D213 Part 2 Performance Assessment Lora Milam

September 25, 2023

[2]:

```
# Import Libraries
import numpy as np
import pandas as pd
import matplotlib as mpl
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
from tensorflow import keras
import string
from sklearn.feature_extraction.text import CountVectorizer
import random
import nltk
nltk.download('punkt')
nltk.download('stopwords')
from nltk.tokenize import word_tokenize
from nltk.corpus import stopwords
import string
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.preprocessing.text import Tokenizer
from sklearn import model_selection
from sklearn import preprocessing
from sklearn.preprocessing import LabelEncoder
from keras.callbacks import EarlyStopping
```

```
2023-09-22 07:12:13.841752: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not
find cuda drivers on your machine, GPU will not be used.
2023-09-22 07:12:13.898666: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not
find cuda drivers on your machine, GPU will not be used.
2023-09-22 07:12:13.899786: I tensorflow/core/platform/cpu_feature_guard.cc:182]
This TensorFlow binary is optimized to use available CPU instructions in
performance-critical operations.
To enable the following instructions: AVX2 AVX512F FMA, in other operations,
rebuild TensorFlow with the appropriate compiler flags.
2023-09-22 07:12:16.019566: W
tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not
find TensorRT
[nltk_data] Downloading package punkt to
[nltk_data]     /home/7d515a27-500e-49a7-accc-
```

```
[nltk_data]     3e4f4339db24/nltk_data…
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package stopwords to
[nltk_data]     /home/7d515a27-500e-49a7-accc-
[nltk_data]     3e4f4339db24/nltk_data…
[nltk_data]   Package stopwords is already up-to-date!
```

[3]:

```
# Definition to import datset as dataframe
def createDF(path, source):
    labels, texts = [],[]
    for i, line in enumerate((open(path).read()).split('\n')):
        content = line.split('\t')
        if len(content) > 1:
            texts.append(content[0])
            labels.append(content[1])
    df = pd.DataFrame()
    df['label'] = labels
    df['text'] = texts
    df['source'] = source
    return df
```

[4]:

```
# Import datasets into dataframes
amazon_df = createDF('D213 Part 2/amazon_cells_labelled.txt', 'amazon')
imdb_df = createDF('D213 Part 2/imdb_labelled.txt', 'imdb')
yelp_df = createDF('D213 Part 2/yelp_labelled.txt', 'yelp')
```

[5]:

```
# Display datasets
display(amazon_df.head())
display(amazon_df.shape)
display(imdb_df.head())
display(imdb_df.shape)
display(yelp_df.head())
display(yelp_df.shape)
```

```
  label                                               text  source
0     0  So there is no way for me to plug it in here i…  amazon
1     1                        Good case, Excellent value.  amazon
2     1                             Great for the jawbone.  amazon
3     0  Tied to charger for conversations lasting more…  amazon
4     1                                  The mic is great.  amazon
```

```
(1000, 3)
```

```
  label                                               text source
0     0  A very, very, very slow-moving, aimless movie …   imdb
1     0  Not sure who was more lost - the flat characte…   imdb
2     0  Attempting artiness with black & white and cle…   imdb
3     0       Very little music or anything to speak of.     imdb
4     1  The best scene in the movie was when Gerardo i…   imdb
```

```
(1000, 3)

   label                                               text source
0      1                           Wow… Loved this place.   yelp
1      0                                 Crust is not good.   yelp
2      0          Not tasty and the texture was just nasty.   yelp
3      1  Stopped by during the late May bank holiday of…   yelp
4      1  The selection on the menu was great and so wer…   yelp

(1000, 3)
```

[6]:
```
# Concatenate datasets
df = pd.concat([amazon_df, imdb_df, yelp_df], ignore_index = True)
```

[7]:
```
df
```

[7]:
```
      label                                               text  source
0         0  So there is no way for me to plug it in here i…  amazon
1         1                        Good case, Excellent value.  amazon
2         1                             Great for the jawbone.  amazon
3         0  Tied to charger for conversations lasting more…  amazon
4         1                                  The mic is great.  amazon
…       …                                                …     …
2995      0  I think food should have flavor and texture an…    yelp
2996      0                         Appetite instantly gone.    yelp
2997      0  Overall I was not impressed and would not go b…    yelp
2998      0  The whole experience was underwhelming, and I …    yelp
2999      0  Then, as if I hadn't wasted enough of my life …    yelp

[3000 rows x 3 columns]
```

[8]:
```
# Describe dataframe
df['chars'] = df.text.apply(len)
df['words'] = df.text.apply(lambda x: len(x.split()))
df['avg_word_len'] = df['chars']/df['words']
df['punctuation'] = df.text.apply(lambda x: len("".join(_ for _ in x if _ in␣
 ↪string.punctuation)))
df['uppercase'] = df.text.apply(lambda x: len([word for word in x.split() if␣
 ↪word.isupper()]))
df['titles'] = df.text.apply(lambda x: len([word for word in x.split() if word.
 ↪istitle()]))
df.head()
```

