Week8_4_NLP_text_embedings_Glove_model

May 31, 2021

NLP: Text Classification2

Importing relevant libraries

[1]:

```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import re
import nltk
import tensorflow as tf
from nltk.corpus import stopwords
nltk.download('stopwords')
from tensorflow import keras
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.layers import LSTM
from tensorflow.keras.layers import Dropout
from tensorflow.keras.wrappers.scikit_learn import KerasClassifier
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.layers import Embedding, Flatten, GlobalMaxPool1D, Conv1D
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.optimizers import Adam
from sklearn.feature_extraction.text import TfidfVectorizer
from wordcloud import WordCloud
from sklearn.model_selection import RandomizedSearchCV
from nltk.stem import WordNetLemmatizer
nltk.download('wordnet')

import warnings
warnings.filterwarnings("ignore")
```

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

```
[nltk_data]     /home/jayanthikishore/nltk_data…
[nltk_data]   Package wordnet is already up-to-date!
```

Load Train and Test data

[2]:

```
# train = pd.read_csv('/Users/preethamvignesh/Desktop/Work/ML_EIT/Data/
 ↪corona_nlpdata/Corona_NLP_train.csv',encoding='latin')
# test = pd.read_csv('/Users/preethamvignesh/Desktop/Work/ML_EIT/Data/
 ↪corona_nlpdata/Corona_NLP_test.csv', encoding ='latin')

train = pd.read_csv('/home/jayanthikishore/Desktop/Analysis/Work/ML_EIT/Data/
 ↪corona_nlpdata/Corona_NLP_train.csv',encoding='latin')
test = pd.read_csv('/home/jayanthikishore/Desktop/Analysis/Work/ML_EIT/Data/
 ↪corona_nlpdata/Corona_NLP_test.csv', encoding ='latin')
```

Data Exploration

[3]:

```
train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 41157 entries, 0 to 41156
Data columns (total 6 columns):
 #   Column         Non-Null Count  Dtype
---  ------         --------------  -----
 0   UserName       41157 non-null  int64
 1   ScreenName     41157 non-null  int64
 2   Location       32567 non-null  object
 3   TweetAt        41157 non-null  object
 4   OriginalTweet  41157 non-null  object
 5   Sentiment      41157 non-null  object
dtypes: int64(2), object(4)
memory usage: 1.9+ MB
```

[4]:

```
train
```

[4]:

```
       UserName  ScreenName                     Location     TweetAt  \
0          3799       48751                       London  16-03-2020
1          3800       48752                           UK  16-03-2020
2          3801       48753                    Vagabonds  16-03-2020
3          3802       48754                          NaN  16-03-2020
4          3803       48755                          NaN  16-03-2020
…           …          …                            …         …
41152     44951       89903  Wellington City, New Zealand  14-04-2020
41153     44952       89904                          NaN  14-04-2020
41154     44953       89905                          NaN  14-04-2020
41155     44954       89906                          NaN  14-04-2020
41156     44955       89907  i love you so much || he/him  14-04-2020
```

```
                                           OriginalTweet           Sentiment
0      @MeNyrbie @Phil_Gahan @Chrisitv https://t.co/i…             Neutral
1      advice Talk to your neighbours family to excha…            Positive
2      Coronavirus Australia: Woolworths to give elde…            Positive
3      My food stock is not the only one which is emp…            Positive
4      Me, ready to go at supermarket during the #COV…  Extremely Negative
…                                                   …                 …
41152  Airline pilots offering to stock supermarket s…             Neutral
41153  Response to complaint not provided citing COVI…  Extremely Negative
41154  You know itÂ s getting tough when @KameronWild…           Positive
41155  Is it wrong that the smell of hand sanitizer i…             Neutral
41156  @TartiiCat Well new/used Rift S are going for …            Negative

[41157 rows x 6 columns]
```

Shape of the Dataset

[5]:

```python
train.shape
```

[5]:

```
(41157, 6)
```

Replace sentiments in column

[6]:

```python
#Replace Extremely Positive & Negative with Positive and Negative
train.loc[train.Sentiment == 'Extremely Negative','Sentiment'] = 'Negative'
train.loc[train.Sentiment == 'Extremely Positive', 'Sentiment'] = 'Positive'

test.loc[test.Sentiment == 'Extremely Negative', 'Sentiment'] = 'Negative'
test.loc[test.Sentiment == 'Extremely Positive', 'Sentiment'] = 'Positive'

train
```

