# imental-analysis-using-lstm-or-gru

April 26, 2024

## 1 *Tweets Sentiment Analysis Using LSTM or GRU*

## 2 import the necessary libraries

```
[4]: import pandas as pd
     import numpy as np
     import matplotlib.pyplot as plt
     import seaborn as sns
     import re
     import nltk
     from textblob import TextBlob
     from wordcloud import WordCloud
     from nltk.corpus import stopwords
     from sklearn.feature_extraction.text import CountVectorizer

     pd.set_option('max_colwidth', None)
```

## 3 Load The Data

```
[5]: df = pd.read_csv('C:/Users/user/Desktop/NLP LAB/NLP Project/hashtag_donaldtrump.
      ↪csv', lineterminator='\n', usecols = ['tweet'])
     df.head(10)
```

```
[5]:                                             tweet
     0  #Elecciones2020 | En #Florida: #JoeBiden dice que #DonaldTrump solo se
     preocupa por él mismo. El demócrata fue anfitrión de encuentros de electores en
     #PembrokePines y #Miramar. Clic AQUÍ
       \n \n https://t.co/qhIWpIUXsT\n_\n#ElSolLatino #yobrilloconelsol
     https://t.co/6FlCBWf1Mi
     1
     Usa 2020, Trump contro Facebook e Twitter: coprono Biden   #donaldtrump
     https://t.co/6ceURhe1VP https://t.co/94jidLjoON
     2                       #Trump: As a student I used to hear for years, for ten
     years, I heard China! In 2019! And we have 1.5 and they don't know how many we
     have and I asked them how many do we have and they said 'sir we don't know.' But
     we have millions. Like 300 million.\n\nUm. What?
```

```
3
2 hours since last tweet from #Trump! Maybe he is VERY busy. Tremendously busy.
4
You get a tie! And you get a tie! #Trump ‘s rally #Iowa https://t.co/jJalUUmh5D
5
@CLady62 Her 15 minutes were over long time ago. Omarosa never represented the
black community! #TheReidOut \n\nShe cried to #Trump begging for a job!
6
@richardmarx Glad u got out of the house! DICK!!#trump 2020
7              @DeeviousDenise @realDonaldTrump @nypost There won’t be many of
them.  Unless you all have been voting more than once again.  But God prevails.
BO was the most corrupt President ever.  Dark to light.  Your lies are all
coming through.  They wouldn’t last forever. #Trump
8
One of the single most effective remedies to eradicate another round of #Trump
Plague in our #WhiteHouse. https://t.co/QGB9ODIVS8
9
#Election2020 #Trump \n#FreedomOfSpeech https://t.co/9slOZFZNHJ
```

