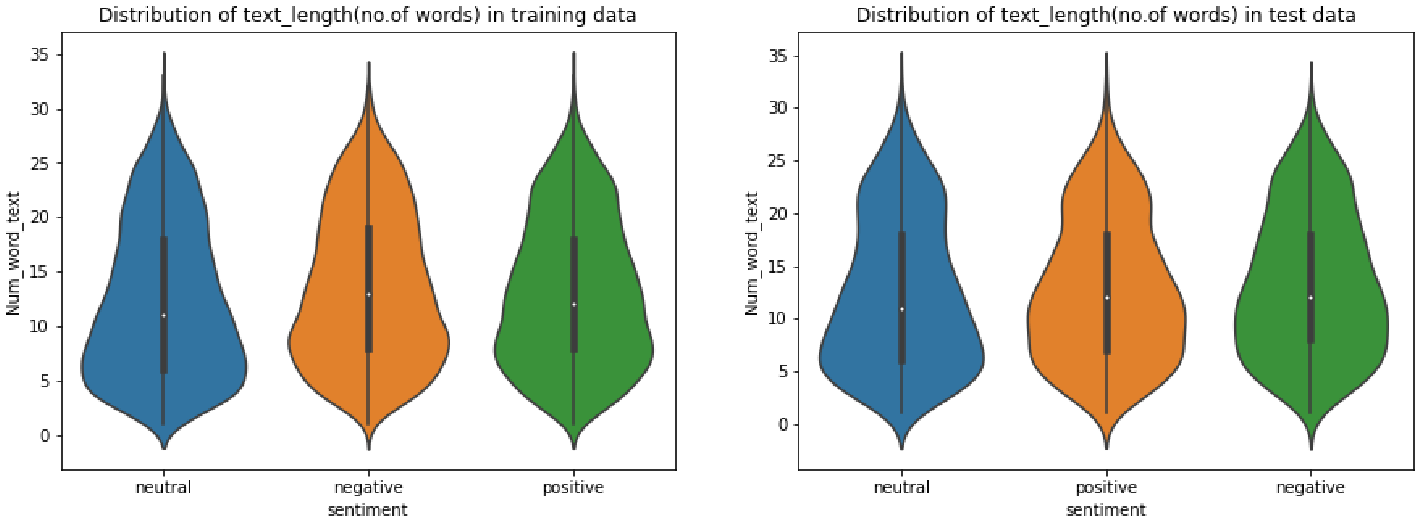
```
test_df['Num_word_text'] = test_df['text'].apply(lambda x:len(str(x).split())) #Number Of words in main text
```

Distributions

In [ ]:

```
f, axes = plt.subplots(1, 2,figsize=(15,5))

sns.countplot(x='sentiment',data=train_df,order=train_df.sentiment.value_counts().index,ax=axes[0])\
.set_title('Count of various sentiment tweets in training data');

sns.countplot(x='sentiment',data=test_df,order=test_df.sentiment.value_counts().index,ax=axes[1]);
plt.title('Count of various sentiment tweets in test data');


f, axes = plt.subplots(1, 2,figsize=(15,5))

sns.violinplot(y=train_df.Num_word_text,x=train_df.sentiment,ax=axes[0])\
.set_title('Distribution of text_length(no.of words) in training data');
sns.violinplot(data=test_df,y=test_df.Num_word_text,x='sentiment',ax=axes[1])\
.set_title('Distribution of text_length(no.of words) in test data');
```





distributions of train and test texts of each sentiment

observations: train and test textdata have same distributions and lenght of text for all sentiments lies between 5

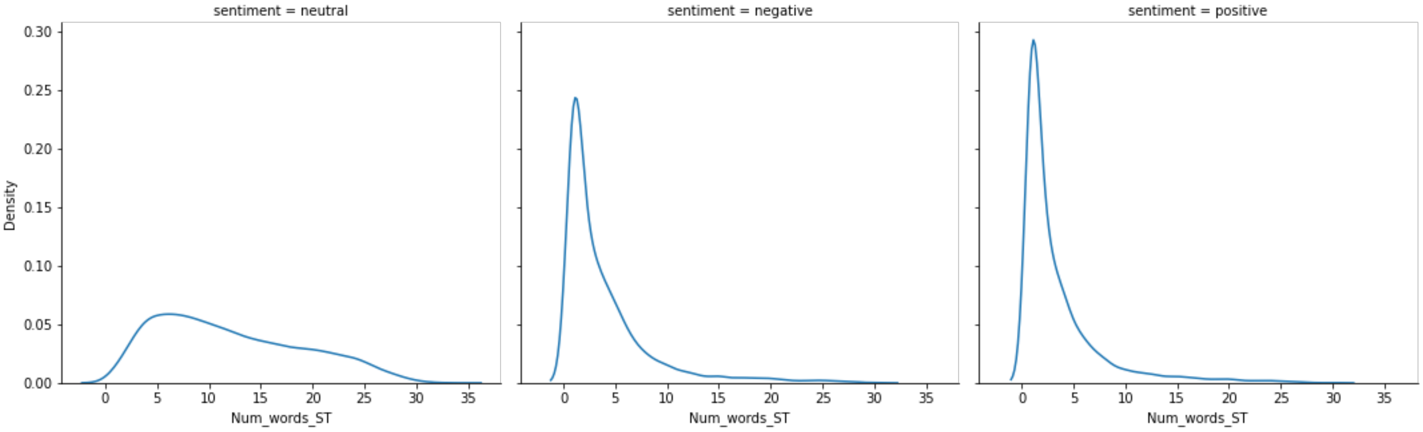
to 10 words

conclusion: train and test having similar distributions

In [ ]:

```
#https://stackoverflow.com/questions/29813694/how-to-add-a-title-to-seaborn-facet-plot
g=sns.FacetGrid(data=train_df,col='sentiment',height=5);
g.map(sns.kdeplot,'Num_words_ST');
plt.subplots_adjust(top=0.87,)
g.fig.suptitle('Distribution of selected_text length(no.of words) in training data for various sentiment labels',fontsize=16);


g=sns.FacetGrid(data=train_df,col='sentiment',height=5);
g.map(sns.kdeplot,'jaccard_score');
plt.subplots_adjust(top=0.87,)
g.fig.suptitle('Distribution of Jaccard score(btwn text & selected_text) in training data for various sentiment labels',fontsize=16);
```

Distribution of selected_text length(no.of words) in training data for various sentiment labels

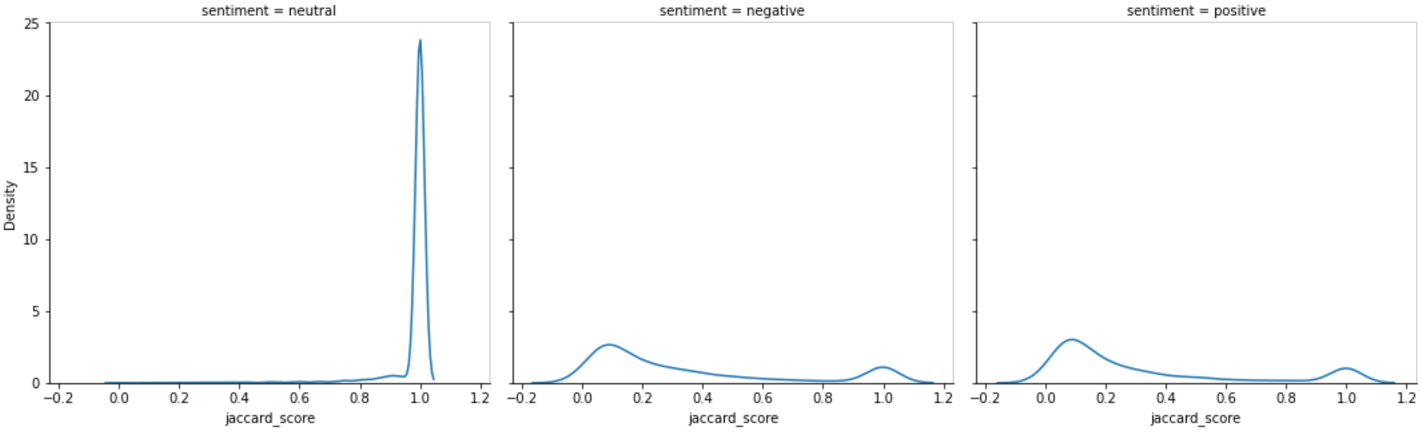


sentiment = neutral

sentiment = negative

sentiment = positive

Distribution of Jaccard score(btwn text & selected_text) in training data for various sentiment labels



sentiment = neutral

sentiment = negative

sentiment = positive

text_words and jaccord score distribution plots

observations:distributions of trian text and test text are very much similar unlike neutral text. jaccard score of negative and positive texts are similar having two peaks. jaccard score of neutral texts are mostly having values 1

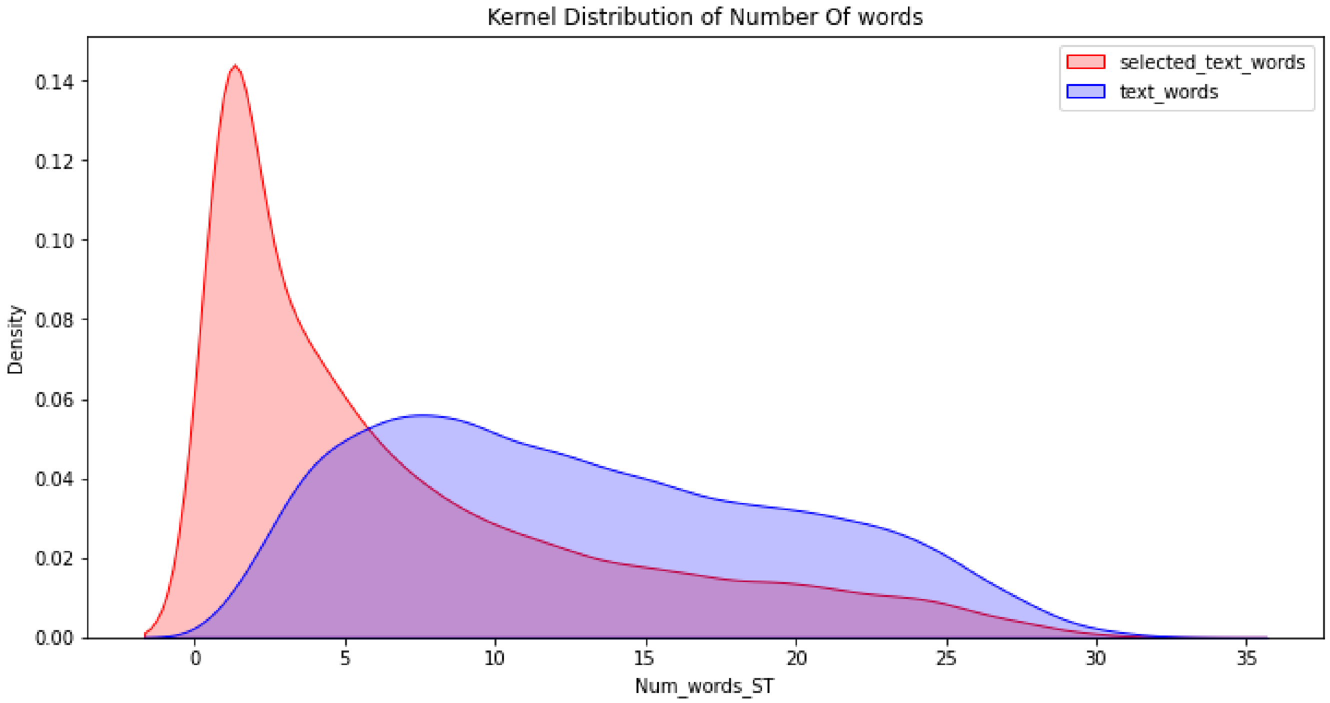
conclusion: positive and negative texts are similar with some kurtosis

In [ ]:

```
plt.figure(figsize=(12,6))
p1=sns.kdeplot(train_df['Num_words_ST'], shade=True, color="r").set_title('Kernel Distribution of Number Of words')
p1=sns.kdeplot(train_df['Num_word_text'], shade=True, color="b")
plt.legend(labels=['selected_text_words','text_words'])
```