[6]:

```
       UserName  ScreenName                      Location     TweetAt  \
0          3799       48751                        London  16-03-2020
1          3800       48752                            UK  16-03-2020
2          3801       48753                     Vagabonds  16-03-2020
3          3802       48754                           NaN  16-03-2020
4          3803       48755                           NaN  16-03-2020
…             …         …                             …         …
41152     44951       89903  Wellington City, New Zealand  14-04-2020
41153     44952       89904                           NaN  14-04-2020
41154     44953       89905                           NaN  14-04-2020
41155     44954       89906                           NaN  14-04-2020
41156     44955       89907  i love you so much || he/him  14-04-2020

                                           OriginalTweet Sentiment
0      @MeNyrbie @Phil_Gahan @Chrisitv https://t.co/i…   Neutral
1      advice Talk to your neighbours family to excha…  Positive
```

```
2      Coronavirus Australia: Woolworths to give elde…  Positive
3      My food stock is not the only one which is emp…  Positive
4      Me, ready to go at supermarket during the #COV…  Negative
…                                                  …         …
41152  Airline pilots offering to stock supermarket s…   Neutral
41153  Response to complaint not provided citing COVI…  Negative
41154  You know itÂ s getting tough when @KameronWild… Positive
41155  Is it wrong that the smell of hand sanitizer i…   Neutral
41156  @TartiiCat Well new/used Rift S are going for …  Negative

[41157 rows x 6 columns]
```

Counting Sentiments

[7]:

```python
from collections import Counter
test_cnt = Counter(test.Sentiment)
train_cnt = Counter(train['Sentiment'])
print(test_cnt)
print(train_cnt)
```

```
Counter({'Negative': 1633, 'Positive': 1546, 'Neutral': 619})
Counter({'Positive': 18046, 'Negative': 15398, 'Neutral': 7713})
```

[8]:

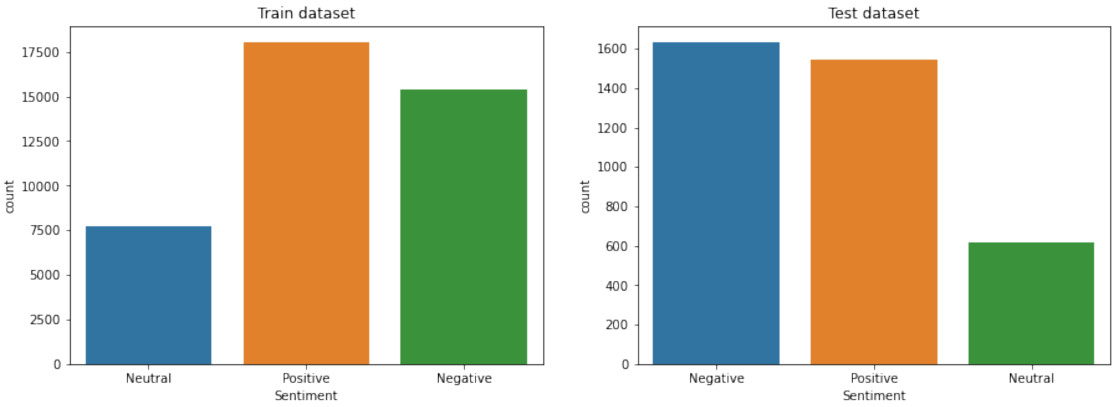
```python
f, axes = plt.subplots(ncols=2, figsize=(15, 5))

sns.countplot(train.Sentiment,ax=axes[0])
axes[0].set_title('Train dataset')

sns.countplot(test.Sentiment,ax=axes[1])
axes[1].set_title('Test dataset')
```

[8]:

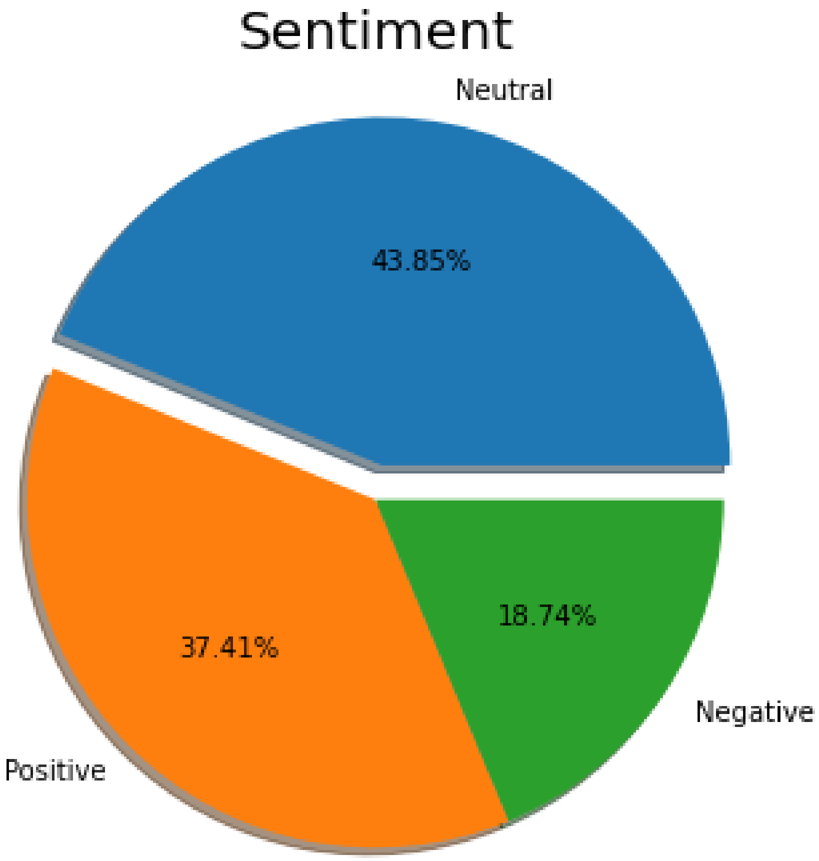
```
Text(0.5, 1.0, 'Test dataset')
```



[9]:

```
labls = ['Neutral', 'Positive','Negative']
size = train['Sentiment'].value_counts()
explode = [0.1,0,0]

plt.rcParams['figure.figsize'] = (6, 6)
plt.pie(size, explode = explode, labels = labls, shadow = True, autopct = '%.2f%%')
plt.title('Sentiment', fontsize = 20)
plt.axis('off')
# plt.legend()
plt.show()
```



Count Locationwise

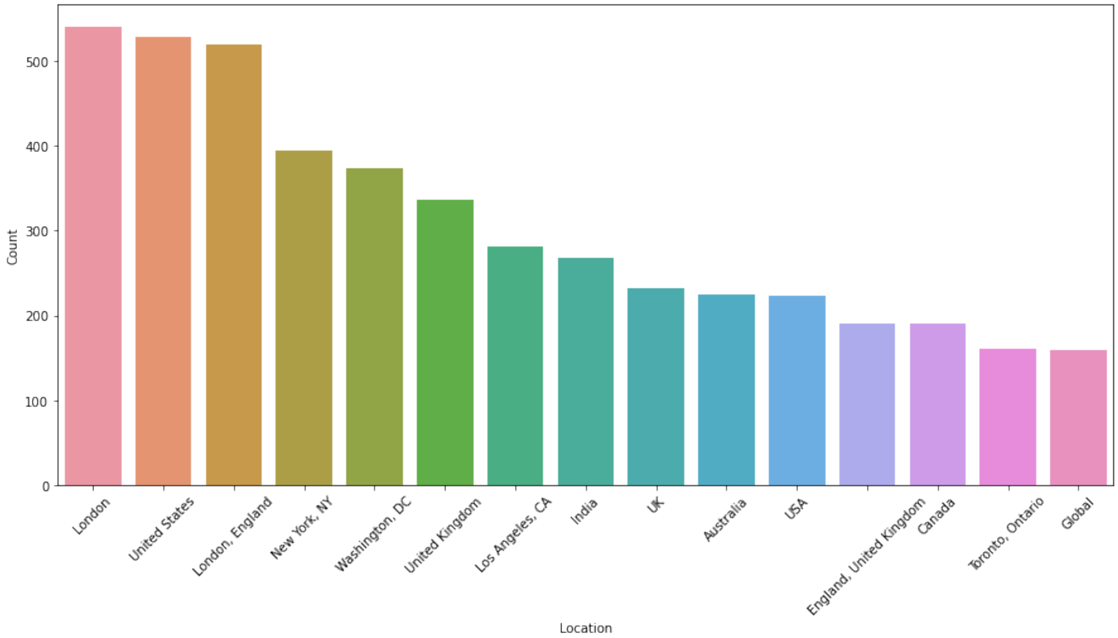
[10]:

```
import matplotlib.pyplot as plt
import pandas as pd
location = train.Location
location = pd.DataFrame(location)
```

```
location['Count'] = 1
location = location.groupby('Location').sum().sort_values(by = 'Count',␣
 ↪ascending = False).nlargest(15,['Count'])
location = location.reset_index()


plt.figure(figsize=(15,7))
# norm = plt.Normalize(location.min(), location.max())
# cmap = plt.get_cmap("magma")
sns.barplot(x = 'Location',y = 'Count', data=location)
plt.xticks(rotation=45)

plt.show()
```