[8]:
```
   label                                               text  source  chars  \
0      0  So there is no way for me to plug it in here i…  amazon     82
1      1                        Good case, Excellent value.  amazon     27
2      1                             Great for the jawbone.  amazon     22
3      0  Tied to charger for conversations lasting more…  amazon     79
```

```
4     1                                 The mic is great.  amazon     17

   words  avg_word_len  punctuation  uppercase  titles
0     21      3.904762            1         21      21
1      4      6.750000            2          4       4
2      4      5.500000            1          4       4
3     11      7.181818            3         11      11
4      4      4.250000            1          4       4
```

[9]:

```
# Determine if any replicated responses
df['text'].value_counts()
```

[9]:

```
Great phone.
2
Not recommended.
2
Works great.
2
I won't be back.
2
I love this place.
2
                                                            ..
The Songs Were The Best And The Muppets Were So Hilarious.
1
It Was So Cool.
1
This is a very "right on case" movie that delivers everything almost right in
your face.                                                         1
It had some average acting from the main person, and it was a low budget as you
clearly can see.                                                 1
Then, as if I hadn't wasted enough of my life there, they poured salt in the
wound by drawing out the time it took to bring the check.    1
Name: text, Length: 2983, dtype: int64
```

[10]:

```
# Determine unique responses
df['text'].unique()
```

[10]:

```
array(['So there is no way for me to plug it in here in the US unless I go by a
converter.',
       'Good case, Excellent value.', 'Great for the jawbone.', …,
       'Overall I was not impressed and would not go back.',
       "The whole experience was underwhelming, and I think we'll just go to
Ninja Sushi next time.",
       "Then, as if I hadn't wasted enough of my life there, they poured salt in
the wound by drawing out the time it took to bring the check."],
      dtype=object)
```

[11]:

```
# Determine min and max length responses
print(min(df['text'].str.len()))
print(max(df['text'].str.len()))
```

```
7
479
```

[12]:

```
# Determine count of unique words
cnt_vect = CountVectorizer()
features_vect_df = cnt_vect.fit(df.text)
features_df = features_vect_df.get_feature_names_out()
print('df total number of unique words:', len(features_df))
```

```
df total number of unique words: 5155
```

[13]:

```
# Sample of unique
random.sample(list(features_df), 10)
```

[13]:

```
['commands',
 'ass',
 'securly',
 'few',
 'cuts',
 'documentary',
 'confuses',
 'phones',
 'tremendous',
 'rolled']
```

[14]:

```
# Unique word matrix
features_vect_df_trans = cnt_vect.transform(df.text)
type(features_vect_df_trans)
```

[14]:

```
scipy.sparse._csr.csr_matrix
```

[15]:

```
# Count of matrix values
features_vect_df_trans.getnnz()
```

[15]:

```
31578
```

[16]:

```
print("Density of matrix: ", features_vect_df_trans.getnnz()*100/
 ↪(features_vect_df_trans.shape[0]*features_vect_df_trans.shape[1]))
```

```
Density of matrix:  0.20419010669253151
```

[17]:

```
# Create training Dataframe
train_df = pd.DataFrame(features_vect_df_trans.todense())
train_df.columns = features_df
```

```
train_df[0:1]
```

```
[17]:    00  10  100  11  12  13  15  15g  15pm  17  …  yucky  yukon  yum  yummy  \
      0   0   0    0   0   0   0   0    0     0   0  …      0      0    0      0

         yun  z500a  zero  zillion  zombie  zombiez
      0    0      0     0        0       0        0

      [1 rows x 5155 columns]
```