Out[ ]:

```
<matplotlib.legend.Legend at 0x7feab81d9f90>
```



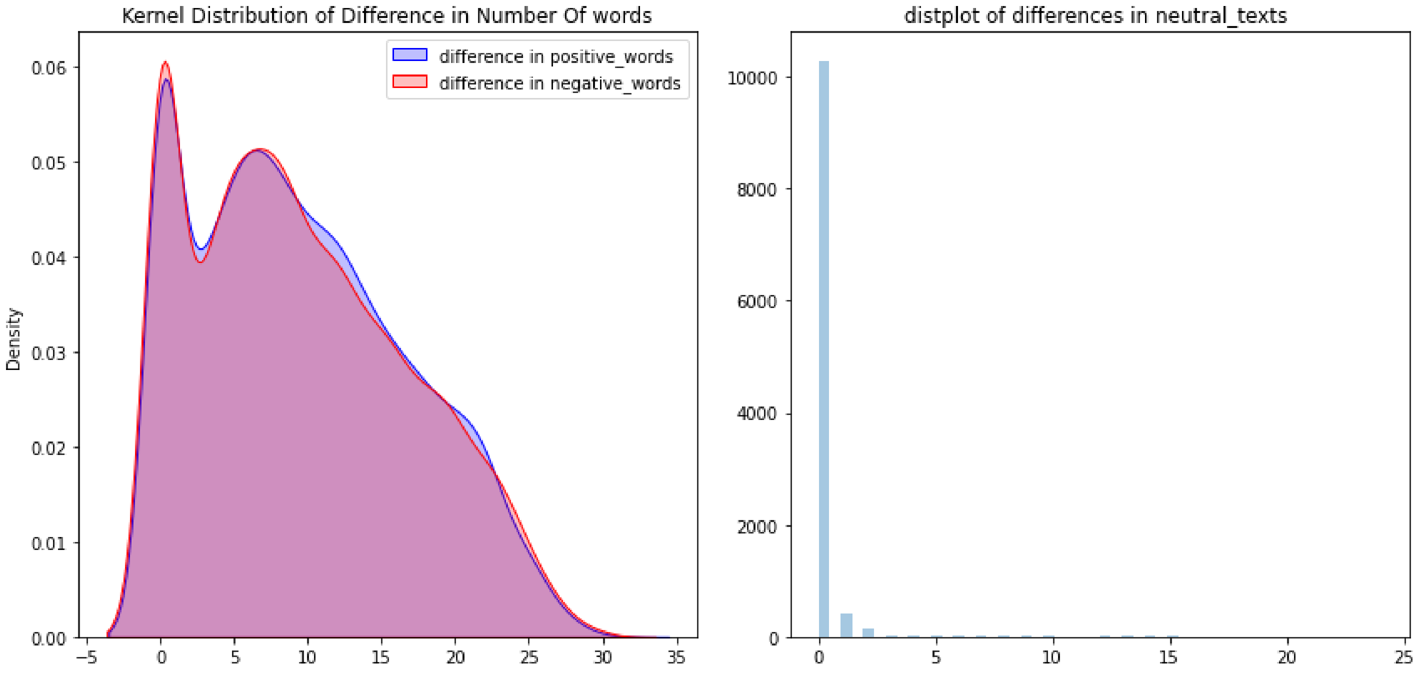
kde plot of text and selected text

observations: number of selected text words are mostley lies between 1 to 10 words.

conclusion: objective is to pick crucial part which supports sentiment thats why small number of words picked from whole text

In [ ]:

```
plt.figure(figsize=(12,6))
plt.subplot(1,2,1)
p1=sns.kdeplot(train_df[train_df['sentiment']=='positive']['difference_in_words'], shade=True, color="b").set_title('Kernel Distribution of Difference in Number Of words')
p2=sns.kdeplot(train_df[train_df['sentiment']=='negative']['difference_in_words'], shade=True, color="r")
plt.legend(labels=['difference in positive_words','difference in negative_words'])

plt.subplot(1,2,2)
sns.distplot(train_df[train_df['sentiment']=='neutral']['difference_in_words'],kde=False).set_title('distplot of differences in neutral_texts ')

plt.tight_layout()
plt.show();
```



difference_in_words difference_in_words

distributions of text with different sentiments

observations: positive and negative sentiments distributions are overlaped very well. neutral sentiment having mostly zero difference between text and selected-text

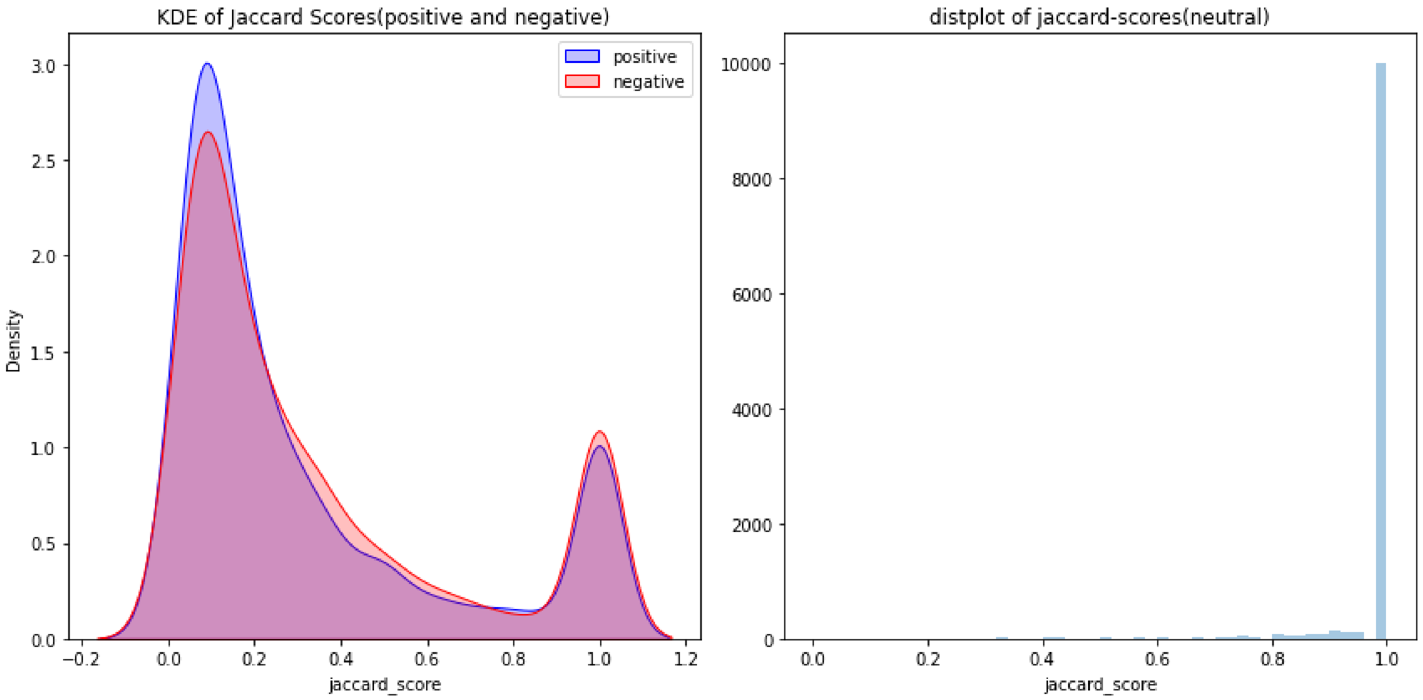
conclusion: for neutral texts most likely to select whole text as sentiment extraction

In [ ]:

```
```

In [ ]:

```
plt.figure(figsize=(12,6))
plt.subplot(1,2,1)
p1=sns.kdeplot(train_df[train_df['sentiment']=='positive']['jaccard_score'], shade=True, color="b").set_title('KDE of Jaccard Scores(positive and negative)')
p2=sns.kdeplot(train_df[train_df['sentiment']=='negative']['jaccard_score'], shade=True, color="r")
plt.legend(labels=['positive','negative'])


plt.subplot(1,2,2)
sns.distplot(train_df[train_df['sentiment']=='neutral']['jaccard_score'],kde=False).set_title('distplot of jaccard-scores(neutral)')

plt.tight_layout()
plt.show()
```



kde plots of jaccard scores with respect to positive and negative sentiment

observations: Positive and negative tweets have high kurtosis and thus values are concentrated in two regions narrow and high density Neutral tweets have a low kurtosis value and their is bump in density near values of 1

text-cleaning

In [ ]:

```
nltk.download('stopwords')
```

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

Out[ ]:

```
True
```

In [ ]:

```
def clean_text(text):
    '''Make text lowercase, remove text in square brackets,remove links,remove punctuatio
n
    and remove words containing numbers.'''
    text = str(text).lower()
    text = re.sub('\[.*?\]', '', text)
    text = re.sub('https?://\S+|www\.\S+', '', text)
    text = re.sub('<.*?>+', '', text)
    text = re.sub('[%s]' % re.escape(string.punctuation), '', text)
    text = re.sub('\n', '', text)
    text = re.sub('\w*\d\w*', '', text)
    return text
def remove_stopword(x):
    return [y for y in x if y not in stopwords.words('english')]
# train_df['temp_list'] = train_df['temp_list'].apply(lambda x:remove_stopword(x))
```

In [ ]:

```
train_df['text'] = train_df['text'].apply(lambda x:clean_text(x))
train_df['selected_text'] = train_df['selected_text'].apply(lambda x:clean_text(x))
```

In [ ]:

```
train_df['temp_list1'] = train_df['text'].apply(lambda x:str(x).split()) #List of words
in every row for text
train_df['temp_list1'] = train_df['temp_list1'].apply(lambda x:remove_stopword(x))
```

most-common_words

In [ ]:

```
top = Counter([item for sublist in train_df['temp_list1'] for item in sublist])
temp = pd.DataFrame(top.most_common(25))
temp = temp.iloc[1:,:]
temp.columns = ['Common_words','count']
temp.style.background_gradient(cmap='Blues')
```

Out[ ]:

	Common_words	count
1	day	2044
2	good	1549
3	get	1426
4	like	1346
5	go	1267
6	dont	1200
7	love	1122
8	work	1112
9	going	1096
10	today	1096
11	got	1072
12	cant	1020
13	happy	976
14	one	971
15	lol	948

	Common_words	count
16	time	942
17	know	930
18	u	923
19	really	908
20	back	891
21	see	797
22	well	744
23	new	740
24	night	737

In [ ]:

```
fig = px.bar(temp, x="count", y="Common_words", title='Commmon Words in Text', orientati
on='h',width=700, height=700,color='Common_words')
fig.show()
```

Most common words Sentiments Wise

In [ ]:

```
Positive_sent = train_df[train_df['sentiment']=='positive']
Positive_sent = train_df[train_df['sentiment']=='positive']
Negative_sent = train_df[train_df['sentiment']=='negative']
Neutral_sent = train_df[train_df['sentiment']=='neutral']
```

In [ ]:

```
top = Counter([item for sublist in Positive_sent['temp_list'] for item in sublist])
temp_positive = pd.DataFrame(top.most_common(20))
temp_positive.columns = ['Common_words','count']
temp_positive.style.background_gradient(cmap='Greens')
```

Out[ ]:

	Common_words	count
0	i	1040
1	good	826
2	happy	730
3	love	697
4	you	623
5	to	608
6	a	589
7	the	571
8	day	456
9	thanks	439
10	great	364
11	it	349
12	my	288
13	fun	287
14	for	284
15	is	272
16	nice	267
17	so	267
18	and	265
19	mothers	259

In [ ]:

```
fig = px.bar(temp_positive, x="count", y="Common_words", title='Most Commmon Positive Words', orientation='h',width=700, height=700,color='Common_words')
fig.show()
```

In [ ]:

```
#MosT common Neutral words
top = Counter([item for sublist in Neutral_sent['temp_list'] for item in sublist])
temp_neutral = pd.DataFrame(top.most_common(20))
temp_neutral = temp_neutral.loc[1:,:]
temp_neutral.columns = ['Common_words','count']
temp_neutral.style.background_gradient(cmap='Reds')
```

Out[ ]:

	Common_words	count
1	to	4103
2	the	3472
3	a	2477
4	my	1971
5	and	1800
6	you	1760
7	in	1574
8	it	1476
9	is	1470
10	for	1406
11	on	1256
12	of	1218
13	me	1081
14	but	1080
15	im	1039
16	have	994
17	that	905
18	just	881
19	with	816

In [ ]:

```
fig = px.bar(temp_neutral, x="count", y="Common_words", title='Most Commmon Neutral Word
s', orientation='h',width=700, height=700,color='Common_words')
fig.show()
```

In [ ]:

```
#MosT common negative words
top = Counter([item for sublist in Negative_sent['temp_list'] for item in sublist])
temp_negative = pd.DataFrame(top.most_common(20))
temp_negative = temp_negative.iloc[1:,:]
temp_negative.columns = ['Common_words','count']
temp_negative.style.background_gradient(cmap='Reds')
```

Out[ ]:

	Common_words	count
1	to	594
2	the	547
3	my	524
4	a	472
5	im	452
6	not	407
7	is	373
8	so	360

	Common_words	count
9	miss	358
10	sad	343
11	it	333
12	me	317
13	sorry	300
14	in	261
15	and	256
16	bad	246
17	that	244
18	you	241
19	hate	230

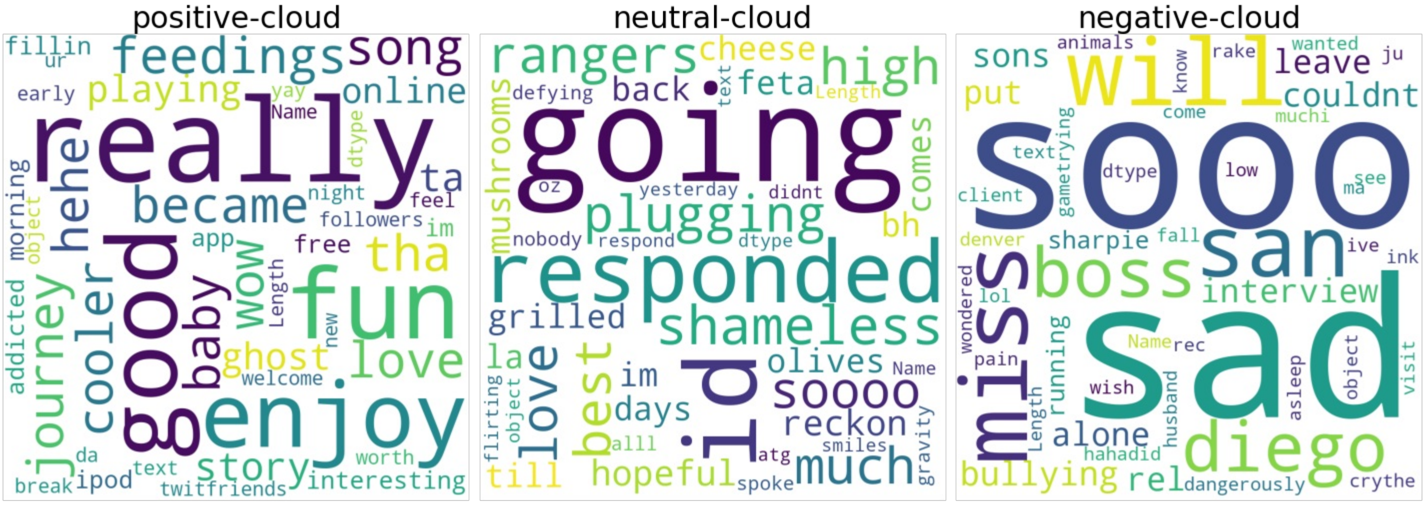
In [ ]:

```
fig = px.bar(temp_negative, x="count", y="Common_words", title='Most Commmon Negative Wor
ds', orientation='h',width=700, height=700,color='Common_words')
fig.show()
```