[11]:
```
time = train.TweetAt
time = pd.DataFrame(time)
Min = time.TweetAt.min()
Max = time.TweetAt.max()
print(f'The date range of the data is between {Min} and {Max}')
```

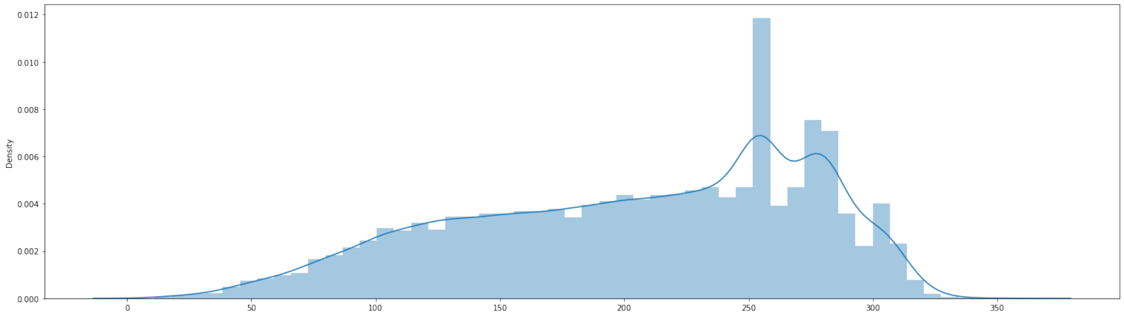
```
The date range of the data is between 01-04-2020 and 31-03-2020
```

[12]:
```
length_tweets = pd.DataFrame(train.OriginalTweet)
length_measured = []
for i in length_tweets.OriginalTweet:
 length_measured.append(len(i))
```

```
plt.figure(figsize=(25,7))
sns.distplot(length_measured)
```

[12]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f92bf071b20>
```



Data Cleaning and drop some variables

[13]:

```
train = train.drop(['UserName','ScreenName'], axis = 1)
test = test.drop(['UserName','ScreenName'], axis = 1)
```

[14]:

```
#Transform it into a datetime column
train['TweetAt'] = pd.to_datetime(train['TweetAt'], format = '%d-%m-%Y')
test['TweetAt'] = pd.to_datetime(test['TweetAt'], format = '%d-%m-%Y')

train.rename(columns={'OriginalTweet': 'Tweet'}, inplace=True)
test.rename(columns={'OriginalTweet': 'Tweet'}, inplace=True)

#Remove urls:
train.Tweet = train.Tweet.str.replace('http\S+|www.\S+', '', case=False)
test.Tweet = test.Tweet.str.replace('http\S+|www.\S+', '', case=False)

# Remove punctuation, special characters & mentions:
train.Tweet = train.Tweet.str.replace(r'[^\w\s]', '', case=False)
test.Tweet = test.Tweet.str.replace(r'[^\w\s]', '', case=False)

# #Remove stopwords:
stop_words = set(stopwords.words('english'))
train.Tweet = train.Tweet.apply(lambda x: ' '.join([word for word in x.split()␣
 ↪if word not in (stop_words)]))
test.Tweet = test.Tweet.apply(lambda x: ' '.join([word for word in x.split() if␣
 ↪word not in (stop_words)]))

#Remove non alphabetic words:
```

```
train.Tweet = train.Tweet.apply(lambda x: ' '.join([word for word in x.split()␣
 ↪if word.isalpha()]))
test.Tweet = test.Tweet.apply(lambda x: ' '.join([word for word in x.split() if␣
 ↪word.isalpha()]))

#Remove emptys rows:
train = train[train.Tweet != '']
test = test[test.Tweet != '']

