CAPSTONE PROJECT

- name: Leticia D Drasler
- pace: Part time
- Scheduled project review data/time: March 22nd, 2022, 1:00PM (Mountain Time)
- Course Instructor: Abhineet
- Blog post URL:
- GitHub repository: https://github.com/lddrasler/Sentiment-Analysis (https://github.com/lddrasler/Sentiment-Analysis)

In [1]:
```
import warnings
warnings.filterwarnings('ignore')

import numpy as np
import pandas as pd
import tensorflow as tf
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline


from sklearn.manifold import TSNE
import re

import emoji
import nltk
from nltk.stem import WordNetLemmatizer
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
from gensim.models import word2vec
```

Loading and analyzing dataset

In [2]:

```
# train
train = pd.read_csv('Corona_NLP_train.csv', encoding='latin-1')

# test
test = pd.read_csv('Corona_NLP_test.csv', encoding='latin-1')

#checking
train.head(5)
```

Out[2]:

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

In [3]:

```
test.head(5)
```

Out[3]:

	UserName	ScreenName	Location	TweetAt	OriginalTweet	Sentiment
0	1	44953	NYC	02-03-2020	TRENDING: New Yorkers encounter empty supermar...	Extremely Negative
1	2	44954	Seattle, WA	02-03-2020	When I couldn't find hand sanitizer at Fred Me...	Positive
2	3	44955	NaN	02-03-2020	Find out how you can protect yourself and love...	Extremely Positive
3	4	44956	Chicagoland	02-03-2020	#Panic buying hits #NewYork City as anxious sh...	Negative
4	5	44957	Melbourne, Victoria	03-03-2020	#toiletpaper #dunnypaper #coronavirus #coronav...	Neutral

In [4]:
```
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
```

In [5]:
```
test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3798 entries, 0 to 3797
Data columns (total 6 columns):
 #   Column         Non-Null Count  Dtype 
---  ------         --------------  ----- 
 0   UserName       3798 non-null   int64 
 1   ScreenName     3798 non-null   int64 
 2   Location       2964 non-null   object
 3   TweetAt        3798 non-null   object
 4   OriginalTweet  3798 non-null   object
 5   Sentiment      3798 non-null   object
dtypes: int64(2), object(4)
memory usage: 178.2+ KB
```

In [6]:
```
train.isna().sum()
```

Out[6]:
```
UserName            0
ScreenName          0
Location         8590
TweetAt             0
OriginalTweet       0
Sentiment           0
dtype: int64
```

In [7]:
```
test.isna().sum()
```

Out[7]:
```
UserName            0
ScreenName          0
Location          834
TweetAt             0
OriginalTweet       0
Sentiment           0
dtype: int64
```

In [8]:
```
train['Location'].isna().sum()
```

Out[8]:
```
8590
```

In [9]:
```
test['Location'].isna().sum()
```

Out[9]:
```
834
```

In [10]:
```
train['Location'][0:20]
```

Out[10]:
```
0                        London
1                            UK
2                    Vagabonds
3                           NaN
4                           NaN
5     Ã T: 36.319708,-82.363649
6          35.926541,-78.753267
7                       Austria
8                Atlanta, GA USA
9               BHAVNAGAR,GUJRAT
10                Makati, Manila
11    Pitt Meadows, BC, Canada
12                   Horningsea
13                  Chicago, IL
14                          NaN
15                Houston, Texas
16                  Saudi Arabia
17               Ontario, Canada
18                 North America
19                    Denver, CO
Name: Location, dtype: object
```

In [11]:
```
train['Sentiment'].value_counts()
```

Out[11]:
```
Positive              11422
Negative               9917
Neutral                7713
Extremely Positive     6624
Extremely Negative     5481
Name: Sentiment, dtype: int64
```

In [12]:
```
test['Sentiment'].value_counts()
```

Out[12]:
```
Negative              1041
Positive               947
Neutral                619
Extremely Positive     599
Extremely Negative     592
Name: Sentiment, dtype: int64
```