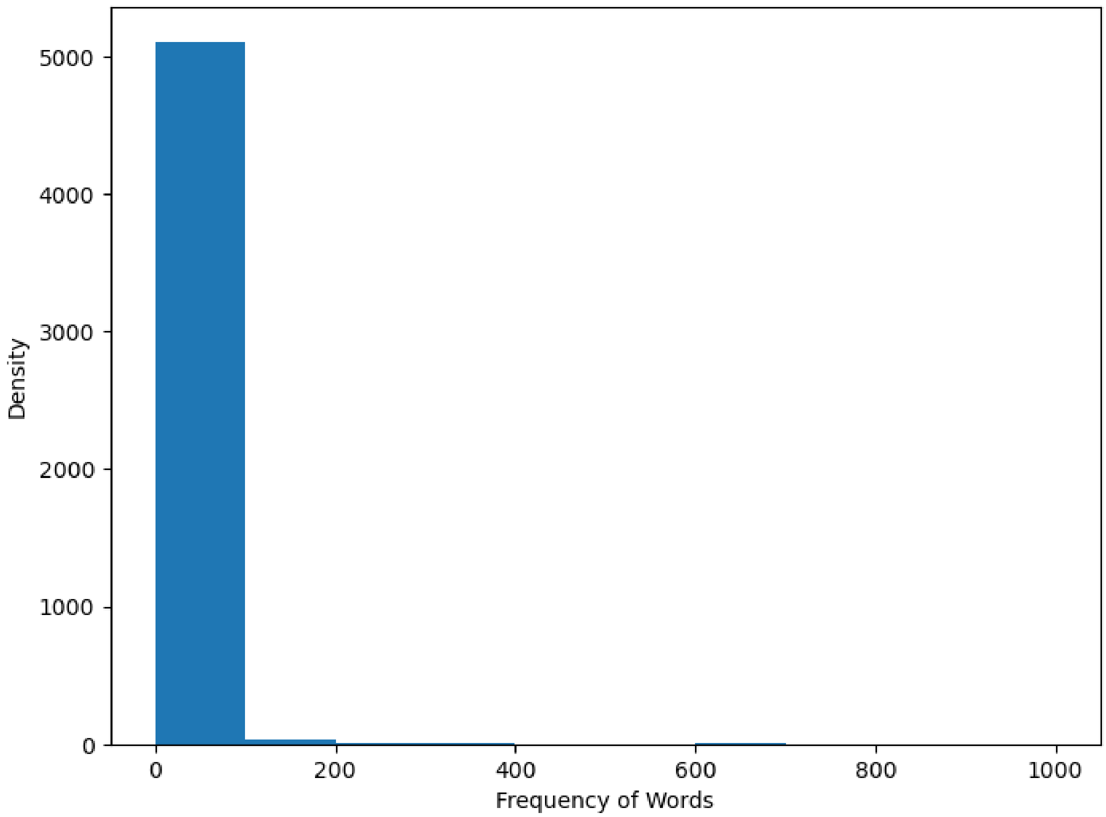
```
[18]: df.text[0:1]
```

```
[18]: 0    So there is no way for me to plug it in here i…
      Name: text, dtype: object
```

```
[19]: # Create dataframe with count
      features_cnt = np.sum(features_vect_df_trans.toarray(), axis = 0)
      features_cnt_df = pd.DataFrame(dict(features_df = features_df, counts =␣
        ↪features_cnt))
```

```
[20]: # Plot histogram
      plt.figure(figsize = (8,6))
      plt.xlabel('Frequency of Words')
      plt.ylabel('Density')
      plt.hist(features_cnt_df.counts, bins = 10, range = (0, 1000))
```

```
[20]: (array([5.108e+03, 2.700e+01, 8.000e+00, 3.000e+00, 1.000e+00, 1.000e+00,
              3.000e+00, 2.000e+00, 0.000e+00, 0.000e+00]),
       array([   0.,  100.,  200.,  300.,  400.,  500.,  600.,  700.,  800.,
               900., 1000.]),
       <BarContainer object of 10 artists>)
```



[21]:

```
# Count of words that do not repeat
len(features_cnt_df[features_cnt_df.counts == 1])
```

[21]:

```
2918
```

[22]:

```
cnt_vect = CountVectorizer(max_features = 3000)
features_vect = cnt_vect.fit(df.text)
features = features_vect.get_feature_names_out()
train_df_features = cnt_vect.transform(df.text)
features_cnts = np.sum(train_df_features.toarray(), axis = 0)
features_cnts = pd.DataFrame(dict(features = features, counts = features_cnts))
features_cnts.sort_values('counts', ascending = False)[0:15]
```

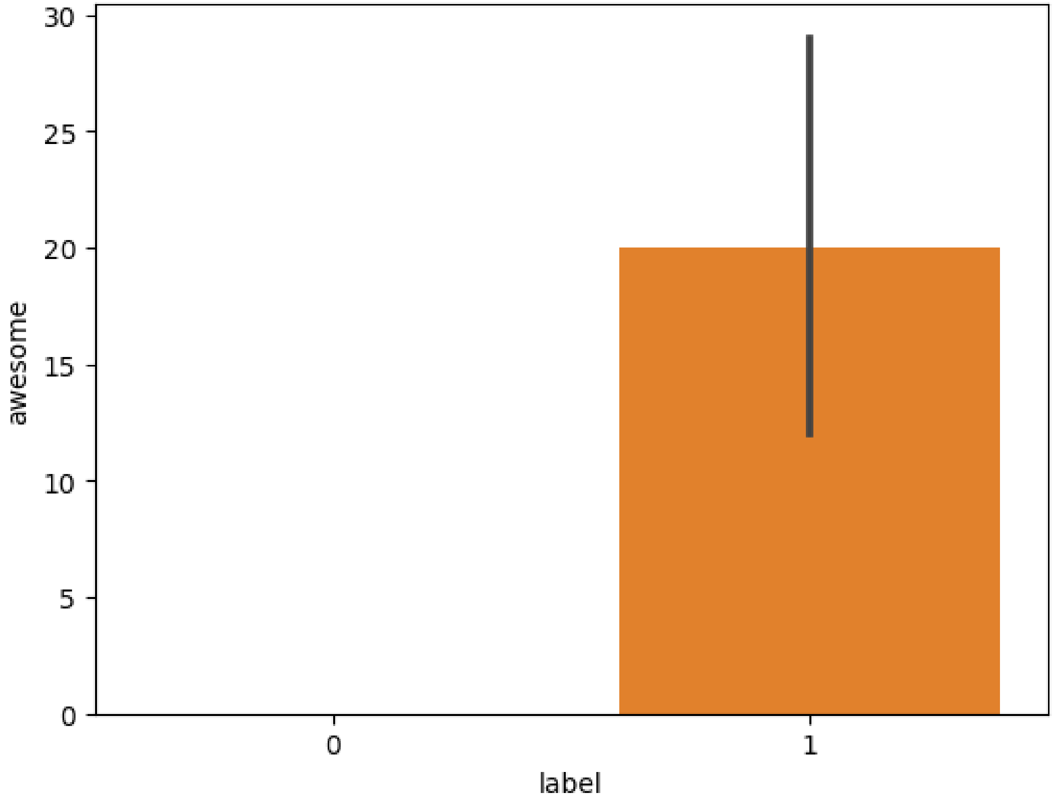
[22]:

```
     features  counts
2377      the    1953
85        and    1138
1036       it     789
1033       is     754
2455       to     670
2404     this     643
1334       of     624
```

```
2814     was   571
1005      in   400
801      for   336
2375    that   316
1315     not   306
2915    with   274
1281      my   254
2736    very   245
```