#Initiate a lemmatizer and lemmatize each word in the data
lemmatizer = WordNetLemmatizer()
train.Tweet = train.Tweet.apply(lambda x: ' '.join([lemmatizer.lemmatize(word)␣
 ↪for word in x.split()]))
test.Tweet = test.Tweet.apply(lambda x: ' '.join([lemmatizer.lemmatize(word)␣
 ↪for word in x.split()]))
```

check the tweets are cleaned are not

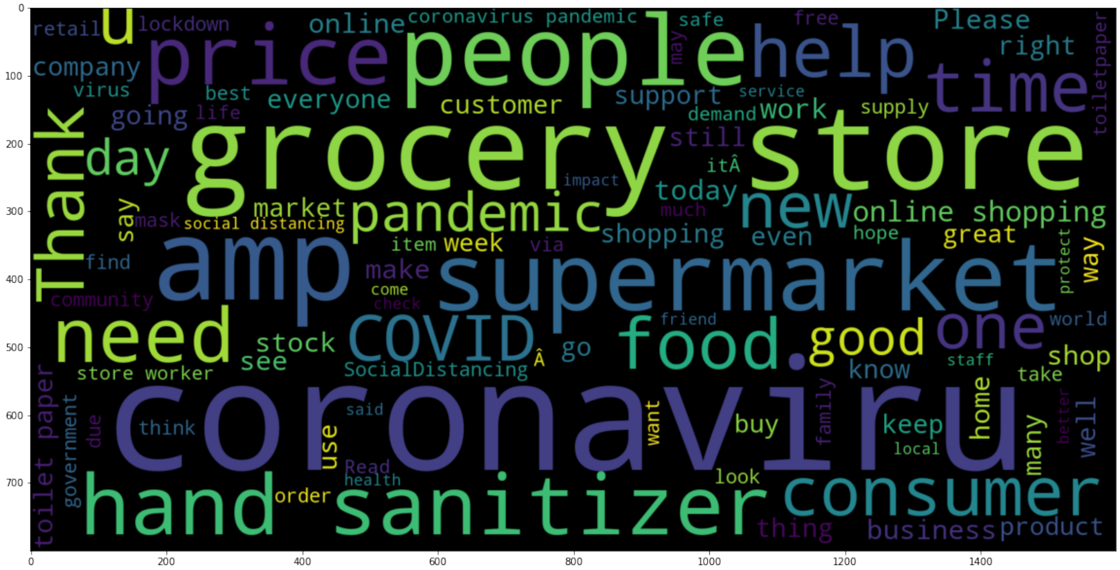
[15]:
```
for i in range(0,5):
    print(i,':',train.Tweet[i])
    print(i,':',test.Tweet[i])
```

```
0 : MeNyrbie Chrisitv
0 : TRENDING New Yorkers encounter empty supermarket shelf pictured Wegmans
Brooklyn soldout online grocer FoodKick MaxDelivery coronavirusfearing shopper
stock
1 : advice Talk neighbour family exchange phone number create contact list phone
number neighbour school employer chemist GP set online shopping account po
adequate supply regular med order
1 : When I couldnt find hand sanitizer Fred Meyer I turned Amazon But pack
PurellCheck coronavirus concern driving price
2 : Coronavirus Australia Woolworths give elderly disabled dedicated shopping
hour amid outbreak
2 : Find protect loved one coronavirus
3 : My food stock one empty PLEASE dont panic THERE WILL BE ENOUGH FOOD FOR
EVERYONE take need Stay calm stay safe coronavirus confinement Confinementotal
ConfinementGeneral
3 : Panic buying hit NewYork City anxious shopper stock foodampmedical supply
healthcare worker becomes BigApple confirmed coronavirus patient OR Bloomberg
staged event QAnon CDC
4 : Me ready go supermarket outbreak Not Im paranoid food stock litteraly empty
The coronavirus serious thing please dont panic It cause shortage
CoronavirusFrance restezchezvous StayAtHome confinement
4 : toiletpaper dunnypaper coronavirus coronavirusaustralia CoronaVirusUpdate
dunnypapergate Costco One week everyone buying baby milk powder next everyone
buying toilet paper
```

Word Cloud for positive tweets

[16]:
```
# Top 100 words for positive tweets:
plt.figure(figsize = (20,20)) # Text that is Fake
wc = WordCloud(max_words = 100 , width = 1600 , height = 800).generate(" ".
↪join(train[(train.Sentiment == 'Positive') | (train.Sentiment == 'Extremely␣
↪Positive')].Tweet))
plt.imshow(wc , interpolation = 'bilinear')
```

[16]:
```
<matplotlib.image.AxesImage at 0x7f92c1c708e0>
```



save the train and test cleaned tweets into local hard disk

[17]:
```
# #Save the data cleaned to be an input for our streamlit app
# train.to_csv('/Users/preethamvignesh/Downloads/train_cleaned.csv',␣
↪index=False)
# test.to_csv('/Users/preethamvignesh/Downloads/test_cleaned.csv', index=False)
```

[18]:
```
#Encode the target:
y_train = pd.get_dummies(train.Sentiment).values
y_test = pd.get_dummies(test.Sentiment).values
y_train
```

[18]:
```
array([[0, 1, 0],
       [0, 0, 1],
       [0, 0, 1],
       …,
       [0, 0, 1],
       [0, 1, 0],
       [1, 0, 0]], dtype=uint8)
```

Embedding Models

[19]:
```
train['num_words'] = train.Tweet.apply(lambda x : len(x.split()))
max(train['num_words'])
```

[19]:
```
53
```

[20]:
```
maxlen = 50

tokenizer = Tokenizer(num_words=10000)
tokenizer.fit_on_texts(train.Tweet.values)