[6]:
```
df.shape
```

[6]:
```
(971156, 1)
```

[7]:
```
df.isnull().sum()
```

[7]:
```
tweet    84
dtype: int64
```

## 4 Contractions to Expansion

[8]:
```
contractions = {
"ain't": "am not / are not / is not / has not / have not",
"aren't": "are not / am not",
"can't": "cannot",
"can't've": "cannot have",
"'cause": "because",
"could've": "could have",
"couldn't": "could not",
"couldn't've": "could not have",
"didn't": "did not",
"doesn't": "does not",
"don't": "do not",
"hadn't": "had not",
"hadn't've": "had not have",
"hasn't": "has not",
"haven't": "have not",
"he'd": "he had / he would",
"he'd've": "he would have",
"he'll": "he shall / he will",
"he'll've": "he shall have / he will have",
"he's": "he has / he is",
"how'd": "how did",
"how'd'y": "how do you",
"how'll": "how will",
"how's": "how has / how is / how does",
"I'd": "I had / I would",
"I'd've": "I would have",
"I'll": "I shall / I will",
"I'll've": "I shall have / I will have",
"I'm": "I am",
"I've": "I have",
"isn't": "is not",
"it'd": "it had / it would",
"it'd've": "it would have",
"it'll": "it shall / it will",
"it'll've": "it shall have / it will have",
"it's": "it has / it is",
"let's": "let us",
"ma'am": "madam",
"mayn't": "may not",
"might've": "might have",
"mightn't": "might not",
"mightn't've": "might not have",
"must've": "must have",
"mustn't": "must not",
"mustn't've": "must not have",
"needn't": "need not",
"needn't've": "need not have",
"o'clock": "of the clock",
"oughtn't": "ought not",
"oughtn't've": "ought not have",
"shan't": "shall not",
"sha'n't": "shall not",
"shan't've": "shall not have",
"she'd": "she had / she would",
"she'd've": "she would have",
"she'll": "she shall / she will",
"she'll've": "she shall have / she will have",
"she's": "she has / she is",
"should've": "should have",
"shouldn't": "should not",
"shouldn't've": "should not have",
"so've": "so have",
"so's": "so as / so is",
"that'd": "that would / that had",
"that'd've": "that would have",
"that's": "that has / that is",
"there'd": "there had / there would",
"there'd've": "there would have",
"there's": "there has / there is",
"they'd": "they had / they would",
"they'd've": "they would have",
"they'll": "they shall / they will",
"they'll've": "they shall have / they will have",
"they're": "they are",
"they've": "they have",
"to've": "to have",
"wasn't": "was not",
"we'd": "we had / we would",
"we'd've": "we would have",
"we'll": "we will",
"we'll've": "we will have",
"we're": "we are",
"we've": "we have",
"weren't": "were not",
"what'll": "what shall / what will",
"what'll've": "what shall have / what will have",
"what're": "what are",
"what's": "what has / what is",
"what've": "what have",
"when's": "when has / when is",
"when've": "when have",
"where'd": "where did",
"where's": "where has / where is",
"where've": "where have",
"who'll": "who shall / who will",
"who'll've": "who shall have / who will have",
"who's": "who has / who is",
"who've": "who have",
"why's": "why has / why is",
"why've": "why have",
"will've": "will have",
"won't": "will not",
"won't've": "will not have",
"would've": "would have",
"wouldn't": "would not",
"wouldn't've": "would not have",
"y'all": "you all",
"y'all'd": "you all would",
"y'all'd've": "you all would have",
"y'all're": "you all are",
"y'all've": "you all have",
"you'd": "you had / you would",
"you'd've": "you would have",
"you'll": "you shall / you will",
"you'll've": "you shall have / you will have",
"you're": "you are",
"you've": "you have"
}
```

[9]:
```
def cont_to_exp(x):
     if type(x) is str:
        x = x.replace('\\', '')
        for key in contractions:
            value = contractions[key]
            x = x.replace(key, value)
        return x
     else:
        return x
```

[10]:
```
cont_to_exp("i don't have any money\.")
```

```
<>:1: SyntaxWarning: invalid escape sequence '\.'
<>:1: SyntaxWarning: invalid escape sequence '\.'
C:\Users\user\AppData\Local\Temp\ipykernel_16628\3475713725.py:1: SyntaxWarning:
invalid escape sequence '\.'
  cont_to_exp("i don't have any money\.")
```

[10]:
```
'i do not have any money.'
```

[11]:
```
df['tweet'] = df['tweet'].apply(lambda x: cont_to_exp(x))
df.head()
```

[11]:
```
                                                tweet
0  #Elecciones2020 | En #Florida: #JoeBiden dice que #DonaldTrump solo se
preocupa por él mismo. El demócrata fue anfitrión de encuentros de electores en
#PembrokePines y #Miramar. Clic AQUÍ
  \n \n https://t.co/qhIWpIUXsT\n_\n#ElSolLatino #yobrilloconelsol
https://t.co/6FlCBWf1Mi
1
Usa 2020, Trump contro Facebook e Twitter: coprono Biden   #donaldtrump
https://t.co/6ceURhe1VP https://t.co/94jidLjoON
2                    #Trump: As a student I used to hear for years, for ten
years, I heard China! In 2019! And we have 1.5 and they do not know how many we
have and I asked them how many do we have and they said 'sir we do not know.'
But we have millions. Like 300 million.\n\nUm. What?
3
```

```
2 hours since last tweet from #Trump! Maybe he is VERY busy. Tremendously busy.
4
You get a tie! And you get a tie! #Trump ‘s rally #Iowa https://t.co/jJalUUmh5D
```