Word-Clouds of sentiments

In [ ]:

```
from wordcloud import WordCloud, STOPWORDS

wordcloud1 = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,min_font_size = 10).generate(str(Positive_sent.text))
wordcloud2 = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,min_font_size = 10).generate(str(Neutral_sent.text))
wordcloud3 = WordCloud(width = 800, height = 800, background_color ='white', stopwords = stopwords,min_font_size = 10).generate(str(Negative_sent.text))

plt.figure(figsize = (20, 10), facecolor = None)
plt.subplot(1,3,1)
plt.imshow(wordcloud1)
plt.axis("off")
plt.title('positive-cloud',size=30)

plt.subplot(1,3,2)
plt.imshow(wordcloud2)
plt.axis("off")
plt.title('neutral-cloud',size=30)

plt.subplot(1,3,3)
plt.imshow(wordcloud3)
plt.axis("off")
plt.tight_layout()
plt.title('negative-cloud',size=30)

plt.show()
```



In [ ]:

```

```

Pre-Processing

text-cleaning

In [ ]:

```
# nltk.download('stopwords')
# !pip install fuzzywuzzy
```

In [ ]:

```
#https://stackoverflow.com/questions/11331982/how-to-remove-any-url-within-a-string-in-python
#https://stackoverflow.com/questions/12851791/removing-numbers-from-string
#https://stackoverflow.com/questions/18082130/python-regex-to-remove-all-words-which-contains-number
#https://www.analyticsvidhya.com/blog/2021/06/text-preprocessing-in-nlp-with-python-codes/
```

```
def text_cleaning(text):
  '''' takes input as raw  text  and removes hyperlinks,Numbers,Angular Brackets,Square Brackets,'\n' character,**** by ABUSE,wordpuntuation '''
  text = str(text).lower()
  text = re.sub('https?://\S+|www\.\S+', '', text)   #Removing hyperlinks
  text=re.sub('\S*\d\S*',' ',text) #Removing Numbers
  text=re.sub('<.*?>+',' ',text)   #Removing Angular Brackets
  text=re.sub('\[.*?\]',' ',text)  #Removing Square Brackets
  text=re.sub('\n',' ',text)        #Removing '\n' character
  text=re.sub('\*+','<ABUSE>',text) #Replacing **** by ABUSE word
  text = "".join([i for i in text if i not in string.punctuation])  # Removing puntuation


  return text

train_df['text']=train_df['text'].apply(lambda x:text_cleaning(x))
test_df['text']=test_df['text'].apply(lambda x:text_cleaning(x))
train_df['selected_text']=train_df['selected_text'].apply(lambda x:text_cleaning(x))
```

In [ ]:

```
# def remove_stopword(x):
#     return [y for y in x if y not in stopwords.words('english')]
# train_df['selected_text']=train_df['selected_text'].apply(lambda x:remove_stopword(x))
# train_df['text']=train_df['text'].apply(lambda x:remove_stopword(x))
```

text-fixing btw text & selected_text

In [ ]:

```
train_df = train_df.drop(train_df[train_df["text"]==' '].index)                 # removing empty cells
train_df = train_df.drop(train_df[train_df["selected_text"]==' '].index)
```

In [ ]:

```
def miss_match(text,selected):
  ''' function takes text and selected text as input and outputs  miss matched words between them '''
  words=[]
  text=text.split()
  selected=selected.split()
  for i in selected:
    if i not in text:
      words.append(i)
  if len(words)>0:
    return " ".join(words)
  else:
    return '****'

train_df['spelling']=train_df.apply(lambda x: miss_match(x.text,x.selected_text),axis=1)
```

In [ ]:

```
#https://www.geeksforgeeks.org/python-list-remove/
def remove_spelling(x):
  ''' function takes of df with selected text ,spelling and removes miss matched spelling words from selected text'''
  selected=x[0]
  spelling=x[1]
  selected=selected.split()
  selected.remove(spelling)
  return " ".join(selected)

train_df['selected_text']=train_df[['selected_text','spelling']].apply(lambda x: remove_spelling(x) if len(x['spelling'])==1  else x['selected_text'],axis=1)
```

fixing neutral text

In [ ]:

```
# finding wrong words(incompleted texts) present between text and selected text
train_df['spelling']=train_df.apply(lambda x: miss_match(x.text,x.selected_text),axis=1)
# replacing missing selected text in neutral sentiment with text
train_df['selected_text']=train_df.apply(lambda x: x['text'] if ( (x['spelling']!='****'
) & (x['sentiment']=='neutral') ) else x['selected_text'],axis=1)
train_df['spelling']=train_df.apply(lambda x: miss_match(x.text,x.selected_text),axis=1)
```

fuzz wuzz fix

In [ ]:

```
'''If length of wrong spelling is greater than 1. In that case one can use fuzzy wuzzy li
brary where we can have a score out of 100, that denotes two string are equal by giving s
imilarity index.'''
def fuzz_wuzz(x):
  ''' function takes df of text,selected_text,spelling and replaces selected text words w
ith text words if fuzz_wuzz ratio > 55 '''
  text=x[0]
  selected=x[1]
  spelling=x[2]
  text=text.split()
  selected=selected.split()                      # 1st iteration of fuzz wuzz
  spelling=spelling.split()
  for s in spelling:
    for t in text:
      if s in selected:                                 # fuzz.ratio > 55( ratio ranges
from 1 to 100)
        if(fuzz.ratio(t,s)>55):
          index=selected.index(s)
          selected[index]=t
  return " ".join(selected)                          #This ratio uses a simple technique
which involves calculating the edit distance (Levenshtein distance) between two strings.
```

In [ ]:

```
train_df['selected_text']=train_df[['text','selected_text','spelling']].apply(lambda x:
fuzz_wuzz(x) if x['spelling']!='****'  else x['selected_text'],axis=1)
train_df['spelling']=train_df.apply(lambda x: miss_match(x.text,x.selected_text),axis=1)
train_df['selected_text']=train_df[['selected_text','spelling']].apply(lambda x: remove_s
pelling(x) if len(x['spelling'])==1  else x['selected_text'],axis=1)
train_df['spelling']=train_df.apply(lambda x: miss_match(x.text,x.selected_text),axis=1)
```

In [ ]:

```
def fuzz_wuzz(x):
  ''' function takes df of text,selected_text,spelling and replaces selected text words w
ith text words if fuzz_wuzz ratio > 35 '''
  text=x[0]
  selected=x[1]
  spelling=x[2]
  text=text.split()                                   # 2nd iteration of fuzz wuzz
  selected=selected.split()
  spelling=spelling.split()
  for s in spelling:
    for t in text:
      if s in selected:
        if(fuzz.ratio(t,s)>35):                        # fuzz.ratio > 35
          index=selected.index(s)
          selected[index]=t
  return " ".join(selected)
```

In [ ]:

```
train_df['selected_text']=train_df[['text','selected_text','spelling']].apply(lambda x:
fuzz_wuzz(x) if x['spelling']!='****'  else x['selected_text'],axis=1)
train_df['spelling']=train_df.apply(lambda x: miss_match(x.text,x.selected_text),axis=1)
```

hand-fixes

In [ ]:

```
train_df.loc[(train_df['spelling']!='****') & (train_df['sentiment']=='positive')]
# for  positive sentiment
```

Out[ ]:

	textID	text	selected_text	sentiment	spelling
1588	a7f72a928a	woooooooooo are you coming to nottingham at...	to lovelovelove	positive	lovelovelove
7410	3463ecdfd6	imintheroom imwatchingthehannahmoviewithmomshe...	great	positive	great
10521	f29edbc282	dora the explorer greetings to your niece	enjoy	positive	enjoy

In [ ]:

```
train_df.loc[(train_df['spelling']!='****') & (train_df['sentiment']=='negative')]
# for negative sentiment
```

Out[ ]:

	textID	text	selected_text	sentiment	spelling
2398	983dfecd25	gonna do laundrynever did laundry a hotel bef...	did miss you r	negative	r
6113	2cb67e64b4	these dogs are going to die if somebody doe...	aam these dogs are going to die if somebody do...	negative	aam
9817	3358792fc9	following and followers nice	not nice	negative	not
13637	d83fd6c942	tweeets fgs tweekdeckkk hates me cryyyy	kk hates me cryyyy	negative	kk
14839	b19376c3bd	just got back fromahem boring but had to eat...	was boring but had to eat nonetheless	negative	was
16201	e78c1ad3f5	off to work off at	lammmeeee	negative	lammmeeee
25293	2fdbe40c03	grreverytime he gets a new girlfriendim at the...	im at the bottom of the totem pole	negative	im

In [ ]:

```
train_df.loc[7410].text='im in the room im watching the hannah movie with mom she said th
is film very great'
train_df.loc[1588].selected_text='woooooooooo'
# positive
train_df.loc[10521].selected_text='greetings'

train_df.loc[2398].selected_text='did miss you'
train_df.loc[6113].selected_text='these dogs are going to die if somebody doesnt save the
m'
train_df.loc[9817].text='following and followers not nice'
train_df.loc[13637].selected_text='hates me  cryyyy'
train_df.loc[14839].selected_text='boring but had to eat nonetheless'
# negative
train_df.loc[16201].selected_text='off to work'
train_df.loc[25293].selected_text='at the bottom of the totem pole'
```

In [ ]:

```
train_df[train_df.selected_text =='']
```

Out[ ]:

	textID	text	selected_text	sentiment	spelling
8729	12f21c8f19	star wars is ABUSE boo i wanna do your job h...		positive	****
26005	0b3fe0ca78			neutral	****

In [ ]:

```
train_df = train_df.drop([8729,26005],axis=0)
```

NLP Models

jaccard score as metric

In [ ]:

```
def jaccard(str1,str2):
  a=set(str1.lower().split())
  b=set(str2.lower().split())
  c=a.intersection(b)
  return float(len(c)) / (len(a) + len(b) - len(c))
```

LSTM

creating target labels

In [ ]:

```
nltk.download('punkt')
```

```
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
```

Out[ ]:

```
True
```

In [ ]:

```
def create_targets(df):
  ''' function takes text and selected_text then creates target labels as 1's&0's  by fin
ding offset of text '''

  df['t_text'] = df['text'].apply(lambda x: nltk.tokenize.word_tokenize(str(x)))
  df['t_selected_text'] = df['selected_text'].apply(lambda x: nltk.tokenize.word_tokeniz
e(str(x)))
  def func(row):
    x,y = row['t_text'],row['t_selected_text'][:]
    for offset in range(len(x)):
      d = dict(zip(x[offset:],y))
      #when k = v that means we found the offset
      check = [k==v for k,v in d.items()]
# 1st approch
      if all(check)== True:
        break
    return [0]*offset + [1]*len(y) + [0]* (len(x)-offset-len(y))

  df['targets'] = df.apply(func,axis=1)
  return df
# train_df = create_targets(train_df)
MAX_TARGET_LEN = max(train_df['targets'].apply(len))

train_df['targets'] = train_df['targets'].apply(lambda x :x + [0] * (MAX_TARGET_LEN-len(
x)))
targets=np.asarray(train_df['targets'].values.tolist())

#https://stackoverflow.com/questions/10346336/list-of-lists-into-numpy-array
y = np.array([np.array(xi,dtype='float32') for xi in targets])
MAX_TARGET_LEN
```

Out[ ]:

```
47
```

In [ ]:

```
def start_index(x):
    text=x[0]
    selected=x[1]
    text=text.split()
    selected=selected.split()
    word=selected[0]
    index=text.index(word)
    return index
def end_index(x):
# 2nd approch
    text=x[0]
    selected=x[1]
    start_index=x[2]
    text=text.split()
    selected= selected.split()
    word=selected[-1]
    try:
        index=text.index(word,start_index)
    except:
        index=text.index(word)
    return index

train_df['start_index']=train_df[['text','selected_text']].apply(lambda x: start_index(x
),axis=1)
train_df['end_index']=train_df[['text','selected_text','start_index']].apply(lambda x: e
nd_index(x),axis=1)
train_df=train_df[train_df.start_index <= train_df.end_index]

y=np.zeros((train_df.shape[0],max(text_split)+1))
for i in range(train_df.shape[0]):
  start=train_df['start_index'][i]
  end=train_df['end_index'][i]
  y[i][start:end+1]=1                                                          #$\colo
r{blue}{\text{good}}$  for coloring text
```

train_test split

In [ ]:

```
X=train_df[['textID','text','selected_text','sentiment']]
X_train,X_valid,y_train,y_valid=train_test_split(X,y,test_size=0.15,random_state=42)
```