Cleaning Train and Test Data

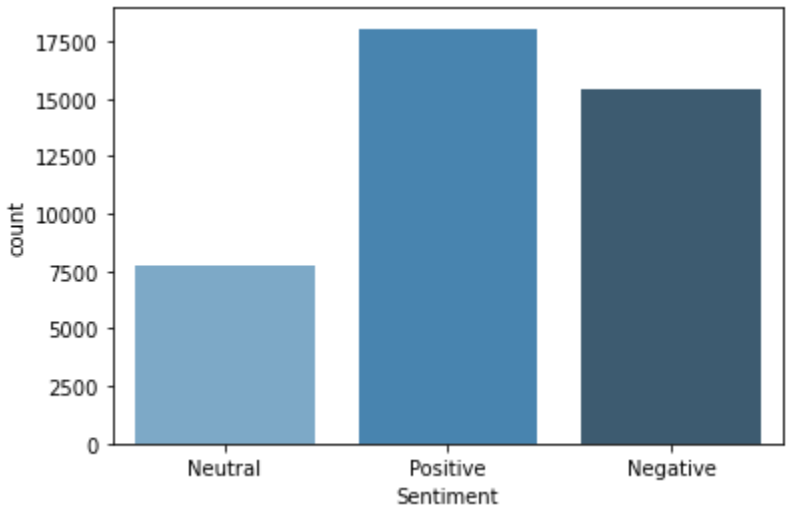
In [13]:
```
train.drop(columns=['Location'], inplace=True)
test.drop(columns=['Location'], inplace=True)
```

In [14]:
```
#changing sentiment train and test

change_sentiment = {"Extremely Positive":2,
                    "Positive":2,
                    "Neutral":0,
                    "Negative":1,
                    "Extremely Negative":1
                    }
train['Sentiment']=train['Sentiment'].map(change_sentiment,0)
test['Sentiment']=test['Sentiment'].map(change_sentiment,0)
```

In [15]:
```
sns.countplot(train['Sentiment'].map({0:'Neutral', 1:'Negative',2:'Positive'}), palette="Blues_d")
```

Out[15]: <AxesSubplot:xlabel='Sentiment', ylabel='count'>



In [16]:
```
# train
tweet_train = train["OriginalTweet"]

#test
tweet_test = test['OriginalTweet']

#checking train
tweet_train[0:10]
```

Out[16]:
```
0    @MeNyrbie @Phil_Gahan @Chrisitv https://t.co/i... (https://t.co/i...)
1    advice Talk to your neighbours family to excha...
2    Coronavirus Australia: Woolworths to give elde...
3    My food stock is not the only one which is emp...
4    Me, ready to go at supermarket during the #COV...
5    As news of the regionÂ s first confirmed COVID...
6    Cashier at grocery store was sharing his insig...
7    Was at the supermarket today. Didn't buy toile...
8    Due to COVID-19 our retail store and classroom...
9    For corona prevention,we should stop to buy th...
Name: OriginalTweet, dtype: object
```

Preprocessing

In [17]:
```
emojis = {':)': 'smile', ':-)': 'smile', ';d': 'wink', ':-E': 'vampire', ':(': 'sad',
          ':-(': 'sad', ':-<': 'sad', ':P': 'raspberry', ':O': 'surprised',
          ':-@': 'shocked', ':@': 'shocked',':-$': 'confused', ':\\': 'annoyed',
          ':#': 'mute', ':X': 'mute', ':^)': 'smile', ':-&': 'confused', '$_$': 'greedy',
          '@@': 'eyeroll', ':-!': 'confused', ':-D': 'smile', ':-0': 'yell', 'O.o': 'confused',
          '<(-_-)>': 'robot', 'd[-_-]b': 'dj', ":'-)": 'sadsmile', ';)': 'wink',
          ';-)': 'wink', 'O:-)': 'angel','O*-)': 'angel','(:-D': 'gossip', '=^.^=': 'cat'}
```