## 5 Clean Data

[ ]:
```
def clean_tweets(text):
    text = re.sub(r'\brt\b', "", text) # remove retweets RT
    text = re.sub(r'[^\w ]+', "", text) # remove mentions4
    text = re.sub(r'([a-z0-9+._-]+@[a-z0-9+._-]+\.[a-z0-9+_-])',"", text) #␣
↪remove emails
    text = re.sub(r'([http|https|ftp|ssh]):/([\w_-]+(?:(?:\.[\w_-]+)+))([\w.,@?
↪^=%/~+#-]*[\w@?^=%&/~+#-])?',"", text) # remove Urls
    text = re.sub(r'\n', "", text)
    return text
```

[ ]:
```
try:
    # Assuming df is your DataFrame containing the 'tweet' column
    df['tweet'] = df['tweet'].astype(str)  # Convert all values to strings

    # Apply clean_tweets function to the 'tweet' column
    df['tweet'] = df['tweet'].apply(lambda x: clean_tweets(x))

    # Continue with your data processing and analysis

except Exception as e:
    print("An error occurred:", e)
```

[ ]:
```
df.head(10)
```

[ ]:
```
                tweet
0                Elecciones2020  En Florida JoeBiden dice que DonaldTrump solo
se preocupa por él mismo El demócrata fue anfitrión de encuentros de electores
en PembrokePines y Miramar Clic AQUÍ httpstcoqhIWpIUXsT_ElSolLatino
yobrilloconelsol httpstco6FlCBWf1Mi
1
Usa 2020 Trump contro Facebook e Twitter coprono Biden  donaldtrump
httpstco6ceURhe1VP httpstco94jidLjoON
2             Trump As a student I used to hear for years for ten years I heard
China In 2019 And we have 15 and they do not know how many we have and I asked
them how many do we have and they said sir we do not know But we have millions
Like 300 millionUm What
3
2 hours since last tweet from Trump Maybe he is VERY busy Tremendously busy
4
You get a tie And you get a tie Trump s rally Iowa httpstcojJalUUmh5D
```

```
5
CLady62 Her 15 minutes were over long time ago Omarosa never represented the
black community TheReidOut She cried to Trump begging for a job
6
richardmarx Glad u got out of the house DICKtrump 2020
7  DeeviousDenise realDonaldTrump nypost There wont be many of them  Unless you
all have been voting more than once again  But God prevails  BO was the most
corrupt President ever  Dark to light  Your lies are all coming through  They
wouldnt last forever Trump
8
One of the single most effective remedies to eradicate another round of Trump
Plague in our WhiteHouse httpstcoQGB9ODIVS8
9
Election2020 Trump FreedomOfSpeech httpstco9slOZFZNHJ
```