[23]:
```
# Plot density of positive word
train_df = pd.DataFrame(train_df_features.todense())
train_df.columns = features
train_df['label'] = df.label
sns.barplot(x = 'label', y = 'awesome', data = train_df, estimator = sum)
```

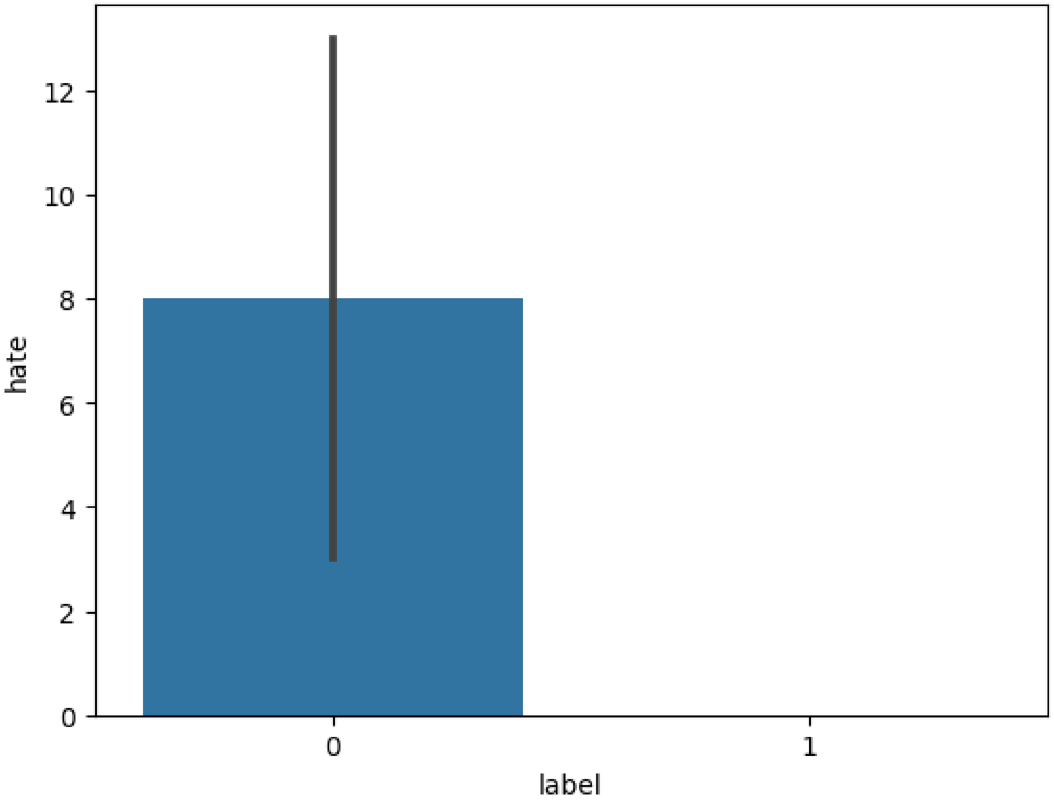
[23]:
```
<Axes: xlabel='label', ylabel='awesome'>
```