In [18]:

```
def preprocess(tweets):
    processedText = []

    # Create Lemmatizer and Stemmer.
    wordLemm = WordNetLemmatizer()

    # Defining regex patterns.
    urlPattern        = r"((http://)[^ ]*|(https://)[^ ]*|( www\.)[^ ]*)"
    userPattern       = '@[^\s]+'
    alphaPattern      = "[^a-zA-Z0-9]"
    sequencePattern   = r"(.)\1\1+"
    seqReplacePattern = r"\1\1"

    for tweet in tweets:
        tweet = tweet.lower()

        # Replace all URls with ''
        tweet = re.sub(urlPattern,"",tweet)
        # Replace all emojis.
        for emoji in emojis.keys():
            tweet = tweet.replace(emoji, "EMOJI" + emojis[emoji])
        # Replace @USERNAME "".
        tweet = re.sub(r"(?:\@|https?\://)\S+"," ",tweet)
        # Replace all non alphabets.
        tweet = re.sub(alphaPattern, " ", tweet)
        # Replace 3 or more consecutive letters by 2 letter.
        tweet = re.sub(sequencePattern, seqReplacePattern, tweet)

        tweetwords = ''
        for word in tweet.split():
            # Checking if the word is a stopword.
            #if word not in stopwordlist:
            if len(word)>1:
                # Lemmatizing the word.
                word = wordLemm.lemmatize(word)
                tweetwords += (word+' ')

        processedText.append(tweetwords)

    return processedText
```

In [19]:
```
#train
train_text = pd.Series(preprocess(tweet_train))

#test
test_text = pd.Series(preprocess(tweet_test))

#checking
train_text
```

Out[19]:
```
0                                                  and and
1         advice talk to your neighbour family to exchan...
2         coronavirus australia woolworth to give elderl...
3         my food stock is not the only one which is emp...
4         me ready to go at supermarket during the covid...
                                ...
41152     airline pilot offering to stock supermarket sh...
41153     response to complaint not provided citing covi...
41154     you know it getting tough when is rationing to...
41155     is it wrong that the smell of hand sanitizer i...
41156     well new used rift are going for 700 00 on ama...
Length: 41157, dtype: object
```

Tokenization

In [20]:
```
# TOKENS TRAIN
train_tokens = train_text.map(word_tokenize)
train_tokens
```

Out[20]:
```
0                                                  [and, and]
1         [advice, talk, to, your, neighbour, family, to...
2         [coronavirus, australia, woolworth, to, give, ...
3         [my, food, stock, is, not, the, only, one, whi...
4         [me, ready, to, go, at, supermarket, during, t...
                                ...
41152     [airline, pilot, offering, to, stock, supermar...
41153     [response, to, complaint, not, provided, citin...
41154     [you, know, it, getting, tough, when, is, rati...
41155     [is, it, wrong, that, the, smell, of, hand, sa...
41156     [well, new, used, rift, are, going, for, 700, ...
Length: 41157, dtype: object
```

In [21]:
```
# TOKENS TEST
test_tokens = test_text.map(word_tokenize)
test_tokens
```

Out[21]:
```
0        [trending, new, yorkers, encounter, empty, sup...
1        [when, couldn, find, hand, sanitizer, at, fred...
2        [find, out, how, you, can, protect, yourself, ...
3        [panic, buying, hit, newyork, city, a, anxious...
4        [toiletpaper, dunnypaper, coronavirus, coronav...
                               ...
3793     [meanwhile, in, supermarket, in, israel, peopl...
3794     [did, you, panic, buy, lot, of, non, perishabl...
3795     [asst, prof, of, economics, wa, on, talking, a...
3796     [gov, need, to, do, somethings, instead, of, b...
3797     [and, member, are, committed, to, the, safety,...
Length: 3798, dtype: object
```

STOP WORDS

In [22]:
```
#STOP WORDS
import nltk
from nltk.corpus import stopwords
stopwords_english = stopwords.words('english')
```

In [23]:
```
def rem_stopwords(train_tokens):
    text_filtered = []
    for tweet in train_tokens:
        tweet_filtered=[]
        for word in tweet:
            if word not in stopwords_english:
                tweet_filtered.append(word)
        text_filtered.append(tweet_filtered)
    return text_filtered

train_stopword =pd.Series(rem_stopwords(train_tokens))
train_stopword
```

Out[23]:
```
0                                                      []
1        [advice, talk, neighbour, family, exchange, ph...
2        [coronavirus, australia, woolworth, give, elde...
3        [food, stock, one, empty, please, panic, enoug...
4        [ready, go, supermarket, covid19, outbreak, pa...
                               ...
41152    [airline, pilot, offering, stock, supermarket,...
41153    [response, complaint, provided, citing, covid,...
41154    [know, getting, tough, rationing, toilet, pape...
41155    [wrong, smell, hand, sanitizer, starting, turn...
41156    [well, new, used, rift, going, 700, 00, amazon...
Length: 41157, dtype: object
```