[ ]:
```
' '.join(df['tweet'].tolist()[:10])
```

[ ]:
```
'Elecciones2020  En Florida JoeBiden dice que DonaldTrump solo se preocupa por
él mismo El demócrata fue anfitrión de encuentros de electores en PembrokePines
y Miramar Clic AQUÍ httpstcoqhIWpIUXsT_ElSolLatino yobrilloconelsol
httpstco6FlCBWf1Mi Usa 2020 Trump contro Facebook e Twitter coprono Biden
donaldtrump httpstco6ceURhe1VP httpstco94jidLjoON Trump As a student I used to
hear for years for ten years I heard China In 2019 And we have 15 and they do
not know how many we have and I asked them how many do we have and they said sir
we do not know But we have millions Like 300 millionUm What 2 hours since last
tweet from Trump Maybe he is VERY busy Tremendously busy You get a tie And you
get a tie Trump s rally Iowa httpstcojJalUUmh5D CLady62 Her 15 minutes were over
long time ago Omarosa never represented the black community TheReidOut She cried
to Trump begging for a job richardmarx Glad u got out of the house DICKtrump
2020 DeeviousDenise realDonaldTrump nypost There wont be many of them  Unless
you all have been voting more than once again  But God prevails  BO was the most
corrupt President ever  Dark to light  Your lies are all coming through  They
wouldnt last forever Trump One of the single most effective remedies to
eradicate another round of Trump Plague in our WhiteHouse httpstcoQGB9ODIVS8
Election2020 Trump FreedomOfSpeech httpstco9slOZFZNHJ'
```

## 6 Check Polarity

If Polarity < 0 —> negative tweet, if Polarity==0 —> Neutral tweet, if Polarity > 0 —> Positive tweet,

[ ]:
```
df['polarity'] = df['tweet'].apply(lambda x: TextBlob(x).sentiment.polarity)
```

[ ]:
```
df['tweet_len'] = df['tweet'].apply(lambda x: len(x))
```

[ ]:
```
df['word_count'] = df['tweet'].apply(lambda x: len(x.split()))
```

```
[ ]: def avg_word_len(x):
         words = x.split()
         word_len = 0
         for word in words:
             word_len += len(word)

         return word_len / len(words)
```

```
[ ]: df['avg_word_len'] = df['tweet'].apply(lambda x: avg_word_len(x))
```

```
[ ]: df.head()
```

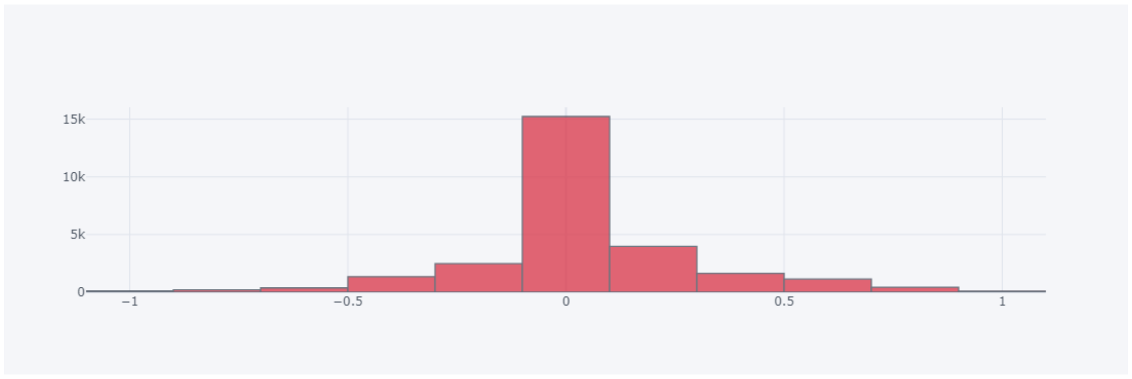
```
[ ]:      tweet  \
     0     Elecciones2020  En Florida JoeBiden dice que DonaldTrump solo se preocupa
     por él mismo El demócrata fue anfitrión de encuentros de electores en
     PembrokePines y Miramar Clic AQUÍ httpstcoqhIWpIUXsT_ElSolLatino
     yobrilloconelsol httpstco6FlCBWf1Mi
     1
     Usa 2020 Trump contro Facebook e Twitter coprono Biden  donaldtrump
     httpstco6ceURhe1VP httpstco94jidLjoON
     2  Trump As a student I used to hear for years for ten years I heard China In
     2019 And we have 15 and they do not know how many we have and I asked them how
     many do we have and they said sir we do not know But we have millions Like 300
     millionUm What
     3
     2 hours since last tweet from Trump Maybe he is VERY busy Tremendously busy
     4
     You get a tie And you get a tie Trump s rally Iowa httpstcojJalUUmh5D

        polarity  tweet_len  word_count  avg_word_len
     0  0.000000        244          30      7.133333
     1  0.000000        105          12      7.750000
     2  0.333333        247          56      3.428571
     3  0.076667         75          14      4.428571
     4  0.000000         69          14      4.000000
```