X_train = tokenizer.texts_to_sequences(train.Tweet.values)
X_test = tokenizer.texts_to_sequences(test.Tweet.values)

X_train = pad_sequences(X_train, maxlen=maxlen)
X_test = pad_sequences(X_test, maxlen=maxlen)

vocab_size = len(tokenizer.word_index) + 1
```

Embedding Model (One Layer)

[21]:
```
embedding_dim = 30
opti = Adam(lr = 0.01)

model_onelayer_embed = Sequential()
model_onelayer_embed.add(Embedding(input_dim=vocab_size,
                           output_dim=embedding_dim,
                           input_length=maxlen))
model_onelayer_embed.add(Flatten())
model_onelayer_embed.add(Dense(16, activation = 'relu'))
model_onelayer_embed.add(Dense(3, activation = 'softmax'))
```

[22]:
```
model_onelayer_embed.compile(loss = 'categorical_crossentropy', optimizer =␣
 ↪opti, metrics = ['accuracy'])
model_onelayer_embed.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding (Embedding)        (None, 50, 30)            1637460
_________________________________________________________________
flatten (Flatten)            (None, 1500)              0
_________________________________________________________________
dense (Dense)                (None, 16)                24016
_________________________________________________________________
dense_1 (Dense)              (None, 3)                 51
```

```
=================================================================
Total params: 1,661,527
Trainable params: 1,661,527
Non-trainable params: 0
_________________________________________________________________
```

[23]:
```
history_onelayer_embed = model_onelayer_embed.fit(X_train, y_train,
                    epochs=2,
                    verbose=True,
                    validation_data=(X_test, y_test),
                    batch_size=16)
```

```
Epoch 1/2
2572/2572 [==============================] - 38s 15ms/step - loss: 0.7971 -
accuracy: 0.6413 - val_loss: 0.6367 - val_accuracy: 0.7488
Epoch 2/2
2572/2572 [==============================] - 36s 14ms/step - loss: 0.4228 -
accuracy: 0.8466 - val_loss: 0.6794 - val_accuracy: 0.7617
```

[ ]:
```
# #Save models and history
# model_onelayer_embed.save('/Users/preethamvignesh/Downloads/
 ↪model_onelayer_embed.h5')
# np.save('/Users/preethamvignesh/Downloads/history_onelayer_embed.
 ↪npy',history_simple_embed.history)
```

Embedding Model (Multi Layer)

[25]:
```
embedding_dim = 50
opti = Adam(lr = 0.01)

multi_layer_Embed = Sequential()
multi_layer_Embed.add(Embedding(input_dim=vocab_size,
                           output_dim=embedding_dim,
                           input_length=maxlen))
multi_layer_Embed.add(Flatten())
multi_layer_Embed.add(Dense(64, activation = 'relu'))
multi_layer_Embed.add(Dense(32, activation = 'relu'))
multi_layer_Embed.add(Dense(16, activation = 'relu'))
multi_layer_Embed.add(Dense(3, activation = 'softmax'))
```

[26]:
```
multi_layer_Embed.compile(loss = 'categorical_crossentropy', optimizer = opti,␣
 ↪metrics = ['accuracy'])
multi_layer_Embed.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_2 (Embedding)      (None, 50, 50)            2729100
_________________________________________________________________
flatten_2 (Flatten)          (None, 2500)              0
_________________________________________________________________
dense_6 (Dense)              (None, 64)                160064
_________________________________________________________________
dense_7 (Dense)              (None, 32)                2080
_________________________________________________________________
dense_8 (Dense)              (None, 16)                528
_________________________________________________________________
dense_9 (Dense)              (None, 3)                 51
=================================================================
Total params: 2,891,823
Trainable params: 2,891,823
Non-trainable params: 0
_________________________________________________________________
```

[27]:

```python
history_multi_Embed = multi_layer_Embed.fit(X_train, y_train,
                    epochs=3,
                    verbose=True,
                    validation_data=(X_test, y_test),
                    batch_size=16)
```

```
Epoch 1/3
2572/2572 [==============================] - 71s 28ms/step - loss: 0.8425 -
accuracy: 0.6055 - val_loss: 0.6178 - val_accuracy: 0.7680
Epoch 2/3
2572/2572 [==============================] - 65s 25ms/step - loss: 0.4319 -
accuracy: 0.8555 - val_loss: 0.5872 - val_accuracy: 0.7875
Epoch 3/3
2572/2572 [==============================] - 61s 24ms/step - loss: 0.2704 -
accuracy: 0.9161 - val_loss: 0.7020 - val_accuracy: 0.7649
```

[ ]:

```python
# #Save models and history
# multi_layer_Embed.save('/Users/preethamvignesh/Downloads/multi_layer_Embed.
 ↪h5')
# np.save('/Users/preethamvignesh/Downloads/history_multi_Embed.
 ↪npy',history_multi_Embed.history)
```

Glove Model (one layer)

[32]:

```python
embeddings_index = {}
with open('/home/jayanthikishore/Desktop/Analysis/Work/ML_EIT/Data/
 ↪corona_nlpdata/glove.6B.50d.txt') as f:
    for line in f:
        word, coefs = line.split(maxsplit=1)
        coefs = np.fromstring(coefs, "f", sep=" ")
        embeddings_index[word] = coefs
```

```
print("Found %s word vectors." % len(embeddings_index))
```

```
Found 400000 word vectors.
```

[33]:

```
num_tokens = len(tokenizer.word_index) + 1
embedding_dim = 50
hits = 0
misses = 0

# Prepare embedding matrix
embedding_matrix = np.zeros((num_tokens, embedding_dim))
for word, i in tokenizer.word_index.items():
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        # Words not found in embedding index will be all-zeros.
        # This includes the representation for "padding" and "OOV"
        embedding_matrix[i] = embedding_vector
        hits += 1
    else:
        misses += 1
print("Converted %d words (%d misses)" % (hits, misses))
```

```
Converted 27068 words (27513 misses)
```

[34]:

```
embedding_dim = 50
opti = Adam(lr=0.01)

model_onelayer_glove = Sequential()
model_onelayer_glove.add(Embedding(vocab_size,␣
 ↪embedding_dim,input_length=maxlen, weights = [embedding_matrix], trainable =␣
 ↪False))
model_onelayer_glove.add(Flatten())
model_onelayer_glove.add(Dense(16, activation = 'relu'))
model_onelayer_glove.add(Dense(3, activation = 'softmax'))
```

[36]:

```
model_onelayer_glove.compile(loss = 'categorical_crossentropy', optimizer =␣
 ↪opti, metrics = ['accuracy'])
model_onelayer_glove.summary()
```

```
Model: "sequential_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_3 (Embedding)      (None, 50, 50)            2729100
_________________________________________________________________
flatten_3 (Flatten)          (None, 2500)              0
_________________________________________________________________
```

```
dense_10 (Dense)             (None, 16)                40016
_________________________________________________________________
dense_11 (Dense)             (None, 3)                 51
=================================================================
Total params: 2,769,167
Trainable params: 40,067
Non-trainable params: 2,729,100
_________________________________________________________________
```

[37]:

```
history_onelayer_glove = model_onelayer_glove.fit(X_train, y_train,
                    epochs=10,
                    verbose=True,
                    validation_data=(X_test, y_test),
                    batch_size=16)
```

```
Epoch 1/10
2572/2572 [==============================] - 3s 997us/step - loss: 0.9492 -
accuracy: 0.5336 - val_loss: 1.0338 - val_accuracy: 0.5419
Epoch 2/10
2572/2572 [==============================] - 2s 926us/step - loss: 0.8695 -
accuracy: 0.6064 - val_loss: 0.8920 - val_accuracy: 0.5793
Epoch 3/10
2572/2572 [==============================] - 2s 938us/step - loss: 0.8590 -
accuracy: 0.6089 - val_loss: 0.9168 - val_accuracy: 0.5785
Epoch 4/10
2572/2572 [==============================] - 2s 909us/step - loss: 0.8537 -
accuracy: 0.6158 - val_loss: 0.8863 - val_accuracy: 0.5742
Epoch 5/10
2572/2572 [==============================] - 2s 955us/step - loss: 0.8449 -
accuracy: 0.6167 - val_loss: 0.9576 - val_accuracy: 0.5155
Epoch 6/10
2572/2572 [==============================] - 2s 912us/step - loss: 0.8429 -
accuracy: 0.6196 - val_loss: 0.9159 - val_accuracy: 0.5721
Epoch 7/10
2572/2572 [==============================] - 2s 928us/step - loss: 0.8302 -
accuracy: 0.6260 - val_loss: 0.9688 - val_accuracy: 0.5742
Epoch 8/10
2572/2572 [==============================] - 2s 928us/step - loss: 0.8287 -
accuracy: 0.6290 - val_loss: 0.9741 - val_accuracy: 0.5677
Epoch 9/10
2572/2572 [==============================] - 2s 936us/step - loss: 0.8332 -
accuracy: 0.6282 - val_loss: 0.9031 - val_accuracy: 0.5808
Epoch 10/10
2572/2572 [==============================] - 2s 896us/step - loss: 0.8256 -
accuracy: 0.6323 - val_loss: 0.9728 - val_accuracy: 0.5540
```

[38]:
```
# #Save models and history
# model_onelayer_glove.save('/Users/preethamvignesh/Downloads/
 ↪model_onelayer_glove.h5')
# np.save('/Users/preethamvignesh/Downloads/history_simple_glove.
 ↪npy',history_onelayer_glove.history)
```

Glove Model (Multi layer)

[39]:
```
embedding_dim = 50
opti = Adam(lr = 0.01)