In [ ]:

```

```

In [ ]:

```
print("X_train shape ",X_train.shape,"  X_test shape ",X_valid.shape)
print("\ny_train shape ",y_train.shape,"  y_test shape ",y_valid.shape)
```

```
X_train shape  (23274, 4)   X_test shape  (4108, 4)

y_train shape  (23274, 33)   y_test shape  (4108, 33)
```

In [ ]:

```
y_train=np.expand_dims(y_train,-1)
y_valid=np.expand_dims(y_valid,-1)
y_train.shape,y_valid.shape                                      # expanding dimensions
```

Out[ ]:

```
((23274, 33, 1), (4108, 33, 1))
```

In [ ]:

```
train_text=X_train['text'].values
```

```
valid_text=X_valid['text'].values
train_sentiment=X_train['sentiment'].values                         # data to be fitted
valid_sentiment=X_valid['sentiment'].values
```

tokenizing

In [ ]:

```
token1=Tokenizer(num_words=None)
max_len_text=32

token1.fit_on_texts(list(train_text))
train_text=token1.texts_to_sequences(train_text)
valid_text=token1.texts_to_sequences(valid_text)


#zero pad the sequences
train_text=pad_sequences(train_text,maxlen=max_len_text,padding='post')
valid_text=pad_sequences(valid_text,maxlen=max_len_text,padding='post')

word_index_text=token1.word_index
```

In [ ]:

```
token2=Tokenizer(num_words=None)
max_len_sentiment=1

token2.fit_on_texts(list(train_sentiment))
train_sentiment=token2.texts_to_sequences(train_sentiment)
valid_sentiment=token2.texts_to_sequences(valid_sentiment)


#zero pad the sequences
train_sentiment=pad_sequences(train_sentiment,maxlen=max_len_sentiment,padding='post')
valid_sentiment=pad_sequences(valid_sentiment,maxlen=max_len_sentiment,padding='post')

word_index_sentiment=token2.word_index
print(word_index_sentiment)
```

```
{'neutral': 1, 'positive': 2, 'negative': 3}
```

glove embeddings

In [ ]:

```
embeddings_index = {}
with open('/content/drive/MyDrive/miscellaneous/glove.6B.100d.txt') as f:  #pre trained g
love vectors of 100 dimensions
  for line in tqdm(f):
    values = line.split(' ')
    word = values[0]
    coefs = np.asarray([float(val) for val in values[1:]])
    embeddings_index[word] = coefs
print('Found %s word vectors.' % len(embeddings_index))
```

In [ ]:

```
embedding_matrix_text=np.zeros((len(word_index_text) + 1, 300))
for word, i in tqdm(word_index_text.items()):
    embedding_vector=embeddings_index.get(word)                                # embedd
ing matrix for text data
    if embedding_vector is not None:
        embedding_matrix_text[i]=embedding_vector
```

```
100%|██████████| 24048/24048 [00:00<00:00, 223297.06it/s]
```

In [ ]:

```
embedding_matrix_sentiment=np.zeros((len(word_index_sentiment) + 1, 300))
for word, i in tqdm(word_index_sentiment.items()):
    embedding_vector=embeddings_index.get(word)                                 # embeddi
ng matrix for sentiment
    if embedding_vector is not None:
        embedding_matrix_sentiment[i]=embedding_vector
```

```
100%|██████████| 3/3 [00:00<00:00, 11814.94it/s]
```

LSTM as base-model

In [ ]:

```
max_len_text   = 46                  # 46 + 1 = 47 which out size(y)
max_len_sentiment  = 1
```

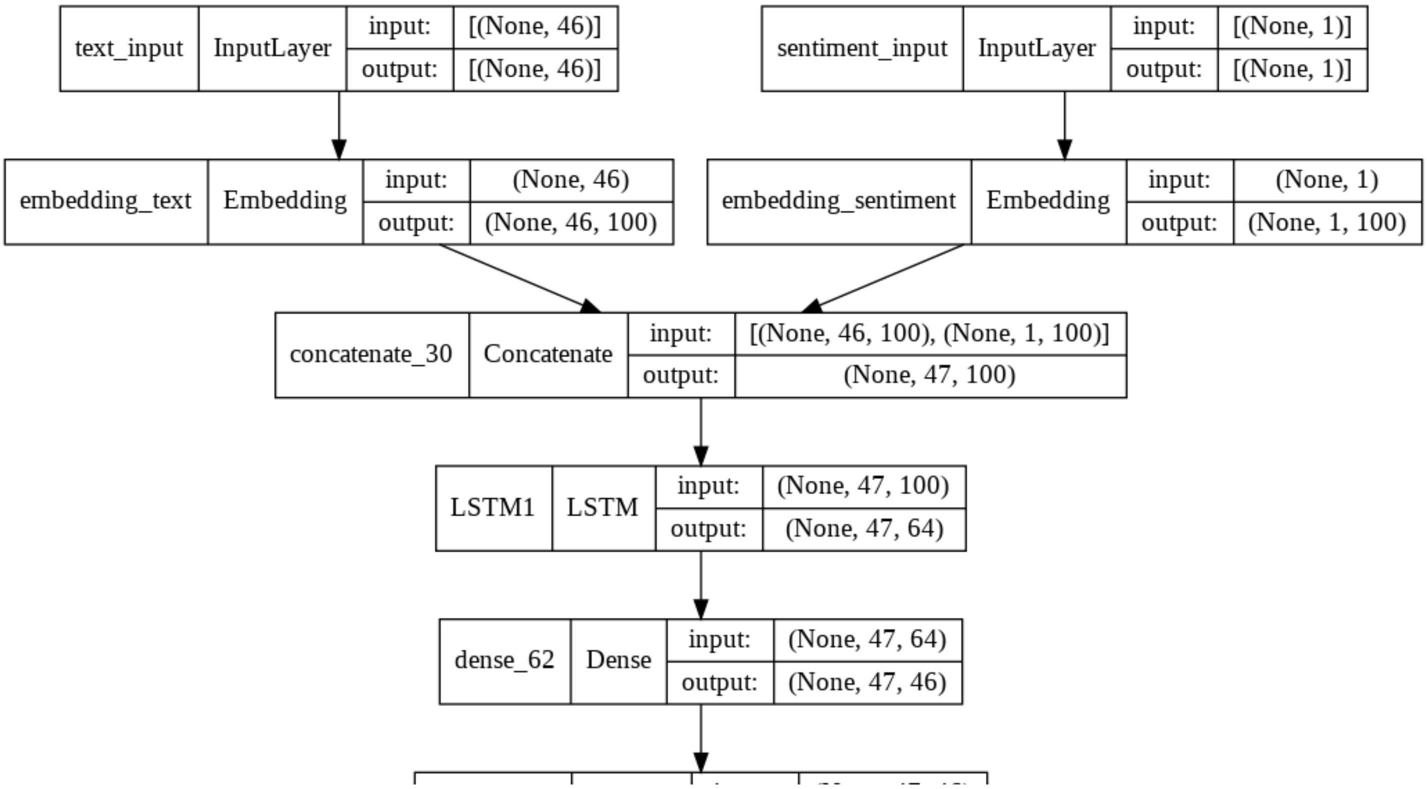
In [ ]:

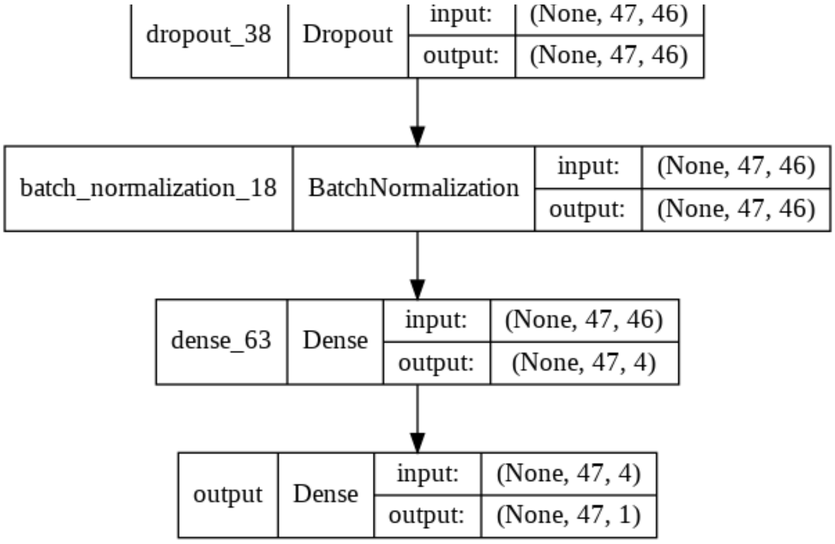
```
#masking the input values with mask_zero= True
text_input=Input(shape=(max_len_text,),name='text_input')
embd_text=Embedding(len(word_index_text)+1,100,weights=[embedding_matrix_text],input_leng
th=max_len_text,trainable=False,mask_zero=True,name='embedding_text')(text_input)

 #masking the input values with mask_zero= True
sentiment_input=Input(shape=(max_len_sentiment,),name='sentiment_input')
embd_sentiment=Embedding(len(word_index_sentiment)+1,100,weights=[embedding_matrix_sentim
ent],input_length=max_len_text,trainable=False,mask_zero=True,name='embedding_sentiment')
(sentiment_input)

con=Concatenate(axis=1)([embd_text,embd_sentiment])
lstm=LSTM(64,return_sequences=True,name='LSTM1')(con)                  #lstm


#dense layers with drop outs and batch normalisation
m=Dense(46,activation="relu",kernel_initializer="he_normal")(lstm)
m=Dropout(0.5)(m)
m=BatchNormalization()(m)
m=Dense(4,activation="relu", kernel_initializer="he_normal")(m)
output=Dense(1,activation='sigmoid',name='output')(m)

model=Model(inputs=[text_input,sentiment_input],outputs=[output])
```

In [ ]:

```
tf.keras.utils.plot_model(model,'Model.png',show_shapes=True,show_layer_names=True)
```

Out[ ]:





In [ ]:

```
model.summary()
```

```
Model: "model_38"
__________________________________________________________________________________________
_________
 Layer (type)                   Output Shape         Param #     Connected to

==========================================================================================
=========
 text_input (InputLayer)        [(None, 46)]         0           []


 sentiment_input (InputLayer)   [(None, 1)]          0           []


 embedding_text (Embedding)     (None, 46, 100)      2404900     ['text_input[0][0]']


 embedding_sentiment (Embedding  (None, 1, 100)      400         ['sentiment_input[0][0]'
]
 )


 concatenate_30 (Concatenate)   (None, 47, 100)      0           ['embedding_text[0][0]',

                                                                  'embedding_sentiment[
0][0]']

 LSTM1 (LSTM)                   (None, 47, 64)       42240       ['concatenate_30[0][0]'
]

 dense_62 (Dense)               (None, 47, 46)       2990        ['LSTM1[0][0]']


 dropout_38 (Dropout)           (None, 47, 46)       0           ['dense_62[0][0]']


 batch_normalization_18 (BatchN  (None, 47, 46)      184         ['dropout_38[0][0]']

 ormalization)


 dense_63 (Dense)               (None, 47, 4)        188         ['batch_normalization_1
 dense_63 (Dense)               (None, 47, 4)        188         ['batch_normalization_1
8[0][0]']


 output (Dense)                 (None, 47, 1)        5           ['dense_63[0][0]']



==========================================================================================
=========
Total params: 2,450,907
Trainable params: 45,515
Non-trainable params: 2,405,392
__________________________________________________________________________________________
_________
```

In [ ]:

```
tensorboard = tf.keras.callbacks.TensorBoard(log_dir='/content/drive/MyDrive/base_Lstm_M
odel/logs/{}'.format(time()))
early_stop = EarlyStopping(monitor='val_loss', patience=2,verbose=1)
# call backs
check_point = ModelCheckpoint('/content/drive/MyDrive/best_lstm.hdf5', monitor='val_loss'
,save_best_only=True, mode='min')
call_backs = [early_stop,check_point,tensorboard]
```

In [ ]:

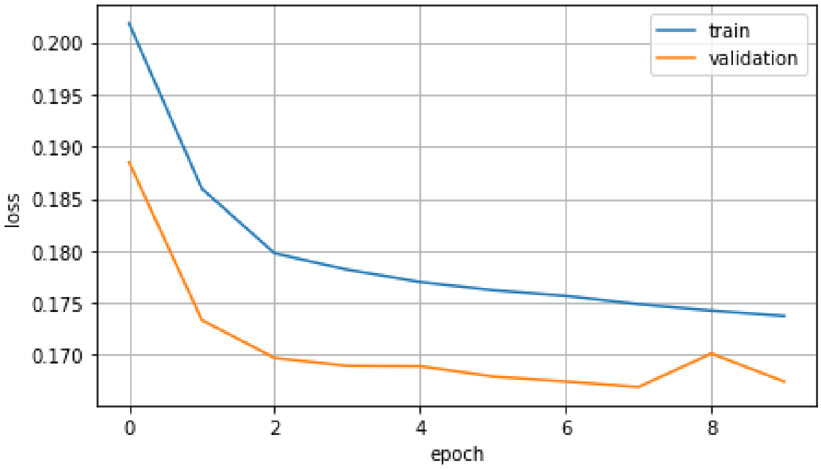
```
model.compile(optimizer='adam',loss='binary_crossentropy',metrics=['accuracy'])
history=model.fit([train_text,train_sentiment],y_train,epochs=30,batch_size=128,validati
on_data=([valid_text,valid_sentiment],[y_valid]),verbose=1,callbacks=call_backs)
```

```
Epoch 1/30
182/182 [==============================] - 21s 92ms/step - loss: 0.2018 - accuracy: 0.551
8 - val_loss: 0.1885 - val_accuracy: 0.5079
Epoch 2/30
182/182 [==============================] - 16s 89ms/step - loss: 0.1860 - accuracy: 0.585
0 - val_loss: 0.1733 - val_accuracy: 0.5909
Epoch 3/30
182/182 [==============================] - 16s 89ms/step - loss: 0.1797 - accuracy: 0.611
1 - val_loss: 0.1697 - val_accuracy: 0.6140
Epoch 4/30
182/182 [==============================] - 16s 89ms/step - loss: 0.1782 - accuracy: 0.620
8 - val_loss: 0.1689 - val_accuracy: 0.6189
Epoch 5/30
182/182 [==============================] - 16s 86ms/step - loss: 0.1770 - accuracy: 0.627
2 - val_loss: 0.1689 - val_accuracy: 0.6188
Epoch 6/30
182/182 [==============================] - 16s 89ms/step - loss: 0.1762 - accuracy: 0.631
4 - val_loss: 0.1679 - val_accuracy: 0.6248
Epoch 7/30
182/182 [==============================] - 16s 87ms/step - loss: 0.1757 - accuracy: 0.633
7 - val_loss: 0.1674 - val_accuracy: 0.6256
Epoch 8/30
182/182 [==============================] - 16s 87ms/step - loss: 0.1749 - accuracy: 0.638
4 - val_loss: 0.1669 - val_accuracy: 0.6284
Epoch 9/30
182/182 [==============================] - 15s 84ms/step - loss: 0.1742 - accuracy: 0.641
5 - val_loss: 0.1701 - val_accuracy: 0.6252
Epoch 10/30
182/182 [==============================] - 15s 83ms/step - loss: 0.1737 - accuracy: 0.643
8 - val_loss: 0.1674 - val_accuracy: 0.6296
Epoch 00010: early stopping
```

train-validation plots

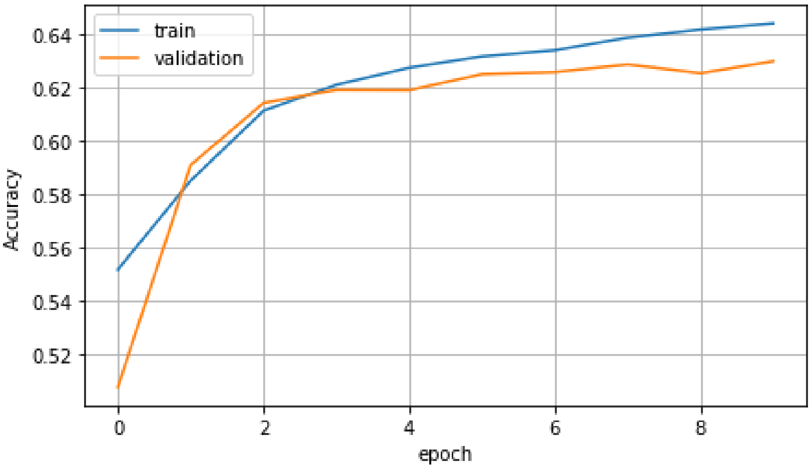
In [ ]:

```
plt.figure(figsize=(7,4))
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.ylabel('loss')
plt.xlabel('epoch')                              # loss curve between train and validati
on data
plt.legend(['train','validation'])
plt.grid()
plt.show()
```



In [ ]:

```
plt.figure(figsize=(7,4))
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.ylabel('Accuracy')                             # metric curve between train and val
idation data
plt.xlabel('epoch')
plt.legend(['train','validation'])
plt.grid()
plt.show()
```



LSTM-predictions

In [ ]:

```
valid_pred=model.predict([valid_text,valid_sentiment])       # predicting ...
valid_pred=np.squeeze(valid_pred)
valid_pred=np.round(valid_pred)
valid_pred.shape
```

Out[ ]:

```
(4108, 47)
```

In [ ]:

```
pred=[]
for vector in valid_pred:
  index=[]
  for i,value in enumerate(vector):                    # convering binary predictions in  1 and
```

```
0's  to sequences by taking index values
    if value == 1:
      index.append(i)
  pred.append(np.array(index))
print(len(pred))
```

```
4108
```

In [ ]:

```
X_valid['prediction']=pred
```

In [ ]:

```
def index2text(x):
  ''' function takes predicted-sequences and revert backs to the text '''
  pred=[]
  text=x[0]
  index=x[1]                                    # converting sequence index values to tex
t
  text=text.split()
  l=len(text)
  for i in index:
    if i < l:
      pred.append(text[i])
  return pred
```

In [ ]:

```
pred_text=X_valid[['text','prediction']].apply(lambda x:index2text(x),axis=1)
X_valid['pred_text']=pred_text

X_valid['pred_text']=X_valid['pred_text'].apply(lambda x: ' '.join(x))
```

In [ ]:

```
X_valid['jaccard']=X_valid.apply(lambda x: jaccard(x.selected_text,x.pred_text),axis=1)
print('Mean training Jaccard score:',np.mean(X_valid['jaccard']))
print("="*150)
print('Mean jaccard score for positive sentiment tweets:',np.mean(X_valid[X_valid['sentim
ent']=='positive']['jaccard']))
print("="*150)
print('Mean jaccard score for negative sentiment tweets',np.mean(X_valid[X_valid['sentime
nt']=='negative']['jaccard']))
print("="*150)
print('Mean jaccard score for neutral sentiment tweets',np.mean(X_valid[X_valid['sentimen
t']=='neutral']['jaccard']))
```

```
Mean training Jaccard score: 0.5237762585575317
=========================================================================================
=============================================================
Mean jaccard score for positive sentiment tweets: 0.37394156270361806
=========================================================================================
=============================================================
Mean jaccard score for negative sentiment tweets 0.35897511782073316
=========================================================================================
=============================================================
Mean jaccard score for neutral sentiment tweets 0.7653527807133832
```

In [ ]:

```
# %load_ext tensorboard
# %tensorboard --logdir /content/drive/MyDrive/Lstm_Model/logs/
```

In [ ]:

```

```

DBERT

In [ ]:

```
!pip install transformers
```

```
Collecting transformers
  Downloading transformers-4.14.1-py3-none-any.whl (3.4 MB)
     |████████████████████████████████| 3.4 MB 29.7 MB/s
Requirement already satisfied: regex!=2019.12.17 in /usr/local/lib/python3.7/dist-package
s (from transformers) (2019.12.20)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.7/dist-packages
(from transformers) (21.3)
Requirement already satisfied: importlib-metadata in /usr/local/lib/python3.7/dist-packag
es (from transformers) (4.8.2)
Requirement already satisfied: tqdm>=4.27 in /usr/local/lib/python3.7/dist-packages (from
transformers) (4.62.3)
Collecting pyyaml>=5.1
  Downloading PyYAML-6.0-cp37-cp37m-manylinux_2_5_x86_64.manylinux1_x86_64.manylinux_2_12
_x86_64.manylinux2010_x86_64.whl (596 kB)
     |████████████████████████████████| 596 kB 33.0 MB/s
Collecting huggingface-hub<1.0,>=0.1.0
  Downloading huggingface_hub-0.2.1-py3-none-any.whl (61 kB)
     |████████████████████████████████| 61 kB 532 kB/s
Collecting tokenizers<0.11,>=0.10.1
  Downloading tokenizers-0.10.3-cp37-cp37m-manylinux_2_5_x86_64.manylinux1_x86_64.manylin
ux_2_12_x86_64.manylinux2010_x86_64.whl (3.3 MB)
     |████████████████████████████████| 3.3 MB 35.9 MB/s
Collecting sacremoses
  Downloading sacremoses-0.0.46-py3-none-any.whl (895 kB)
     |████████████████████████████████| 895 kB 41.8 MB/s
Requirement already satisfied: requests in /usr/local/lib/python3.7/dist-packages (from t
ransformers) (2.23.0)
Requirement already satisfied: filelock in /usr/local/lib/python3.7/dist-packages (from t
ransformers) (3.4.0)
Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.7/dist-packages (fro
m transformers) (1.19.5)
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/python3.7/dis
t-packages (from huggingface-hub<1.0,>=0.1.0->transformers) (3.10.0.2)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /usr/local/lib/python3.7/dist-
packages (from packaging>=20.0->transformers) (3.0.6)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packages (from
importlib-metadata->transformers) (3.6.0)
Requirement already satisfied: chardet<4,>=3.0.2 in /usr/local/lib/python3.7/dist-package
s (from requests->transformers) (3.0.4)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.7/dist-packages (fr
om requests->transformers) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.7/dist-packag
es (from requests->transformers) (2021.10.8)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in /usr/local/lib/
python3.7/dist-packages (from requests->transformers) (1.24.3)
Requirement already satisfied: click in /usr/local/lib/python3.7/dist-packages (from sacr
emoses->transformers) (7.1.2)
Requirement already satisfied: joblib in /usr/local/lib/python3.7/dist-packages (from sac
remoses->transformers) (1.1.0)
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from sacrem
oses->transformers) (1.15.0)
Installing collected packages: pyyaml, tokenizers, sacremoses, huggingface-hub, transform
ers
  Attempting uninstall: pyyaml
    Found existing installation: PyYAML 3.13
    Uninstalling PyYAML-3.13:
      Successfully uninstalled PyYAML-3.13
Successfully installed huggingface-hub-0.2.1 pyyaml-6.0 sacremoses-0.0.46 tokenizers-0.10
.3 transformers-4.14.1
```

In [ ]:

```
from transformers import BertTokenizer,DistilBertTokenizer
tokenizer = DistilBertTokenizer.from_pretrained('distilbert-base-uncased',add_prefix_spac
e=True)           # importing DBERT tokenizer for text tokenization
```

In [ ]:

```
x_train, x_val , y_train , y_val = train_test_split(train_df[['text','sentiment']],train_df['selected_text'],test_size=0.2, random_state=42)
x_train.shape, x_val.shape , y_train.shape , y_val.shape
```

Out[ ]:

```
((21976, 2), (5495, 2), (21976,), (5495,))
```

DBERT PreP for Train

In [ ]:

```
def train_prep(MAX_LEN,tokenizer):
                                                                                                 # train input_ids and atten_mask  start and end tokens indexes
  count = x_train.shape[0]
  input_ids = np.zeros((count,MAX_LEN),dtype='int32')
  attention_mask = np.zeros((count,MAX_LEN),dtype='int32')
  start_tokens = np.zeros((count,MAX_LEN),dtype='int32')
  end_tokens = np.zeros((count,MAX_LEN),dtype='int32')
  toks_all = []

  count=0
  for i,each in tqdm(enumerate(x_train.values)):
    val = tokenizer.encode_plus(each[0],each[1],add_special_tokens=True,max_length=MAX_LEN,return_attention_mask=True,pad_to_max_length=True,return_tensors='tf',verbose=False)
    input_ids[i] = val['input_ids']
    attention_mask[i] = val['attention_mask']
    text1 = " "+" ".join(each[0].split())
    text2 = " ".join(y_train.values[i].split())

    idx = text1.find(text2)
    chars = np.zeros((len(text1)))
    chars[idx:idx+len(text2)]=1
    if text1[idx-1]==' ':
      chars[idx-1] = 1


    enc = tokenizer.encode(text1)
    offsets = []; idx=0
    for t in enc:                                                                      # adding tuple of start_token and end_token indexs
      w=tokenizer.decode([t])
      offsets.append((idx,idx+len(w)))
      idx += len(w)

    toks = []
    for c,(a,b) in enumerate(offsets):
      sm = np.sum(chars[a:b])
      if sm>0:
        toks.append(c)
    toks_all.append(toks)
    if len(toks)>0:
      count+=1
      start_tokens[i,(toks[0])+1] = 1                                     # if start token 1 else 0
      end_tokens[i,(toks[-1])+1] = 1                                      # if end token 1 else 0

  return toks_all,input_ids,attention_mask,start_tokens,end_tokens
```

In [ ]:

```
toks_all,input_ids,attention_mask,start_tokens,end_tokens = train_prep(MAX_LEN=128,tokenizer=tokenizer)      # train ids
```

DBERT PreP for Valid

In [ ]:

```
def valid_prep(MAX_LEN,tokenizer):

  count = y_val.shape[0]
  input_ids_val = np.zeros((count,MAX_LEN),dtype='int32')
  attention_mask_val = np.zeros((count,MAX_LEN),dtype='int32')
  start_tokens_val = np.zeros((count,MAX_LEN),dtype='int32')
  end_tokens_val = np.zeros((count,MAX_LEN),dtype='int32')

  count=0
  for i,each in tqdm(enumerate(x_val.values)):
    val = tokenizer.encode_plus(each[0],each[1],add_special_tokens=True,max_length=MAX_L
EN,return_attention_mask=True,pad_to_max_length=True,return_tensors='tf',verbose=False)
    input_ids_val[i] = val['input_ids']
    attention_mask_val[i] = val['attention_mask']
    text1 = " "+" ".join(each[0].split())
    text2 = " ".join(y_val.values[i].split())
    #finding the start index
    idx = text1.find(text2)
    chars = np.zeros((len(text1)))
    chars[idx:idx+len(text2)]=1
    if text1[idx-1]==' ':
      chars[idx-1] = 1


    enc = tokenizer.encode(text1)
    offsets = []; idx=0
    for t in enc:
      w=tokenizer.decode([t])
      offsets.append((idx,idx+len(w)))
      idx += len(w)

    toks = []
    for c,(a,b) in enumerate(offsets):
      sm = np.sum(chars[a:b])
      if sm>0:
        toks.append(c)
    toks_all.append(toks)
    if len(toks)>0:
      count+=1
      start_tokens_val[i,(toks[0])+1] = 1
      end_tokens_val[i,(toks[-1])+1] = 1

  return input_ids_val,attention_mask_val,start_tokens_val,end_tokens_val
```