## 7 Distribution of Sentiment Polarity

```
[ ]: from plotly.offline import iplot
     import cufflinks as cf
     cf.go_offline()
     cf.set_config_file(offline=False)
```

```
[26]: df['polarity'].iplot(kind='hist', color = 'red', bins = 20)
```



Most of the tweets are neutral, this is also because of another language tweets, there are tweets which from another language so thats why many of the tweets give 0 polarity

## 8 Word Count Distribution

[27]:
```
df['word_count'].iplot(kind = 'hist', xTitle = 'words', yTitle = 'Count', title␣
↪= 'Sentiment Polarity Distribution')
```

As you can see the most of tweet have 10 to 20 words

## 9 Avg Length of Words Distribution

[28]:
```
df['avg_word_len'].iplot(kind='hist', bins = 50, xTitle = 'Avg_word_len',␣
↪yTitle = 'count', title = 'Avg_Word_len Distribution')
```

## 10 Tweet Length Distribution

[29]:
```
df['tweet_len'].iplot(kind='hist', bins= 100, color = 'orange',␣
↪linecolor='gray', xTitle='Tweet Length', yTitle='Count', title = 'Tweet␣
↪Length Distribution')
```

## 11 Plot Word Cloud

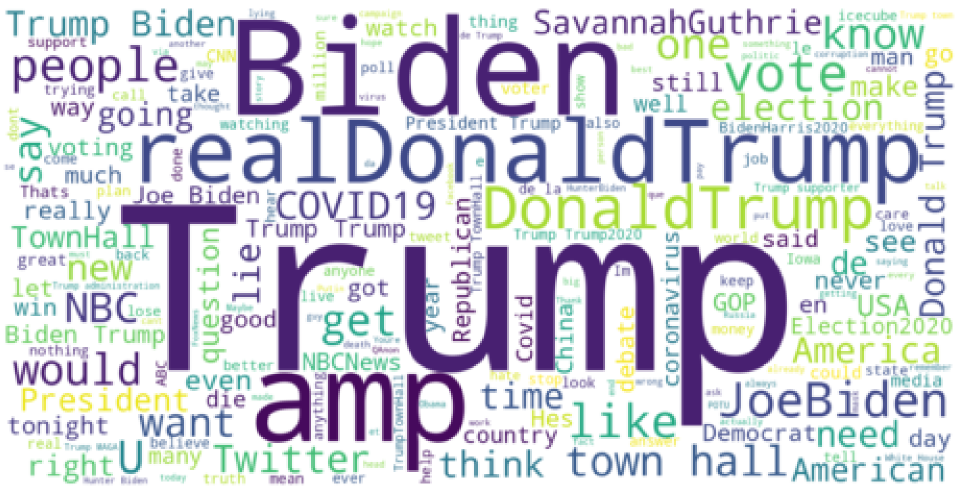
[32]:
```
import nltk
nltk.download('stopwords')
```

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

[32]:
```
True
```

```
[33]: allwords = ' '.join([twt for twt in df['tweet']])
      wordcloud = WordCloud(width = 1600, height=800, random_state=42,␣
       ↪background_color = 'white', stopwords = stopwords.words('english'),␣
       ↪min_font_size = 10).generate(allwords)

      plt.imshow(wordcloud, interpolation='bilinear')
      plt.axis('off')
      plt.show()
```