model_multi_glove = Sequential()
model_multi_glove.add(Embedding(vocab_size, embedding_dim,input_length=maxlen,␣
 ↪weights = [embedding_matrix], trainable = False))
model_multi_glove.add(Flatten())
model_multi_glove.add(Dense(64, activation = 'relu'))
model_multi_glove.add(Dense(32, activation = 'relu'))
model_multi_glove.add(Dense(16, activation = 'relu'))
model_multi_glove.add(Dense(3, activation = 'softmax'))
```

[40]:
```
model_multi_glove.compile(loss = 'categorical_crossentropy', optimizer =␣
 ↪'adam', metrics = ['accuracy'])
model_multi_glove.summary()
```

```
Model: "sequential_6"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_4 (Embedding)      (None, 50, 50)            2729100
_________________________________________________________________
flatten_4 (Flatten)          (None, 2500)              0
_________________________________________________________________
dense_12 (Dense)             (None, 64)                160064
_________________________________________________________________
dense_13 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_14 (Dense)             (None, 16)                528
_________________________________________________________________
dense_15 (Dense)             (None, 3)                 51
=================================================================
Total params: 2,891,823
Trainable params: 162,723
Non-trainable params: 2,729,100
_________________________________________________________________
```

[41]:
```
history_Multi_glove = model_multi_glove.fit(X_train, y_train,
                    epochs=10,
                    verbose=True,
                    validation_data=(X_test, y_test),
                    batch_size=16)
```

```
Epoch 1/10
2572/2572 [==============================] - 3s 1ms/step - loss: 0.9117 -
accuracy: 0.5603 - val_loss: 0.8668 - val_accuracy: 0.5821
Epoch 2/10
2572/2572 [==============================] - 3s 1ms/step - loss: 0.8085 -
accuracy: 0.6394 - val_loss: 0.8660 - val_accuracy: 0.5972
Epoch 3/10
2572/2572 [==============================] - 3s 1ms/step - loss: 0.7534 -
accuracy: 0.6621 - val_loss: 0.8968 - val_accuracy: 0.5932
Epoch 4/10
2572/2572 [==============================] - 3s 1ms/step - loss: 0.6792 -
accuracy: 0.6994 - val_loss: 0.9116 - val_accuracy: 0.5845
Epoch 5/10
2572/2572 [==============================] - 3s 1ms/step - loss: 0.5897 -
accuracy: 0.7478 - val_loss: 1.0060 - val_accuracy: 0.5837
Epoch 6/10
2572/2572 [==============================] - 3s 1ms/step - loss: 0.5077 -
accuracy: 0.7901 - val_loss: 1.0951 - val_accuracy: 0.5735
Epoch 7/10
2572/2572 [==============================] - 3s 1ms/step - loss: 0.4328 -
accuracy: 0.8249 - val_loss: 1.2890 - val_accuracy: 0.5679
Epoch 8/10
2572/2572 [==============================] - 3s 992us/step - loss: 0.3786 -
accuracy: 0.8503 - val_loss: 1.4203 - val_accuracy: 0.5687
Epoch 9/10
2572/2572 [==============================] - 3s 1ms/step - loss: 0.3397 -
accuracy: 0.8671 - val_loss: 1.4965 - val_accuracy: 0.5635
Epoch 10/10
2572/2572 [==============================] - 3s 994us/step - loss: 0.2980 -
accuracy: 0.8823 - val_loss: 1.6471 - val_accuracy: 0.5574
```

```
[ ]: # #Save models and history
     # model_multi_glove.save('/Users/preethamvignesh/Downloads/model_multi_glove.
      ↪h5')
     # np.save('/Users/preethamvignesh/Downloads/history_Multi_glove.
      ↪npy',history_Multi_glove.history)
```

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```