In [ ]:

```
input_ids_val,attention_mask_val,start_tokens_val,end_tokens_val = valid_prep(MAX_LEN=128
,tokenizer=tokenizer)
```

Model

In [ ]:

```
from transformers import TFBertForQuestionAnswering,TFDistilBertForQuestionAnswering
bert= TFDistilBertForQuestionAnswering.from_pretrained('distilbert-base-uncased')
```

```
Some layers from the model checkpoint at distilbert-base-uncased were not used when initi
alizing TFDistilBertForQuestionAnswering: ['vocab_projector', 'vocab_transform', 'activat
ion_13', 'vocab_layer_norm']
- This IS expected if you are initializing TFDistilBertForQuestionAnswering from the chec
kpoint of a model trained on another task or with another architecture (e.g. initializing
a BertForSequenceClassification model from a BertForPreTraining model).
- This IS NOT expected if you are initializing TFDistilBertForQuestionAnswering from the
checkpoint of a model that you expect to be exactly identical (initializing a BertForSequ
enceClassification model from a BertForSequenceClassification model).
Some layers of TFDistilBertForQuestionAnswering were not initialized from the model check
point at distilbert-base-uncased and are newly initialized: ['dropout_19', 'qa_outputs']
You should probably TRAIN this model on a down-stream task to be able to use it for predi
```

```
ctions and inference.
```

In [ ]:

```
#https://stackoverflow.com/questions/64901831/huggingface-transformer-model-returns-strin
g-instead-of-logits

input1 = Input(shape=(MAX_LEN,),name='input_id',dtype=tf.int32)
input2 = Input(shape=(MAX_LEN,),name='attention_mask',dtype=tf.int32)
start_scores,end_scores = bert(input1,attention_mask = input2).values()
dense1 = Dense(units=MAX_LEN,activation='relu',name='dense1',kernel_regularizer = tf.ker
as.regularizers.L2(l2=0.00001))(start_scores)
softmax1 = Activation('softmax')(dense1)
dense2 = Dense(units=MAX_LEN,activation='relu',name='dense2',kernel_regularizer = tf.ker
as.regularizers.L2(l2=0.00001))(end_scores)
softmax2 = Activation('softmax')(dense2)
model = Model(inputs=[input1,input2],outputs=[softmax1,softmax2])
```

In [ ]:

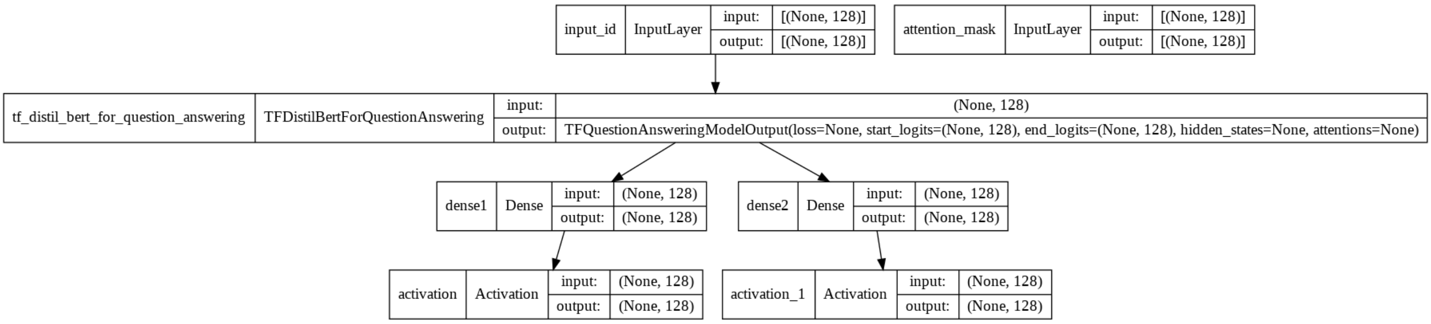
```
model.summary()
```

```
Model: "model_1"
_________________________________________________________________________________________________
_________
 Layer (type)                     Output Shape          Param #     Connected to

=================================================================================================
=========
 input_id (InputLayer)            [(None, 128)]         0           []


 attention_mask (InputLayer)      [(None, 128)]         0           []


 tf_distil_bert_for_question_an    TFQuestionAnswering    66364418    ['input_id[0][0]',

 swering (TFDistilBertForQuesti    ModelOutput(loss=No                 'attention_mask[0][0]']

 onAnswering)                     ne, start_logits=(N

                                  one, 128),

                                   end_logits=(None,

                                  128),

                                   hidden_states=None

                                  , attentions=None)


 dense1 (Dense)                   (None, 128)           16512       ['tf_distil_bert_for_qu
estion_ans

                                                                    wering[0][1]']


 dense2 (Dense)                   (None, 128)           16512       ['tf_distil_bert_for_qu
estion_ans

                                                                    wering[0][0]']


 activation_2 (Activation)        (None, 128)           0           ['dense1[0][0]']


 activation_3 (Activation)        (None, 128)           0           ['dense2[0][0]']
 activation_7 (Activation)       (None, 128)          0           ['dense2[0][0]']



=========================================================================================
=========
Total params: 66,397,442
Trainable params: 66,397,442
Non-trainable params: 0
_________________________________________________________________________________________
_________
```

In [ ]:

```
tf.keras.utils.plot_model(model,'Model.png',show_shapes=True,show_layer_names=True)
```

Out[ ]:



In [ ]:

```
input_data = (input_ids,attention_mask)                                         # train data
input
output_data = (start_tokens,end_tokens)                                         # train data
ouput

val = (input_ids_val,attention_mask_val)                                        # valid data
input
output_val = (start_tokens_val,end_tokens_val)                                  # valid data
output
val_data = (val,output_val)
```

In [ ]:

```
# call backs

estop = tf.keras.callbacks.EarlyStopping(monitor='val_loss',patience=2)
tensorboard = tf.keras.callbacks.TensorBoard(log_dir='/content/drive/MyDrive/BertQA_logd
ir',histogram_freq=1, write_graph=True)
checkpoint= tf.keras.callbacks.ModelCheckpoint(filepath='/content/drive/MyDrive/BertQA_mo
del.hdf5',save_weights_only=True,monitor='val_loss',save_best_only=True)
callbacks=[tensorboard,checkpoint,estop]
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

In [ ]:

```
opt = tf.keras.optimizers.Adam(learning_rate=0.0001, epsilon=1e-08, clipnorm=1.0)
model.compile(optimizer=opt,loss='categorical_crossentropy')

train_dataset = tf.data.Dataset.from_tensor_slices((input_data, output_data)).shuffle(bu
ffer_size=1024).batch(32)
val_dataset = tf.data.Dataset.from_tensor_slices(val_data).batch(32)

DBertQA = model.fit(train_dataset,epochs=15,validation_data=val_dataset,callbacks=callba
cks)
```

```
Epoch 1/15
687/687 [==============================] - 651s 911ms/step - loss: 2.7133 - activation_6_
loss: 1.2333 - activation_7_loss: 1.4775 - val_loss: 3.1283 - val_activation_6_loss: 1.50
72 - val_activation_7_loss: 1.6186
Epoch 2/15
Epoch 2/15
687/687 [==============================] - 622s 906ms/step - loss: 1.7135 - activation_6_
loss: 0.8428 - activation_7_loss: 0.8682 - val_loss: 3.0290 - val_activation_6_loss: 1.44
67 - val_activation_7_loss: 1.5798
Epoch 3/15
687/687 [==============================] - 621s 904ms/step - loss: 1.2315 - activation_6_
loss: 0.5894 - activation_7_loss: 0.6397 - val_loss: 3.1905 - val_activation_6_loss: 1.50
87 - val_activation_7_loss: 1.6793
Epoch 4/15
687/687 [==============================] - 617s 897ms/step - loss: 0.9011 - activation_6_
loss: 0.4307 - activation_7_loss: 0.4680 - val_loss: 3.5893 - val_activation_6_loss: 1.67
60 - val_activation_7_loss: 1.9108
```

In [ ]:

```
MAX_LEN=128
# reload
def create_model():
  input1 = Input(shape=(MAX_LEN,),name='input_id',dtype=tf.int32)
  input2 = Input(shape=(MAX_LEN,),name='attention_mask',dtype=tf.int32)
  start_scores,end_scores = bert(input1,attention_mask = input2).values()
  dense1 = Dense(units=MAX_LEN,activation='relu',name='dense1',kernel_regularizer = tf.k
eras.regularizers.L2(l2=0.00001))(start_scores)
  softmax1 = Activation('softmax')(dense1)
  dense2 = Dense(units=MAX_LEN,activation='relu',name='dense2',kernel_regularizer = tf.k
eras.regularizers.L2(l2=0.00001))(end_scores)
  softmax2 = Activation('softmax')(dense2)
  model = Model(inputs=[input1,input2],outputs=[softmax1,softmax2])
  opt = tf.keras.optimizers.Adam(learning_rate=0.0001, epsilon=1e-08, clipnorm=1.0)
  model.compile(optimizer=opt,loss='categorical_crossentropy')
  return model

model = create_model()
```

In [ ]:

```
model.load_weights('/content/drive/MyDrive/BertQA_model.hdf5')
```

Prediction

In [ ]:

```
val = (input_ids_val,attention_mask_val)
start_val , end_val = model.predict(val)
# valid predictions
start_val.shape,end_val.shape
```

Out[ ]:

```
((5495, 128), (5495, 128))
```

In [ ]:

```
pred_values_val=[]
from tqdm import tqdm
for i in tqdm(range(start_val.shape[0])):
  a = np.argmax(start_val[i])
  b = np.argmax(end_val[i])
  text1 = " "+" ".join(x_val['text'].values[i].split())
# pred_answer
  enc = tokenizer.encode(text1)
  val = tokenizer.decode(enc[a:b+1])
  pred_values_val.append(val)
```

```
100%|██████████| 5495/5495 [00:03<00:00, 1601.33it/s]
```

In [ ]:

```
for i in range(len(pred_values_val)):
  pred_values_val[i] = pred_values_val[i].replace('[SEP]','')                # removin
g [SEP] tokens
```

In [ ]:

```
scores_val=[]
x_val['pred_text'] = pred_values_val
# jaccard score calcuation
x_val['selected_text'] = y_val.values
scores=[]
for i in tqdm(range(x_val.shape[0])):
  scores_val.append(jaccard(x_val['pred_text'].values[i],x_val['selected_text'].values[i
]))

x_val['jaccard']=scores_val
```

```
100%|██████████| 5495/5495 [00:00<00:00, 47740.44it/s]
```

In [ ]:

```
x_val.head(10)
```

Out[ ]:

	text	sentiment	pred_text	selected_text	jaccard
7917	this is my update	neutral	this is my update	this is my update	1.000000
15845	whaaat i still have next week	neutral	whaaat i still have next week	whaaat i still have next week	1.000000
21278	happy birthday little sister of mine also go...	positive	happy birthday little sister of mine also good...	happy birthday little sister of mine	0.600000
22338	do some research for my article	neutral	do some research for my article	do some research for my article	1.000000
22474	are you okay	neutral	are you okay	are you okay	1.000000
21560	turned my alarm off this morning because i tho...	negative	turned my alarm off this morning because i tho...	fail	0.043478
8870	elaines my online mommy too she gives good a...	positive	she gives good advice	she gives good advice	1.000000
22030	good ABUSE homie hahahahaha thats what im tal...	positive	good abuse ho	good	0.333333
6693	there are days of summervac school comes alo...	neutral	there are days of summervac school comes along...	the annual problem of r generation is finding ...	0.590909
15718	i have tea have just found a picture of the b...	neutral	i have tea have just found a picture of the bi...	i have tea have just found a picture of the b...	1.000000

In [ ]:

```
print('Mean Jaccard score for val data:',x_val['jaccard'].values.mean())
```

```
Mean Jaccard score for val data: 0.6101828553749852
```

In [ ]:

```
print('Mean training Jaccard score:',np.mean(x_val['jaccard']))
print("="*150)
print('Mean jaccard score for positive sentiment tweets:',np.mean(x_val[x_val['sentiment'
]=='positive']['jaccard']))
print("="*150)
print('Mean jaccard score for negative sentiment tweets',np.mean(x_val[x_val['sentiment']
=='negative']['jaccard']))
print("="*150)
print('Mean jaccard score for neutral sentiment tweets',np.mean(x_val[x_val['sentiment']=
='neutral']['jaccard']))
```

```
Mean training Jaccard score: 0.6101828553749853
===========================================================================================
==============================================================
Mean jaccard score for positive sentiment tweets: 0.3745756631390002
===========================================================================================
==============================================================
Mean jaccard score for negative sentiment tweets 0.35826182939871276
==================================================================================================================================
Mean jaccard score for neutral sentiment tweets 0.9672193330825384
```

DBERT+CNN

In [ ]:

```
from sklearn.model_selection import train_test_split
x_train, x_val , y_train , y_val = train_test_split(train_df[['text','sentiment']],train_df['selected_text'],test_size=0.2, random_state=42)
x_train.shape, x_val.shape , y_train.shape , y_val.shape
```

Out[ ]:

```
((21976, 2), (5495, 2), (21976,), (5495,))
```

In [ ]:

```
from transformers import BertTokenizer,DistilBertTokenizer
tokenizer = DistilBertTokenizer.from_pretrained('distilbert-base-uncased',add_prefix_space=True)
```

DBERT PreP for Train

In [ ]:

```
toks_all,input_ids,attention_mask,start_tokens,end_tokens = train_prep(MAX_LEN=92,tokenizer=tokenizer2)        # train
```

DBERT PreP for Valid

In [ ]:

```
input_ids_val,attention_mask_val,start_tokens_val,end_tokens_val = valid_prep(MAX_LEN=92,tokenizer=tokenizer)   # valid
```

Model

In [ ]:

```
from transformers import TFRobertaForQuestionAnswering
roberta = TFRobertaForQuestionAnswering.from_pretrained('roberta-base')
```

```
All model checkpoint layers were used when initializing TFRobertaForQuestionAnswering.