## 12 Now Create a Model For Sentiment Analysi

```
[34]: def polarity_to_sentiment(x):
      #     if type(x) is float:
      #         for i in range(0, len(x)):
          if x > 0:
              return 1 # 1 = Positive
          if x < 0:
              return 0 # 0 = negative
          else:
              return 2 # 2 = Neutral
```

```
[35]: df['sentiments'] = df['polarity'].apply(lambda x: polarity_to_sentiment(x))
```

```
[36]: df.head()
```

```
[36]:      tweet  \
      0     Elecciones2020  En Florida JoeBiden dice que DonaldTrump solo se preocupa
      por él mismo El demócrata fue anfitrión de encuentros de electores en
```

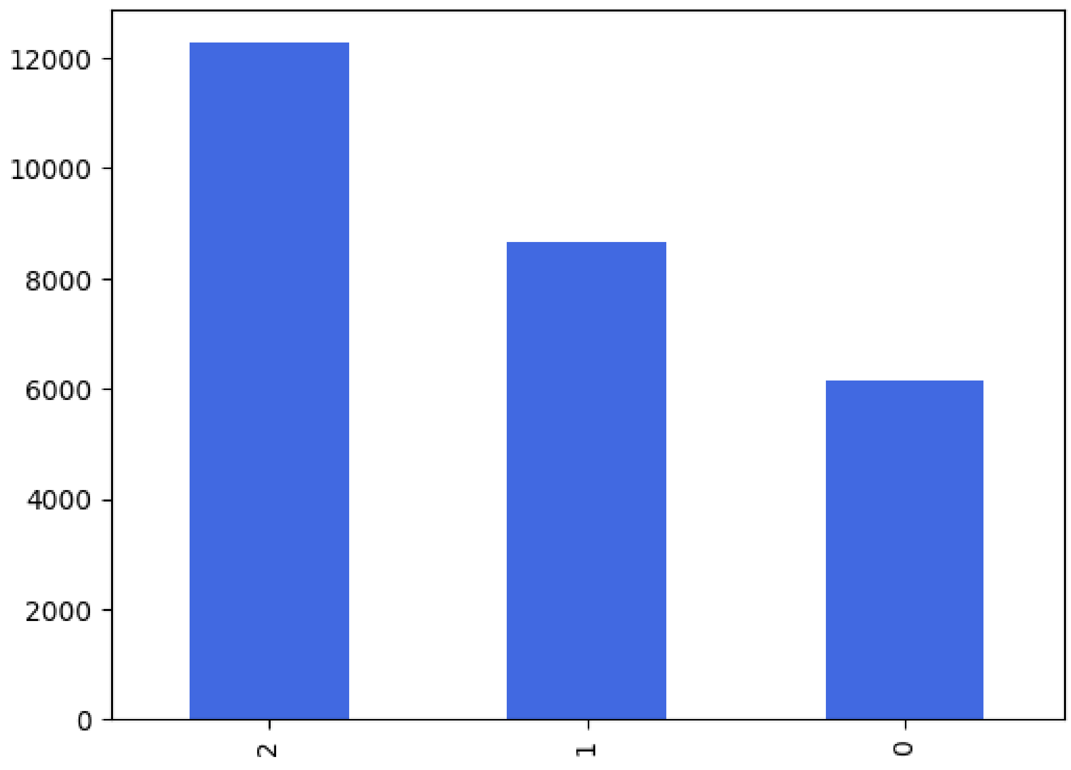
```
PembrokePines y Miramar Clic AQUÍ httpstcoqhIWpIUXsT_ElSolLatino
yobrilloconelsol httpstco6FlCBWf1Mi
1
Usa 2020 Trump contro Facebook e Twitter coprono Biden  donaldtrump
httpstco6ceURhe1VP httpstco94jidLjoON
2  Trump As a student I used to hear for years for ten years I heard China In
2019 And we have 15 and they do not know how many we have and I asked them how
many do we have and they said sir we do not know But we have millions Like 300
millionUm What
3
2 hours since last tweet from Trump Maybe he is VERY busy Tremendously busy
4
You get a tie And you get a tie Trump s rally Iowa httpstcojJalUUmh5D

   polarity  tweet_len  word_count  avg_word_len  sentiments
0  0.000000        244          30      7.133333           2
1  0.000000        105          12      7.750000           2
2  0.333333        247          56      3.428571           1
3  0.076667         75          14      4.428571           1
4  0.000000         69          14      4.000000           2
```