[24]:
```
# Plot density of negative word
train_df = pd.DataFrame(train_df_features.todense())
train_df.columns = features
train_df['label'] = df.label
```

```
sns.barplot(x = 'label', y = 'hate', data =train_df, estimator = sum)
```

```
[24]: <Axes: xlabel='label', ylabel='hate'>
```



```
[25]: df
```

```
[25]:
     label                                               text  source  chars  \
0        0  So there is no way for me to plug it in here i…  amazon     82
1        1                        Good case, Excellent value.  amazon     27
2        1                             Great for the jawbone.  amazon     22
3        0  Tied to charger for conversations lasting more…  amazon     79
4        1                                  The mic is great.  amazon     17
…    …                                                ……     …    …
2995     0  I think food should have flavor and texture an…    yelp     66
2996     0                          Appetite instantly gone.    yelp     24
2997     0  Overall I was not impressed and would not go b…    yelp     50
2998     0  The whole experience was underwhelming, and I …    yelp     91
2999     0  Then, as if I hadn't wasted enough of my life …    yelp    134

      words  avg_word_len  punctuation  uppercase  titles
0        21      3.904762            1         21      21
```

```
1         4      6.750000            2          4       4
2         4      5.500000            1          4       4
3        11      7.181818            3         11      11
4         4      4.250000            1          4       4
…     …           …          …        …     …
2995     12      5.500000            1         12      12
2996      3      8.000000            1          3       3
2997     10      5.000000            1         10      10
2998     16      5.687500            3         16      16
2999     28      4.785714            4         28      28

[3000 rows x 9 columns]
```

```
[26]: # Review statistics
      display(df.groupby(['source', 'label']).describe().loc[:, (slice(None),␣
        ↪['mean', 'std'])].reset_index())
      display(df.groupby(['source', 'label']).describe().loc[:, (slice(None), ['min',␣
        ↪'max'])].reset_index())
```

```
   source label   chars              words             avg_word_len             \
                   mean        std    mean        std         mean       std
0  amazon     0  56.824  34.022464  10.578   6.578028     5.653474  1.262250
1  amazon     1  53.628  35.234764   9.914   6.785772     5.670933  1.113802
2    imdb     0  77.088  50.887753  13.582   9.036293     5.811760  0.942026
3    imdb     1  87.456  60.820773  15.128  10.102859     5.826515  0.992945
4    yelp     0  60.750  34.224935  11.498   6.611916     5.401276  0.896919
5    yelp     1  55.882  30.228390  10.290   5.831459     5.606414  0.951573

  punctuation           uppercase             titles
         mean       std      mean        std    mean        std
0       2.002  1.509488    10.578   6.578028  10.578   6.578028
1       1.842  1.296301     9.914   6.785772   9.914   6.785772
2       2.494  1.954893    13.582   9.036293  13.582   9.036293
3       2.650  2.282525    15.128  10.102859  15.128  10.102859
4       2.000  1.424098    11.498   6.611916  11.498   6.611916
5       1.930  1.658494    10.290   5.831459  10.290   5.831459
   source label chars        words       avg_word_len       punctuation         \
                  min    max   min   max          min   max         min   max
0  amazon     0  11.0  149.0  1.0  30.0     3.857143  14.0         0.0  11.0
1  amazon     1  11.0  148.0  1.0  30.0     3.166667  13.0         0.0   9.0
2    imdb     0   8.0  321.0  1.0  56.0     4.181818  11.5         1.0  14.0
3    imdb     1   7.0  479.0  1.0  71.0     3.200000  12.0         0.0  18.0
4    yelp     0  11.0  149.0  2.0  32.0     3.666667  12.5         0.0  11.0
5    yelp     1  11.0  148.0  1.0  32.0     3.666667  11.0         0.0  19.0

  uppercase       titles
        min   max    min   max
```

```
0       1.0  30.0    1.0  30.0
1       1.0  30.0    1.0  30.0
2       1.0  56.0    1.0  56.0
3       1.0  71.0    1.0  71.0
4       2.0  32.0    2.0  32.0
5       1.0  32.0    1.0  32.0
```

[27]:

```
df
```

[27]:

```
      label                                               text  source  chars  \
0         0  So there is no way for me to plug it in here i…  amazon     82
1         1                       Good case, Excellent value.  amazon     27
2         1                            Great for the jawbone.  amazon     22
3         0  Tied to charger for conversations lasting more…  amazon     79
4         1                                 The mic is great.  amazon     17
…       …                                                …     …      …
2995      0  I think food should have flavor and texture an…    yelp     66
2996      0                        Appetite instantly gone.    yelp     24
2997      0  Overall I was not impressed and would not go b…    yelp     50
2998      0  The whole experience was underwhelming, and I …    yelp     91
2999      0  Then, as if I hadn't wasted enough of my life …    yelp    134

      words  avg_word_len  punctuation  uppercase  titles
0        21      3.904762            1         21      21
1         4      6.750000            2          4       4
2         4      5.500000            1          4       4
3        11      7.181818            3         11      11
4         4      4.250000            1          4       4
…       …           …          …         …      …
2995     12      5.500000            1         12      12
2996      3      8.000000            1          3       3
2997     10      5.000000            1         10      10
2998     16      5.687500            3         16      16
2999     28      4.785714            4         28      28

[3000 rows x 9 columns]
```

[28]:

```
# Split the words into tokens
i = 0
df['clean_text'] = ''
for row in df.text:
    # Add spaces after punctuation
    row = row.replace('.', '. ', row.count('.')).replace(',', ', ',row.
 ↪count(','))
    # Tokenize words
    tokens = word_tokenize(row)
    # Make all words lowercase
    tokens = [token.lower() for token in tokens]
    # Remove punctuation
    table = str.maketrans('', '', string.punctuation)
    # Remove numbers
    words = [token.translate(table) for token in tokens]
    # Filter stopwords
    words = [word for word in words if word.isalnum()]
    stop_words = set(stopwords.words('english'))
    words = [word for word in words if not word in stop_words]
    df['clean_text'][i] = ' '.join(words)
    i += 1
df.clean_text = df.source + ' ' + df.clean_text
df.head()
```

```
/tmp/ipykernel_3674/3478022845.py:19: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['clean_text'][i] = ' '.join(words)
```