In [24]:
```
#stop word test data

test_stopword = pd.Series(rem_stopwords(test_tokens))
test_stopword
```

Out[24]:
```
0       [trending, new, yorkers, encounter, empty, sup...
1       [find, hand, sanitizer, fred, meyer, turned, a...
2                [find, protect, loved, one, coronavirus]
3       [panic, buying, hit, newyork, city, anxious, s...
4       [toiletpaper, dunnypaper, coronavirus, coronav...
                              ...
3793    [meanwhile, supermarket, israel, people, dance...
3794    [panic, buy, lot, non, perishable, item, echo,...
3795    [asst, prof, economics, wa, talking, recent, r...
3796    [gov, need, somethings, instead, biar, je, rak...
3797    [member, committed, safety, employee, end, use...
Length: 3798, dtype: object
```

In [25]:
```
# replacing DF with cleaned tweets

#train
train['text'] = train_stopword
train.drop(columns='OriginalTweet', axis=1, inplace=True)
#test
test['text'] = test_stopword
test.drop(columns='OriginalTweet', axis=1, inplace=True)
```

In [26]:
```
def is_blank(tokenized_text):
    return tokenized_text if tokenized_text !=[] else np.nan
```

In [27]:
```
#train

train.text = train.text.map(is_blank)

#test

test.text = test.text.map(is_blank)
```

In [28]:
```
train.dropna(inplace=True)
test.dropna(inplace=True)
```

In [29]:
```
train.text
```

Out[29]:
```
1        [advice, talk, neighbour, family, exchange, ph...
2        [coronavirus, australia, woolworth, give, elde...
3        [food, stock, one, empty, please, panic, enoug...
4        [ready, go, supermarket, covid19, outbreak, pa...
5        [news, region, first, confirmed, covid, 19, ca...
                               ...
41152    [airline, pilot, offering, stock, supermarket,...
41153    [response, complaint, provided, citing, covid,...
41154    [know, getting, tough, rationing, toilet, pape...
41155    [wrong, smell, hand, sanitizer, starting, turn...
41156    [well, new, used, rift, going, 700, 00, amazon...
Name: text, Length: 41128, dtype: object
```

In [30]:
```
total_vocab = set(word for tweet in train.text for word in tweet)
len(total_vocab)
```

Out[30]:
```
41575
```

Word Cloud

In [51]:
```
train[train.Sentiment==2].text
```

Out[51]:
```
1         [advice, talk, neighbour, family, exchange, ph...
2         [coronavirus, australia, woolworth, give, elde...
3         [food, stock, one, empty, please, panic, enoug...
5         [news, region, first, confirmed, covid, 19, ca...
6         [cashier, grocery, store, wa, sharing, insight...
                                ...
41146     [gold, price, rose, year, high, today, due, co...
41148     [uv, light, sterilizer, sanitizer, mask, mobil...
41150     [never, situation, amp, world, going, supermar...
41151     [definitely, man, feel, like, fall, need, hono...
41154     [know, getting, tough, rationing, toilet, pape...
Name: text, Length: 18044, dtype: object
```

In [68]:

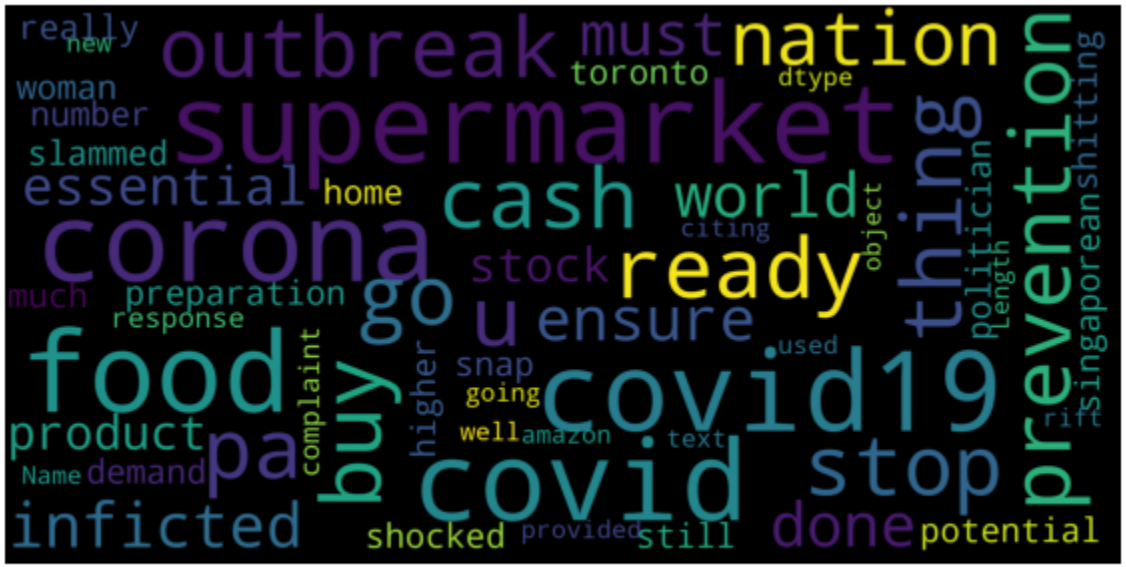
```
from wordcloud import WordCloud, STOPWORDS, ImageColorGenerator

word_cloud = WordCloud(
                      background_color='black',
                      stopwords=set(STOPWORDS),
                      max_words=200,
                      max_font_size=40,
                      scale=5).generate(str(train[train.Sentiment==2].text))
fig = plt.figure(1, figsize=(10,10))
plt.axis('off')
fig.suptitle('Positive Twitter words COVID-19', fontsize=20)
fig.subplots_adjust(top=2.3)
plt.imshow(word_cloud)
plt.show()
```

Positive Twitter words COVID-19

In [70]:

```
word_cloud = WordCloud(
                      background_color='black',
                      stopwords=set(STOPWORDS),
                      max_words=200,
                      max_font_size=40,
                      scale=5).generate(str(train[train.Sentiment==1].text))
fig = plt.figure(2, figsize=(10,10))
plt.axis('off')
fig.suptitle('Negative Twitter words COVID-19', fontsize=20)
fig.subplots_adjust(top=2.3)
plt.imshow(word_cloud)
plt.show()
```



Negative Twitter words COVID-19

GloVe

In [32]:
```
glove = {}
with open('glove.6B.50d.txt', 'rb') as f:
    for line in f:
        parts = line.split()
        word = parts[0].decode('utf-8')
        if word in total_vocab:
            vector = np.array(parts[1:], dtype=np.float32)
            glove[word] = vector

len(glove.keys())
```

Out[32]: 26221

Vectorization

In [33]:
```
#VECTORIZATION

class W2vVectorizer(object):

    def __init__(self, w2v):
        # Takes in a dictionary of words and vectors as input
        self.w2v = w2v
        if len(w2v) == 0:
            self.dimensions = 0
        else:
            self.dimensions = len(w2v[next(iter(glove))])

    # Note: Even though it doesn't do anything, it's required that this object implement a fit method or else
    # it can't be used in a scikit-learn pipeline
    def fit(self, X, y):
        return self

    def transform(self, X):
        return np.array([
            np.mean([self.w2v[w] for w in words if w in self.w2v]
                    or [np.zeros(self.dimensions)], axis=0) for words in X])
```

Baseline Models

In [34]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.linear_model import LogisticRegression
from sklearn.pipeline import Pipeline
from sklearn.model_selection import cross_val_score

rf =  Pipeline([('Word2Vec Vectorizer', W2vVectorizer(glove)),
                ('Random Foresut', RandomForestClassifier(n_estimators=100, verbose=True))])
svc = Pipeline([('Word2Vec Vectorizer', W2vVectorizer(glove)),
                  ('Support Vector Machine', SVC())])
lr = Pipeline([('Word2Vec Vectorizer', W2vVectorizer(glove)),
                ('Logistic Regression', LogisticRegression())])
```

In [35]:
```
# defining X and Y for baseline
X_train = train['text']
y_train = train['Sentiment']