## 13 Distribution of Sentiments

[37]:
```python
df['sentiments'].value_counts().plot.bar(color='royalblue')
```

[37]:
```
<Axes: >
```



## 14 Split the Data to Dependent and Indepedent

[39]:
```
# dependent Features
y = df['sentiments']

# Independent Features
X = df.drop('sentiments', axis=1)
```

## 15 PorterStemmer

[40]:
```
messages = X.copy()
```

[41]:
```
from nltk import PorterStemmer
nltk.download('stopwords')
nltk.download('words')
words = set(nltk.corpus.words.words())
stopwords = set(stopwords.words('english'))
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data…
[nltk_data]   Package stopwords is already up-to-date!
```

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

[42]:
```
ps = PorterStemmer()
corpus = []
for i in range(0, len(messages)):
    review = re.sub('[^a-zA-Z]', ' ', messages['tweet'][i])
    review = review.lower()
    review = review.split()
    review = [w for w in nltk.wordpunct_tokenize(str(review)) if w.lower() in␣
 ↪words or not w.isalpha()]

    review = [ps.stem(word) for word in review if not word in stopwords]
    review = ' '.join(review)
    corpus.append(review)
```

[43]:
```
corpus[0]
```

[43]:
```
"[' ', ' en ', ' ', ' ', ' dice ', ' ', ' ', ' solo ', ' se ', ' ', ' ', ' l ',
' ', ' el ', ' ', ' ', ' ', ' ', ' n ', ' de ', ' ', ' de ', ' ', ' en ', ' ', '
', ' ', ' ', ' ', ' ', ' ', ' ', ' ', ' ', ' mi ']"
```

## 16 Tokenize the Data

[44]:
```
from tensorflow.keras.preprocessing.text import Tokenizer
```

[45]:
```
voc_size = 50000
max_len = 120
embedding_features = 32
```

[46]:
```
tokenizer = Tokenizer(num_words=voc_size, oov_token = '<OOV>')
tokenizer.fit_on_texts(corpus)
```

Here, the value of oov_token is set to be 'OOV'. That means any unknown words will be replaced by oov_token

## 17 Embedding

[47]:
```
sequences = tokenizer.texts_to_sequences(corpus)
```

[48]:
```
from tensorflow.keras.preprocessing.sequence import pad_sequences
embedded_doc = pad_sequences(sequences, maxlen=max_len, padding= 'post',␣
 ↪truncating = 'post')
embedded_doc[0]
```

```
[48]: array([   2,    2,    2,   25,    2,    2,    2,    2,    2,    2, 1018,
                  2,    2,    2,    2,    2,    2,  791,    2,    2,  100,    2,
                  2,    2,    2,    2,    2,   84,    2,    2,    2,    2,   60,
                  2,    2,    2,    2,    2,    2,    2,    2,    2,    2,   23,
                  2,    2,    7,    2,    2,    2,    2,    7,    2,    2,    2,
                  2,   25,    2,    2,    2,    2,    2,    2,    2,    2,    2,
                  2,    2,    2,    2,    2,    2,    2,    2,    2,    2,    2,
                  2,    2,  991,    2,    0,    0,    0,    0,    0,    0,    0,
                  0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
                  0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
                  0,    0,    0,    0,    0,    0,    0,    0,    0,    0],
            dtype=int32)
```

```
[49]: X_final = np.array(embedded_doc)
      y_final = np.array(y)
```

```
[50]: X_final.shape, y_final.shape
```

```
[50]: ((27075, 120), (27075,))
```