[28]:

```
  label                                                text  source  chars  \
0     0  So there is no way for me to plug it in here i…  amazon     82
1     1                        Good case, Excellent value.  amazon     27
2     1                             Great for the jawbone.  amazon     22
3     0  Tied to charger for conversations lasting more…  amazon     79
4     1                                  The mic is great.  amazon     17

   words  avg_word_len  punctuation  uppercase  titles  \
0     21      3.904762            1         21      21
1      4      6.750000            2          4       4
2      4      5.500000            1          4       4
3     11      7.181818            3         11      11
4      4      4.250000            1          4       4

                                           clean_text
0              amazon way plug us unless go converter
1                    amazon good case excellent value
2                                amazon great jawbone
3  amazon tied charger conversations lasting 45 m…
4                                    amazon mic great
```

[29]:

```
# Add column of count of clean words
df['clean_words'] = df.clean_text.apply(lambda x: len(x.split()))
df.head()
```

[29]:

```
  label                                               text  source  chars  \
0     0  So there is no way for me to plug it in here i…  amazon     82
1     1                        Good case, Excellent value.  amazon     27
2     1                             Great for the jawbone.  amazon     22
3     0  Tied to charger for conversations lasting more…  amazon     79
4     1                                  The mic is great.  amazon     17

   words  avg_word_len  punctuation  uppercase  titles  \
0     21      3.904762            1         21      21
1      4      6.750000            2          4       4
2      4      5.500000            1          4       4
3     11      7.181818            3         11      11
4      4      4.250000            1          4       4

                                        clean_text  clean_words
0           amazon way plug us unless go converter            7
1                 amazon good case excellent value            5
2                             amazon great jawbone            3
3  amazon tied charger conversations lasting 45 m…          9
4                                 amazon mic great            3
```

[30]:

```python
print(min(df['clean_words']))
print(max(df['clean_words']))
```

```
2
42
```

[31]:

```python
features_vect_df2 = cnt_vect.fit(df.clean_text)
features_df2 = features_vect_df2.get_feature_names_out()
print('df2 total number of unique words ', len(features_df2))
```

```
df2 total number of unique words  3000
```

[32]:

```python
# Describe clean data
df['chars_clean'] = df.clean_text.apply(len)
df['words_clean'] = df.clean_text.apply(lambda x: len(x.split()))
df['avg_word_len_clean'] = df['chars_clean'] / df['words_clean']
df['punctuation_clean'] = df.clean_text.apply(lambda x: len("".join(_ for _ in x if _ in string.punctuation)))
df['uppercase_clean'] = df.clean_text.apply(lambda x: len([word for word in x.split() if word.isupper()]))
df['titles_clean'] = df.clean_text.apply(lambda x: len([word for word in x.split() if word.istitle()]))
df.head()
```

[32]:

```
  label                                               text  source  chars  \
0     0  So there is no way for me to plug it in here i…  amazon     82
```

```
1     1                        Good case, Excellent value.  amazon     27
2     1                             Great for the jawbone.  amazon     22
3     0  Tied to charger for conversations lasting more…  amazon     79
4     1                                  The mic is great.  amazon     17

   words  avg_word_len  punctuation  uppercase  titles  \
0     21      3.904762            1         21      21
1      4      6.750000            2          4       4
2      4      5.500000            1          4       4
3     11      7.181818            3         11      11
4      4      4.250000            1          4       4

                                          clean_text  clean_words  \
0             amazon way plug us unless go converter            7
1                   amazon good case excellent value            5
2                               amazon great jawbone            3
3  amazon tied charger conversations lasting 45 m…            9
4                                   amazon mic great            3

   chars_clean  words_clean  avg_word_len_clean  punctuation_clean  \
0           38            7            5.428571                  0
1           32            5            6.400000                  0
2           20            3            6.666667                  0
3           67            9            7.444444                  0
4           16            3            5.333333                  0

   uppercase_clean  titles_clean
0                7             7
1                5             5
2                3             3
3                9             9
4                3             3
```