X_test = test['text']
y_test = test['Sentiment']
```

In [36]:
```
models = [('Random Forest', rf),
          ('Support Vector Machine', svc),
          ('Logistic Regression', lr)]
```

In [192]:
```
scores = [(name, cross_val_score(model, X_train, y_train, cv=2).mean()) for name, model, in models]
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 100 out of 100 | elapsed:   13.5s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 100 out of 100 | elapsed:    0.5s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 100 out of 100 | elapsed:   17.0s finished
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 100 out of 100 | elapsed:    0.4s finished
```

In [193]:
```
scores
```

Out[193]:
```
[('Random Forest', 0.5950447383777475),
 ('Support Vector Machine', 0.6281851779809375),
 ('Logistic Regression', 0.6108976852752384)]
```

In [194]:
```
rf.fit(X_train, y_train)
svc.fit(X_train, y_train)
lr.fit(X_train, y_train)
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 100 out of 100 | elapsed:   31.8s finished
```

Out[194]:
```
Pipeline(steps=[('Word2Vec Vectorizer',
                 <__main__.W2vVectorizer object at 0x00000145F8793FC8>),
                ('Logistic Regression', LogisticRegression())])
```

In [195]:
```
# applying to test
```

In [196]:
```
print(rf.score(X_test,y_test))
print(svc.score(X_test, y_test))
print(lr.score(X_test, y_test))
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done 100 out of 100 | elapsed:    0.0s finished

0.5974710221285564
0.6298735511064278
0.6140674394099052
```

Neural Network with Embedding

In [37]:
```
# untokenizing to fit on keras layers

def tokens_to_string(tokenized_text):
    return " ".join(word for word in tokenized_text)
```

In [38]:
```
# defining X and Y for keras

# train
X_train = train['text'].map(tokens_to_string)
y_train_dummy = pd.get_dummies(y_train).values

# test
X_test = test['text'].map(tokens_to_string)
y_test_dummy = pd.get_dummies(y_test).values
```

In [39]:
```
from keras.preprocessing.sequence import pad_sequences
from keras.layers import Input, Dense, LSTM, Embedding
from keras.layers import Dropout, Activation, Bidirectional, GlobalMaxPool1D
from keras.models import Sequential
from keras import initializers, regularizers, constraints, optimizers, layers
from keras.preprocessing import text, sequence
```

In [40]:
```
tokenizer = text.Tokenizer(num_words=20000)
tokenizer.fit_on_texts(list(X_train))
list_tokenized_headlines = tokenizer.texts_to_sequences(X_train)
X_t = sequence.pad_sequences(list_tokenized_headlines, maxlen=100)

X_test=sequence.pad_sequences(tokenizer.texts_to_sequences(X_test), maxlen=100)
```

In [41]:
```
model = Sequential()
```

In [42]:
```
embedding_size = 128
model.add(Embedding(20000, embedding_size))
model.add(LSTM(25, return_sequences=True))
model.add(GlobalMaxPool1D())
model.add(Dropout(0.5))
model.add(Dense(50, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(3, activation='softmax'))
```

In [43]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

In [44]:
```
from tensorflow import keras
callbacks=[keras.callbacks.ModelCheckpoint('embedding_NN.keras', save_best_only=False)]
```

In [45]:
```
model.fit(X_t, y_train_dummy, epochs=2, batch_size=32, validation_split=0.2,callbacks=callbacks)
```

```
Epoch 1/2
1029/1029 [==============================] - 123s 114ms/step - loss: 0.7527 - accuracy: 0.6782 - val_loss: 0.4791 - v
al_accuracy: 0.8355
Epoch 2/2
1029/1029 [==============================] - 116s 113ms/step - loss: 0.4599 - accuracy: 0.8479 - val_loss: 0.4592 - v
al_accuracy: 0.8393
```

Out[45]:
```
<keras.callbacks.History at 0x1dc1d6f8c88>
```

Fitting test final model

In [46]:
```
loss, acc = model.evaluate(X_test,y_test_dummy)
```

```
119/119 [==============================] - 3s 24ms/step - loss: 0.5023 - accuracy: 0.8185
```

In [47]:
```
print('Test Accuracy: %f' % (acc*100))
```

```
Test Accuracy: 81.849313
```

In [ ]:
```

```