## 18 Model Creation

```
[51]: from tensorflow.keras.models import Sequential
      from tensorflow.keras.layers import Embedding, LSTM, Dense, Dropout, GRU
```

```
[52]: model = Sequential()
      model.add(Embedding(voc_size, embedding_features, input_length = max_len))
      # model.add(Dropout(0.3))
      model.add(GRU(100))
      model.add(Dense(62, activation = 'relu'))
      # model.add(Dropout(0.3))
      model.add(Dense(32, activation = 'relu'))
      # model.add(Dropout(0.3))
      model.add(Dense(3, activation = 'softmax'))
      model.compile(loss = 'sparse_categorical_crossentropy', optimizer = 'adam',␣
        ↪metrics = ['accuracy'])
      print(model.summary())
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding (Embedding)       (None, 120, 32)           1600000

 gru (GRU)                   (None, 100)               40200
 dense (Dense)               (None, 62)                6262

 dense_1 (Dense)             (None, 32)                2016

 dense_2 (Dense)             (None, 3)                 99

=================================================================
Total params: 1648577 (6.29 MB)
Trainable params: 1648577 (6.29 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
None
```

## 19 Split the Data into Train and Test

[53]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X_final, y_final, test_size␣
  ↪= 0.25, stratify = y, random_state=42)
```

## 20 Train The Mode

[54]:
```
model.fit(X_train, y_train, validation_data = (X_test, y_test), epochs = 10,␣
  ↪batch_size=32)
```

```
Epoch 1/10
635/635 [==============================] - 94s 141ms/step - loss: 0.9939 -
accuracy: 0.5160 - val_loss: 0.9056 - val_accuracy: 0.5685
Epoch 2/10
635/635 [==============================] - 84s 133ms/step - loss: 0.6278 -
accuracy: 0.7403 - val_loss: 0.5443 - val_accuracy: 0.7979
Epoch 3/10
635/635 [==============================] - 88s 138ms/step - loss: 0.4757 -
accuracy: 0.8263 - val_loss: 0.5013 - val_accuracy: 0.8205
Epoch 4/10
635/635 [==============================] - 84s 133ms/step - loss: 0.4271 -
accuracy: 0.8496 - val_loss: 0.4935 - val_accuracy: 0.8257
Epoch 5/10
635/635 [==============================] - 85s 134ms/step - loss: 0.3868 -
accuracy: 0.8657 - val_loss: 0.5156 - val_accuracy: 0.8301
Epoch 6/10
635/635 [==============================] - 84s 133ms/step - loss: 0.3475 -
accuracy: 0.8834 - val_loss: 0.5181 - val_accuracy: 0.8159
Epoch 7/10
635/635 [==============================] - 84s 133ms/step - loss: 0.3176 -
accuracy: 0.8978 - val_loss: 0.5638 - val_accuracy: 0.8230
Epoch 8/10
```

```
635/635 [==============================] - 85s 133ms/step - loss: 0.2980 -
accuracy: 0.9046 - val_loss: 0.5425 - val_accuracy: 0.8316
Epoch 9/10
635/635 [==============================] - 84s 133ms/step - loss: 0.2729 -
accuracy: 0.9143 - val_loss: 0.5761 - val_accuracy: 0.8274
Epoch 10/10
635/635 [==============================] - 89s 140ms/step - loss: 0.2495 -
accuracy: 0.9224 - val_loss: 0.5766 - val_accuracy: 0.8263
```

```
[54]: <keras.src.callbacks.History at 0x78f6791ef7f0>
```

## 21 Performance Metrics and Accuracy

```
[55]: y_pred = ((model.predict(X_test)>0.5).astype('int32'))
```

```
212/212 [==============================] - 8s 33ms/step
```

## 22 Confusion Matrix

```
[56]: from sklearn.metrics import confusion_matrix
      confusion_matrix(y_test, np.argmax(y_pred, axis = 1))
```

```
[56]: array([[1205,  197,  133],
             [ 349, 1615,  203],
             [ 149,  176, 2742]])
```

## 23 Accuracy

```
[57]: from sklearn.metrics import accuracy_score
      accuracy_score(y_test, np.argmax(y_pred, axis=1))
```

```
[57]: 0.8216871029694194
```