[33]:

```
display(df.groupby(['source', 'label']).describe().loc[:, (slice(None),␣
  ↪['mean', 'std'])].reset_index())
display(df.groupby(['source', 'label']).describe().loc[:, (slice(None), ['min',␣
  ↪'max'])].reset_index())
```

```
   source label   chars              words              avg_word_len            \
                   mean        std    mean        std         mean       std
0  amazon     0  56.824  34.022464  10.578   6.578028    5.653474  1.262250
1  amazon     1  53.628  35.234764   9.914   6.785772    5.670933  1.113802
2    imdb     0  77.088  50.887753  13.582   9.036293    5.811760  0.942026
3    imdb     1  87.456  60.820773  15.128  10.102859    5.826515  0.992945
4    yelp     0  60.750  34.224935  11.498   6.611916    5.401276  0.896919
5    yelp     1  55.882  30.228390  10.290   5.831459    5.606414  0.951573
```

```
  punctuation           … words_clean           avg_word_len_clean  \
         mean       std  …        mean       std               mean
0       2.002  1.509488  …       6.382  3.214458           6.615592
1       1.842  1.296301  …       6.288  3.382890           6.579993
2       2.494  1.954893  …       7.974  4.839853           6.389784
3       2.650  2.282525  …       9.054  5.699830           6.516323
4       2.000  1.424098  …       6.888  3.415081           6.052106
5       1.930  1.658494  …       6.444  3.009481           6.252849

            punctuation_clean      uppercase_clean           titles_clean  \
        std              mean  std            mean       std         mean
0  1.096950               0.0  0.0           6.382  3.214458        6.382
1  0.870683               0.0  0.0           6.288  3.382890        6.288
2  1.033080               0.0  0.0           7.974  4.839853        7.974
3  1.045467               0.0  0.0           9.054  5.699830        9.054
4  0.913245               0.0  0.0           6.888  3.415081        6.888
5  0.927252               0.0  0.0           6.444  3.009481        6.444


        std
0  3.214458
1  3.382890
2  4.839853
3  5.699830
4  3.415081
5  3.009481

[6 rows x 28 columns]
   source label chars        words       avg_word_len       punctuation        \
                  min    max   min   max          min   max         min   max
0  amazon     0  11.0  149.0   1.0  30.0     3.857143  14.0         0.0  11.0
1  amazon     1  11.0  148.0   1.0  30.0     3.166667  13.0         0.0   9.0
2    imdb     0   8.0  321.0   1.0  56.0     4.181818  11.5         1.0  14.0
3    imdb     1   7.0  479.0   1.0  71.0     3.200000  12.0         0.0  18.0
4    yelp     0  11.0  149.0   2.0  32.0     3.666667  12.5         0.0  11.0
5    yelp     1  11.0  148.0   1.0  32.0     3.666667  11.0         0.0  19.0

   … words_clean       avg_word_len_clean            punctuation_clean       \
   …         min   max                min        max                min  max
0  …         2.0  17.0           4.333333  10.666667                0.0  0.0
1  …         2.0  18.0           4.600000  10.000000                0.0  0.0
2  …         2.0  32.0           4.000000  10.444444                0.0  0.0
3  …         2.0  42.0           3.666667  10.166667                0.0  0.0
4  …         2.0  20.0           3.500000   9.666667                0.0  0.0
5  …         2.0  18.0           3.750000   9.000000                0.0  0.0

  uppercase_clean       titles_clean
```

```
               min   max          min   max
0              2.0  17.0          2.0  17.0
1              2.0  18.0          2.0  18.0
2              2.0  32.0          2.0  32.0
3              2.0  42.0          2.0  42.0
4              2.0  20.0          2.0  20.0
5              2.0  18.0          2.0  18.0

[6 rows x 28 columns]
```

[34]:

```
# Pre-padding
tokenizer = Tokenizer(num_words = 50)
seq = tokenizer.texts_to_sequences(df.text)
pad = pad_sequences(seq, padding = "pre", truncating = "pre", maxlen = 42)
pad
```

[34]:

```
array([[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)
```

[35]:

```
tokenizer.fit_on_texts(df.clean_text)
word_index = tokenizer.word_index
```

[36]:

```
# Post-padding
seq = tokenizer.texts_to_sequences(df.clean_text)
pad = pad_sequences(seq, padding = 'post', truncating = 'post', maxlen = 45)
pad
```

[36]:

```
array([[ 1, 46, 27, …,  0,  0,  0],
       [ 1,  5, 33, …,  0,  0,  0],
       [ 1,  6,  0, …,  0,  0,  0],
       …,
       [ 3, 18, 27, …,  0,  0,  0],
       [ 3, 43, 27, …,  0,  0,  0],
       [ 3,  4, 14, …,  0,  0,  0]], dtype=int32)
```

[37]:

```
# Training/testing Split
x_train, x_test, y_train, y_test = model_selection.train_test_split(pad,␣
 ↪LabelEncoder().fit_transform(df.label))
```

[38]:

```
# Export clean data
df.to_csv('D213_task2_clean')
```

[39]:

```
early_stop_monitor = EarlyStopping(monitor = 'val_loss', min_delta = 0,␣
↪patience = 2, verbose = 0, mode = 'auto', baseline = None,␣
↪restore_best_weights = False)
```

[40]:

```
# Model hyperparameters
model = tf.keras.Sequential([
    tf.keras.layers.Embedding(3000, 16, input_length = 45),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(6, activation = 'relu'),
    tf.keras.layers.Dense(1, activation = 'sigmoid')
])
```

[41]:

```
# Model summary
model.summary()
```

```
Model: "sequential"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding (Embedding)       (None, 45, 16)            48000

 flatten (Flatten)           (None, 720)               0

 dense (Dense)               (None, 6)                 4326

 dense_1 (Dense)             (None, 1)                 7

=================================================================
Total params: 52333 (204.43 KB)
Trainable params: 52333 (204.43 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

[42]:

```
# Compile model
model.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics =␣
↪['accuracy'], run_eagerly = True)
```

[43]:

```
x_val = x_train[:5155]
p_x_train = x_train[5155:]
y_val = y_train[:5155]
p_y_train = y_train[5155:]
```

[44]:

```
fitmodel = model.fit(x_train, y_train, epochs = 100, batch_size = 128,␣
↪validation_data = (x_val,y_val), verbose = 1, callbacks =␣
↪[early_stop_monitor])
```