Some layers of TFRobertaForQuestionAnswering were not initialized from the model checkpoint at roberta-base and are newly initialized: ['qa_outputs']
You should probably TRAIN this model on a down-stream task to be able to use it for predictions and inference.
```

In [ ]:

```
input1 = Input(shape=(MAX_LEN,),name='input_id',dtype=tf.int32)
input2 = Input(shape=(MAX_LEN,),name='attention_mask',dtype=tf.int32)
start_scores,end_scores = bert(input1,attention_mask = input2).values()

drop1 = Dropout(0.1)(start_scores)
drop1  = tf.expand_dims(drop1,axis=-1)
layer1 = tf.keras.layers.Conv1D(1,1)(drop1)                                          # conv1d instead dense
layer1= Flatten()(layer1)
softmax1 = Activation('softmax')(layer1)
```

```
drop2 = Dropout(0.1)(end_scores)
drop2  = tf.expand_dims(drop2,axis=-1)
layer2 = tf.keras.layers.Conv1D(1,1)(drop2)                                                # c
onv1d
layer2 = Flatten()(layer2)
softmax2 = Activation('softmax')(layer2)

model = Model(inputs=[input1,input2],outputs=[softmax1,softmax2])
```

In [ ]:

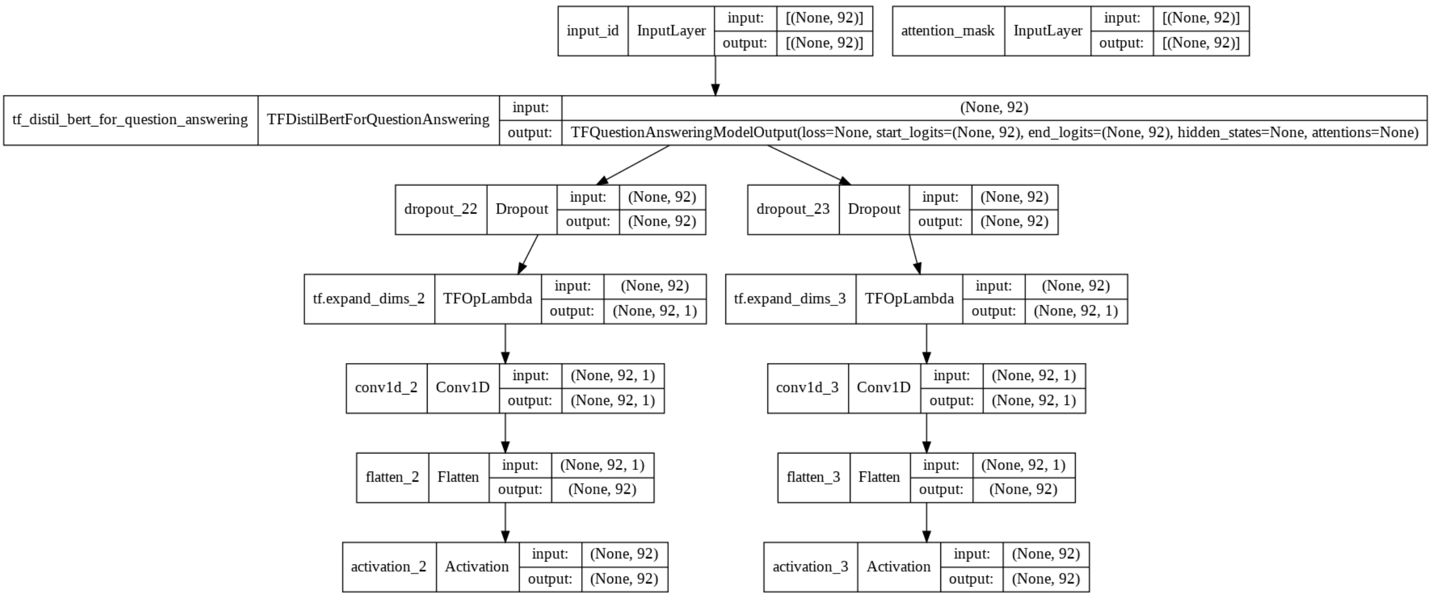
```
model.summary()
```

```
Model: "model"
__________________________________________________________________________________________
_________
 Layer (type)                   Output Shape         Param #     Connected to

==========================================================================================
=========
 input_id (InputLayer)          [(None, 92)]         0           []


 attention_mask (InputLayer)    [(None, 92)]         0           []


 tf_distil_bert_for_question_an  TFQuestionAnswering  66364418    ['input_id[0][0]',

 swering (TFDistilBertForQuesti  ModelOutput(loss=No               'attention_mask[0][0]']

 onAnswering)                   ne, start_logits=(N

                                one, 92),

                                 end_logits=(None,

                                92),

                                 hidden_states=None

                                , attentions=None)


 dropout_22 (Dropout)           (None, 92)           0           ['tf_distil_bert_for_qu
estion_ans

                                                                 wering[1][1]']


 dropout_23 (Dropout)           (None, 92)           0           ['tf_distil_bert_for_qu
estion_ans

                                                                 wering[1][0]']


 tf.expand_dims_2 (TFOpLambda)  (None, 92, 1)        0           ['dropout_22[0][0]']


 tf.expand_dims_3 (TFOpLambda)  (None, 92, 1)        0           ['dropout_23[0][0]']


 conv1d_2 (Conv1D)              (None, 92, 1)        2           ['tf.expand_dims_2[0][0
]']

 conv1d_3 (Conv1D)              (None, 92, 1)        2           ['tf.expand_dims_3[0][0
]']


 flatten_2 (Flatten)            (None, 92)           0           ['conv1d_2[0][0]']


 flatten_3 (Flatten)            (None, 92)           0           ['conv1d_3[0][0]']


 activation_2 (Activation)      (None, 92)           0           ['flatten_2[0][0]']


 activation_3 (Activation)      (None, 92)           0           ['flatten_3[0][0]']


==========================================================================================
=========
Total params: 66,364,422
Trainable params: 66,364,422
Non-trainable params: 0
__________________________________________________________________________________________
_________
```

In [ ]:

```
tf.keras.utils.plot_model(model,'Model.png',show_shapes=True,show_layer_names=True)
```

Out[ ]:


input_id | InputLayer | input: [(None, 92)] | output: [(None, 92)]
attention_mask | InputLayer | input: [(None, 92)] | output: [(None, 92)]
tf_distil_bert_for_question_answering | TFDistilBertForQuestionAnswering | input: (None, 92) | output: TFQuestionAnsweringModelOutput(loss=None, start_logits=(None, 92), end_logits=(None, 92), hidden_states=None, attentions=None)
dropout_22 | Dropout | input: (None, 92) | output: (None, 92)
dropout_23 | Dropout | input: (None, 92) | output: (None, 92)
tf.expand_dims_2 | TFOpLambda | input: (None, 92) | output: (None, 92, 1)
tf.expand_dims_3 | TFOpLambda | input: (None, 92) | output: (None, 92, 1)
conv1d_2 | Conv1D | input: (None, 92, 1) | output: (None, 92, 1)
conv1d_3 | Conv1D | input: (None, 92, 1) | output: (None, 92, 1)
flatten_2 | Flatten | input: (None, 92, 1) | output: (None, 92)
flatten_3 | Flatten | input: (None, 92, 1) | output: (None, 92)
activation_2 | Activation | input: (None, 92) | output: (None, 92)
activation_3 | Activation | input: (None, 92) | output: (None, 92)

In [ ]:

```
input_data = (input_ids,attention_mask)
output_data = (start_tokens,end_tokens)

val = (input_ids_val,attention_mask_val)
output_val = (start_tokens_val,end_tokens_val)
val_data = (val,output_val)
```

In [ ]:

```
# call backs

estop = tf.keras.callbacks.EarlyStopping(monitor='val_loss',patience=2)
tensorboard = tf.keras.callbacks.TensorBoard(log_dir='/content/drive/MyDrive/DBert_CNN_Q
A_logdir',histogram_freq=1, write_graph=True)
checkpoint= tf.keras.callbacks.ModelCheckpoint(filepath='/content/drive/MyDrive/DBert_CNN
_QA_model.hdf5',save_weights_only=True,monitor='val_loss',save_best_only=True)
```

```
callbacks=[tensorboard,checkpoint,estop]
```

In [ ]:

```
opt = tf.keras.optimizers.Adam(learning_rate=3e-5, epsilon=1e-08, clipnorm=1.0)
model.compile(optimizer=opt,loss='categorical_crossentropy')
train_dataset = tf.data.Dataset.from_tensor_slices((input_data, output_data)).shuffle(bu
ffer_size=1024).batch(32)
val_dataset = tf.data.Dataset.from_tensor_slices(val_data).batch(32)
model.fit(train_dataset,epochs=6,validation_data=val_dataset,callbacks=callbacks)
```

```
Epoch 1/6
687/687 [==============================] - 498s 676ms/step - loss: 4.8225 - activation_lo
ss: 2.9820 - activation_1_loss: 1.8405 - val_loss: 3.2080 - val_activation_loss: 1.9704 -
val_activation_1_loss: 1.2375
Epoch 2/6
687/687 [==============================] - 464s 676ms/step - loss: 3.1306 - activation_lo
ss: 1.6946 - activation_1_loss: 1.4360 - val_loss: 2.2210 - val_activation_loss: 1.1005 -
val_activation_1_loss: 1.1205
Epoch 3/6
687/687 [==============================] - 465s 677ms/step - loss: 2.4754 - activation_lo
ss: 1.2204 - activation_1_loss: 1.2551 - val_loss: 2.1318 - val_activation_loss: 0.9897 -
val_activation_1_loss: 1.1420
Epoch 4/6
687/687 [==============================] - 463s 674ms/step - loss: 2.1526 - activation_lo
ss: 1.0490 - activation_1_loss: 1.1036 - val_loss: 2.1249 - val_activation_loss: 0.9806 -
val_activation_1_loss: 1.1443
Epoch 5/6
687/687 [==============================] - 460s 669ms/step - loss: 1.8837 - activation_lo
ss: 0.9164 - activation_1_loss: 0.9673 - val_loss: 2.3131 - val_activation_loss: 1.0440 -
val_activation_1_loss: 1.2691
Epoch 6/6
687/687 [==============================] - 460s 669ms/step - loss: 1.6471 - activation_lo
ss: 0.7807 - activation_1_loss: 0.8664 - val_loss: 2.4936 - val_activation_loss: 1.1292 -
val_activation_1_loss: 1.3644
```

Out[ ]:

```
<keras.callbacks.History at 0x7f9e220b3b90>
```

Prediction

In [ ]:

```
val = (input_ids_val,attention_mask_val)
start_val , end_val = model.predict(val)                 # validation predictions
start_val.shape,end_val.shape
```

Out[ ]:

```
((5495, 92), (5495, 92))
```

In [ ]:

```
pred_values_val=[]
from tqdm import tqdm
for i in tqdm(range(start_val.shape[0])):
  a = np.argmax(start_val[i])
  b = np.argmax(end_val[i])
  text1 = " "+" ".join(x_val['text'].values[i].split())             # pred_answer
  enc = tokenizer.encode(text1)
  val = tokenizer.decode(enc[a:b+1])
  pred_values_val.append(val)
```

```
100%|██████████| 5495/5495 [00:05<00:00, 1027.70it/s]
```

In [ ]:

```
for i in range(len(pred_values_val)):
  pred_values_val[i] = pred_values_val[i].replace('[SEP]','')  # removing [sep] token
```

In [ ]:

In [ ]:

```
scores_val=[]
x_val['pred_text'] = pred_values_val
x_val['selected_text'] = y_val.values
scores=[]
for i in tqdm(range(x_val.shape[0])):
  scores_val.append(jaccard(x_val['pred_text'].values[i],x_val['selected_text'].values[i
]))          # jaccard score calculations

x_val['jaccard']=scores_val
```

```
100%|██████████| 5495/5495 [00:00<00:00, 72385.31it/s]
```

In [ ]:

```
x_val.head(20)
```

Out[ ]:

	text	sentiment	pred_text	selected_text	jaccard
7917	this is my update	neutral	this is my update	this is my update	1.000000
15845	whaaat i still have next week	neutral	whaaat i still have next week	whaaat i still have next week	1.000000
21278	happy birthday little sister of mine also go...	positive		happy birthday little sister of mine	0.000000
22338	do some research for my article	neutral	do some research for my article	do some research for my article	1.000000
22474	are you okay	neutral	are you okay	are you okay	1.000000
21560	turned my alarm off this morning because i tho...	negative		fail	0.000000
8870	elaines my online mommy too she gives good a...	positive	she gives good advice	she gives good advice	1.000000
22030	good ABUSE homie hahahahaha thats what im tal...	positive	good	good	1.000000
6693	there are days of summervac school comes alo...	neutral	there are days of summervac school comes along...	the annual problem of r generation is finding ...	0.590909
15718	i have tea have just found a picture of the b...	neutral	i have tea have just found a picture of the bi...	i have tea have just found a picture of the b...	1.000000
15279	craving coffee	neutral	craving coffee	craving coffee	1.000000
20672	time for tv in bedthen spending all day catchi...	negative	summer classes	i hate online summer classes	0.400000
17239	well it almost was a good day guess i just ret...	positive	day guess	good day	0.333333
26658	the ultimate shirt folding tool i saw using ...	positive	the ultimate shirt folding tool i saw using th...	ultimate	0.062500
6199	no months	neutral	no months	no months	1.000000
10794	the least i can do for you is retweet it when...	neutral	the least i can do for you is retweet it when ...	the least i can do for you is retweet it when ...	1.000000
2899	oh snap kinda nuts right now ive told at lea...	positive	kinda nuts right now ive told at least thanks ...	thanks	0.100000
12789	says gud eve guys lets play poker yeah cant re...	positive	cant read my poker face	says gud eve guys	0.000000
5036	awesome im glad you like it fyi platinum no...	positive	awesome im	glad	0.000000
2938	im celebrating my mother and also celebrating...	positive	im celebrating my mother and also celebrating ...	celebrating	0.083333

In [ ]:

```
print('Mean training Jaccard score:',np.mean(x_val['jaccard']))
print("="*150)
print('Mean jaccard score for positive sentiment tweets:',np.mean(x_val[x_val['sentiment'
]=='positive']['jaccard']))
print("="*150)
print('Mean jaccard score for negative sentiment tweets',np.mean(x_val[x_val['sentiment']
=='negative']['jaccard']))
print("="*150)
print('Mean jaccard score for neutral sentiment tweets',np.mean(x_val[x_val['sentiment']=
='neutral']['jaccard']))
```

```
Mean training Jaccard score: 0.6030671173925883
=========================================================================================
=============================================================
Mean jaccard score for positive sentiment tweets: 0.35358649825746774
=========================================================================================
=============================================================
Mean jaccard score for negative sentiment tweets 0.34616903507066615
=========================================================================================
=============================================================
Mean jaccard score for neutral sentiment tweets 0.9743021383030607
```

In [ ]:

```

```

BERT+CNN

In [ ]:

```
import pickle
train_df = pickle.load(open('/content/drive/MyDrive/Copy of train_df_prep.pkl','rb'))
```

In [ ]:

```
from sklearn.model_selection import train_test_split
x_train, x_val , y_train , y_val = train_test_split(train_df[['text','sentiment']],train
_df['selected_text'],test_size=0.2, random_state=42)
x_train.shape, x_val.shape , y_train.shape , y_val.shape
```

Out[ ]:

```
((21976, 2), (5495, 2), (21976,), (5495,))
```

In [ ]:

```
from transformers import BertTokenizer,DistilBertTokenizer
tokenizer = BertTokenizer.from_pretrained('bert-base-uncased',add_prefix_space=True)
```

BERT PreP for Train

In [ ]:

```
toks_all,input_ids,attention_mask,start_tokens,end_tokens = train_prep(MAX_LEN=92,tokeni
zer=tokenizer)       # train ids
```

```
21976it [00:41, 527.08it/s]
```

BERT PreP for Valid

In [ ]:

```
input_ids_val,attention_mask_val,start_tokens_val,end_tokens_val = valid_prep(MAX_LEN=92,
tokenizer=tokenizer)                # valid ids
```

```
5495it [00:10, 524.71it/s]
```

Model

In [ ]:

```
from transformers import TFBertForQuestionAnswering,TFDistilBertForQuestionAnswering
bert= TFBertForQuestionAnswering.from_pretrained('bert-base-uncased')
```

```
All model checkpoint layers were used when initializing TFBertForQuestionAnswering.

Some layers of TFBertForQuestionAnswering were not initialized from the model checkpoint
at bert-base-uncased and are newly initialized: ['qa_outputs']
You should probably TRAIN this model on a down-stream task to be able to use it for predi
ctions and inference.
```

In [ ]:

```
MAX_LEN = 92
input1 = Input(shape=(MAX_LEN,),name='input_id',dtype=tf.int32)
input2 = Input(shape=(MAX_LEN,),name='attention_mask',dtype=tf.int32)
start_scores,end_scores = bert(input1,attention_mask = input2).values()

drop1 = Dropout(0.1)(start_scores)
drop1  = tf.expand_dims(drop1,axis=-1)
layer1 = tf.keras.layers.Conv1D(1,1)(drop1)                                          #
conv1d instead dense
layer1= Flatten()(layer1)
softmax1 = Activation('softmax')(layer1)

drop2 = Dropout(0.1)(end_scores)
drop2  = tf.expand_dims(drop2,axis=-1)
layer2 = tf.keras.layers.Conv1D(1,1)(drop2)                                         # c
onv1d
layer2 = Flatten()(layer2)
softmax2 = Activation('softmax')(layer2)

model = Model(inputs=[input1,input2],outputs=[softmax1,softmax2])
```

In [ ]:

```
model.summary()
```

```
Model: "model"
__________________________________________________________________________________________
_________
 Layer (type)                   Output Shape         Param #     Connected to

==========================================================================================
=========
 input_id (InputLayer)          [(None, 92)]         0           []


 attention_mask (InputLayer)    [(None, 92)]         0           []


 tf_bert_for_question_answering  TFQuestionAnswering  108893186   ['input_id[0][0]',

  (TFBertForQuestionAnswering)  ModelOutput(loss=No               'attention_mask[0][0]']

                                ne, start_logits=(N

                                one, 92),

                                 end_logits=(None,

                                92),

                                 hidden_states=None

                                , attentions=None)
 dropout_37 (Dropout)           (None, 92)           0           ['tf_bert_for_question_
answering[
                                                                  0][1]']


 dropout_38 (Dropout)           (None, 92)           0           ['tf_bert_for_question_
answering[
                                                                  0][0]']


 tf.expand_dims (TFOpLambda)    (None, 92, 1)        0           ['dropout_37[0][0]']


 tf.expand_dims_1 (TFOpLambda)  (None, 92, 1)        0           ['dropout_38[0][0]']


 conv1d (Conv1D)                (None, 92, 1)        2           ['tf.expand_dims[0][0]'
]

 conv1d_1 (Conv1D)              (None, 92, 1)        2           ['tf.expand_dims_1[0][0
]']

 flatten (Flatten)              (None, 92)           0           ['conv1d[0][0]']


 flatten_1 (Flatten)            (None, 92)           0           ['conv1d_1[0][0]']


 activation (Activation)        (None, 92)           0           ['flatten[0][0]']


 activation_1 (Activation)      (None, 92)           0           ['flatten_1[0][0]']


============================================================================================
=========
Total params: 108,893,190
Trainable params: 108,893,190
Non-trainable params: 0
____________________________________________________________________________________________
_________
```

In [ ]:

```
input_data = (input_ids,attention_mask)
output_data = (start_tokens,end_tokens)

val = (input_ids_val,attention_mask_val)
output_val = (start_tokens_val,end_tokens_val)
val_data = (val,output_val)
```

In [ ]:

```
# call backs

estop = tf.keras.callbacks.EarlyStopping(monitor='val_loss',patience=1)
tensorboard = tf.keras.callbacks.TensorBoard(log_dir='/content/drive/MyDrive/Bert_CNN_QA
_logdir',histogram_freq=1, write_graph=True)
```

```
checkpoint= tf.keras.callbacks.ModelCheckpoint(filepath='/content/drive/MyDrive/Bert_CNN_
QA_model.h5',save_weights_only=True,monitor='val_loss',save_best_only=True)
callbacks=[tensorboard,checkpoint,estop]
```

In [ ]:

```
opt = tf.keras.optimizers.Adam(learning_rate=3e-5, epsilon=1e-08, clipnorm=1.0)
model.compile(optimizer=opt,loss='categorical_crossentropy')
train_dataset = tf.data.Dataset.from_tensor_slices((input_data, output_data)).shuffle(bu
ffer_size=1024).batch(32)
val_dataset = tf.data.Dataset.from_tensor_slices(val_data).batch(32)
model.fit(train_dataset,epochs=6,validation_data=val_dataset,callbacks=callbacks)
```

```
Epoch 1/6
687/687 [==============================] - 951s 1s/step - loss: 3.1454 - activation_loss:
1.4626 - activation_1_loss: 1.6828 - val_loss: 2.0833 - val_activation_loss: 0.9624 - val
_activation_1_loss: 1.1209
Epoch 2/6
687/687 [==============================] - 902s 1s/step - loss: 2.3858 - activation_loss:
1.1510 - activation_1_loss: 1.2347 - val_loss: 1.8716 - val_activation_loss: 0.9020 - val
_activation_1_loss: 0.9695
Epoch 3/6
687/687 [==============================] - 894s 1s/step - loss: 2.0379 - activation_loss:
0.9903 - activation_1_loss: 1.0476 - val_loss: 1.9763 - val_activation_loss: 0.9435 - val
_activation_1_loss: 1.0329
```

Out[ ]:

```
<keras.callbacks.History at 0x7f12f47fca50>
```

In [ ]:

```
model.save("/content/drive/MyDrive/bert_cnn_model.h5")
print("Saved model to disk")
```

```
Saved model to disk
```

In [ ]:

```
val = (input_ids_val,attention_mask_val)
start_val , end_val = model.predict(val)                    # validation predictions
start_val.shape,end_val.shape
```

Out[ ]:

```
((5495, 92), (5495, 92))
```

In [ ]:

```
pred_values_val=[]
from tqdm import tqdm
for i in tqdm(range(start_val.shape[0])):
  a = np.argmax(start_val[i])
  b = np.argmax(end_val[i])
  text1 = " "+" ".join(x_val['text'].values[i].split())              # pred_answer
  enc = tokenizer.encode(text1)
  val = tokenizer.decode(enc[a:b+1])
  pred_values_val.append(val)
```

```
100%|██████████| 5495/5495 [00:03<00:00, 1453.32it/s]
```

In [ ]:

```
for i in range(len(pred_values_val)):
  pred_values_val[i] = pred_values_val[i].replace('[SEP]','')   # removing [sep] token
```

In [ ]:

```
scores_val=[]
x_val['pred_text'] = pred_values_val
x_val['selected_text'] = y_val.values
scores=[]
```

```
for i in tqdm(range(x_val.shape[0])):
  scores_val.append(jaccard(x_val['pred_text'].values[i],x_val['selected_text'].values[i
]))          # jaccard score calculations

x_val['jaccard']=scores_val
```

```
100%|██████████| 5495/5495 [00:00<00:00, 79204.17it/s]
```

In [ ]:

```
x_val.head(20)
```

Out[ ]:

	text	sentiment	pred_text	selected_text	jaccard
7917	this is my update	neutral	this is my update	this is my update	1.000000
15845	whaaat i still have next week	neutral	whaaat i still have next week	whaaat i still have next week	1.000000
21278	happy birthday little sister of mine also go...	positive	happy birthday	happy birthday little sister of mine	0.333333
22338	do some research for my article	neutral	do some research for my article	do some research for my article	1.000000
22474	are you okay	neutral	are you okay	are you okay	1.000000
21560	turned my alarm off this morning because i tho...	negative		fail	0.000000
8870	elaines my online mommy too she gives good a...	positive	advice	she gives good advice	0.250000
22030	good ABUSE homie hahahahaha thats what im tal...	positive	good	good	1.000000
6693	there are days of summervac school comes alo...	neutral	there are days of summervac school comes along...	the annual problem of r generation is finding ...	0.590909
15718	i have tea have just found a picture of the b...	neutral	i have tea have just found a picture of the bi...	i have tea have just found a picture of the b...	1.000000
15279	craving coffee	neutral	craving coffee	craving coffee	1.000000
20672	time for tv in bedthen spending all day catchi...	negative	summer classes	i hate online summer classes	0.400000
17239	well it almost was a good day guess i just ret...	positive	day guess i	good day	0.250000
26658	the ultimate shirt folding tool i saw using ...	positive	the ultimate shirt folding tool i saw using th...	ultimate	0.062500
6199	no months	neutral	no months	no months	1.000000
10794	the least i can do for you is retweet it when...	neutral	the least i can do for you is retweet it when ...	the least i can do for you is retweet it when ...	1.000000
2899	oh snap kinda nuts right now ive told at lea...	positive	kinda nuts right now ive told at least thanks ...	thanks	0.100000
12789	says gud eve guys lets play poker yeah cant re...	positive	cant read my poker face	says gud eve guys	0.000000
5036	awesome im glad you like it fyi platinum no...	positive	awesome im	glad	0.000000
2938	im celebrating my mother and also celebrating...	positive	im celebrating my mother and also celebrating ...	celebrating	0.083333

In [ ]:

```
print('Mean training Jaccard score:',np.mean(x_val['jaccard']))
print("="*150)
print('Mean jaccard score for positive sentiment tweets:',np.mean(x_val[x_val['sentiment'
]=='positive']['jaccard']))
print("="*150)
print('Mean jaccard score for negative sentiment tweets',np.mean(x_val[x_val['sentiment']
=='negative']['jaccard']))
```

```
print("="*150)
print('Mean jaccard score for neutral sentiment tweets',np.mean(x_val[x_val['sentiment']=
='neutral']['jaccard']))
```

```
Mean training Jaccard score: 0.6003635046014968
=========================================================================================
=============================================================
Mean jaccard score for positive sentiment tweets: 0.35372741948989095
=========================================================================================
=============================================================
Mean jaccard score for negative sentiment tweets 0.34164678987434965
=========================================================================================
=============================================================
Mean jaccard score for neutral sentiment tweets 0.9706531575031069
```