```
Epoch 1/100
```

```
18/18 [==============================] - 1s 39ms/step - loss: 0.6934 - accuracy:
0.4978 - val_loss: 0.6928 - val_accuracy: 0.5000
Epoch 2/100
18/18 [==============================] - 1s 40ms/step - loss: 0.6925 - accuracy:
0.5249 - val_loss: 0.6922 - val_accuracy: 0.5067
Epoch 3/100
18/18 [==============================] - 1s 41ms/step - loss: 0.6918 - accuracy:
0.5004 - val_loss: 0.6912 - val_accuracy: 0.5089
Epoch 4/100
18/18 [==============================] - 1s 36ms/step - loss: 0.6907 - accuracy:
0.5502 - val_loss: 0.6895 - val_accuracy: 0.5667
Epoch 5/100
18/18 [==============================] - 1s 42ms/step - loss: 0.6885 - accuracy:
0.5351 - val_loss: 0.6869 - val_accuracy: 0.5422
Epoch 6/100
18/18 [==============================] - 1s 38ms/step - loss: 0.6854 - accuracy:
0.5982 - val_loss: 0.6830 - val_accuracy: 0.5880
Epoch 7/100
18/18 [==============================] - 1s 41ms/step - loss: 0.6809 - accuracy:
0.5956 - val_loss: 0.6780 - val_accuracy: 0.5987
Epoch 8/100
18/18 [==============================] - 1s 36ms/step - loss: 0.6757 - accuracy:
0.6307 - val_loss: 0.6717 - val_accuracy: 0.6453
Epoch 9/100
18/18 [==============================] - 1s 37ms/step - loss: 0.6576 - accuracy:
0.6573 - val_loss: 0.6378 - val_accuracy: 0.6791
Epoch 10/100
18/18 [==============================] - 1s 34ms/step - loss: 0.6233 - accuracy:
0.6804 - val_loss: 0.6104 - val_accuracy: 0.6764
Epoch 11/100
18/18 [==============================] - 1s 36ms/step - loss: 0.5976 - accuracy:
0.6702 - val_loss: 0.5906 - val_accuracy: 0.6804
Epoch 12/100
18/18 [==============================] - 1s 34ms/step - loss: 0.5845 - accuracy:
0.6751 - val_loss: 0.5767 - val_accuracy: 0.6751
Epoch 13/100
18/18 [==============================] - 1s 34ms/step - loss: 0.5747 - accuracy:
0.6764 - val_loss: 0.5704 - val_accuracy: 0.6733
Epoch 14/100
18/18 [==============================] - 1s 34ms/step - loss: 0.5706 - accuracy:
0.6751 - val_loss: 0.5655 - val_accuracy: 0.6769
Epoch 15/100
18/18 [==============================] - 1s 35ms/step - loss: 0.5684 - accuracy:
0.6756 - val_loss: 0.5649 - val_accuracy: 0.6827
Epoch 16/100
18/18 [==============================] - 1s 33ms/step - loss: 0.5650 - accuracy:
0.6787 - val_loss: 0.5630 - val_accuracy: 0.6836
Epoch 17/100
```

```
18/18 [==============================] - 1s 34ms/step - loss: 0.5619 - accuracy:
0.6796 - val_loss: 0.5592 - val_accuracy: 0.6791
Epoch 18/100
18/18 [==============================] - 1s 35ms/step - loss: 0.5591 - accuracy:
0.6800 - val_loss: 0.5580 - val_accuracy: 0.6858
Epoch 19/100
18/18 [==============================] - 1s 35ms/step - loss: 0.5591 - accuracy:
0.6787 - val_loss: 0.5563 - val_accuracy: 0.6849
Epoch 20/100
18/18 [==============================] - 1s 35ms/step - loss: 0.5597 - accuracy:
0.6858 - val_loss: 0.5574 - val_accuracy: 0.6787
Epoch 21/100
18/18 [==============================] - 1s 34ms/step - loss: 0.5571 - accuracy:
0.6822 - val_loss: 0.5557 - val_accuracy: 0.6813
Epoch 22/100
18/18 [==============================] - 1s 38ms/step - loss: 0.5554 - accuracy:
0.6778 - val_loss: 0.5603 - val_accuracy: 0.6840
Epoch 23/100
18/18 [==============================] - 1s 39ms/step - loss: 0.5565 - accuracy:
0.6844 - val_loss: 0.5577 - val_accuracy: 0.6769
```

[45]:
```
early_stop_monitor = EarlyStopping(monitor = 'val_loss', min_delta = 0,␣
 ↪patience = 2, verbose = 0, mode = 'auto', baseline = None,␣
 ↪restore_best_weights = False)
model.fit(x_train, y_train, validation_split = .3, callbacks =␣
 ↪[early_stop_monitor])
```

```
50/50 [==============================] - 2s 31ms/step - loss: 0.5549 - accuracy:
0.6921 - val_loss: 0.5687 - val_accuracy: 0.6593
```

[45]:
```
<keras.src.callbacks.History at 0x7fd6ac0508d0>
```

[46]:
```
results = model.evaluate(x_test, y_test)
```

```
24/24 [==============================] - 0s 11ms/step - loss: 0.5899 - accuracy:
0.6387
```

[47]:
```
reverse_word_index = dict([(value, key) for (key, value) in word_index.items()])
```

[48]:
```
def decode_review(text):
    return " ".join([reverse_word_index.get(i, '?') for i in text])
```

[49]:
```
x_test[1]
```

[49]:
```
array([ 3,  4, 16,  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,  0,  0,  0], dtype=int32)
```

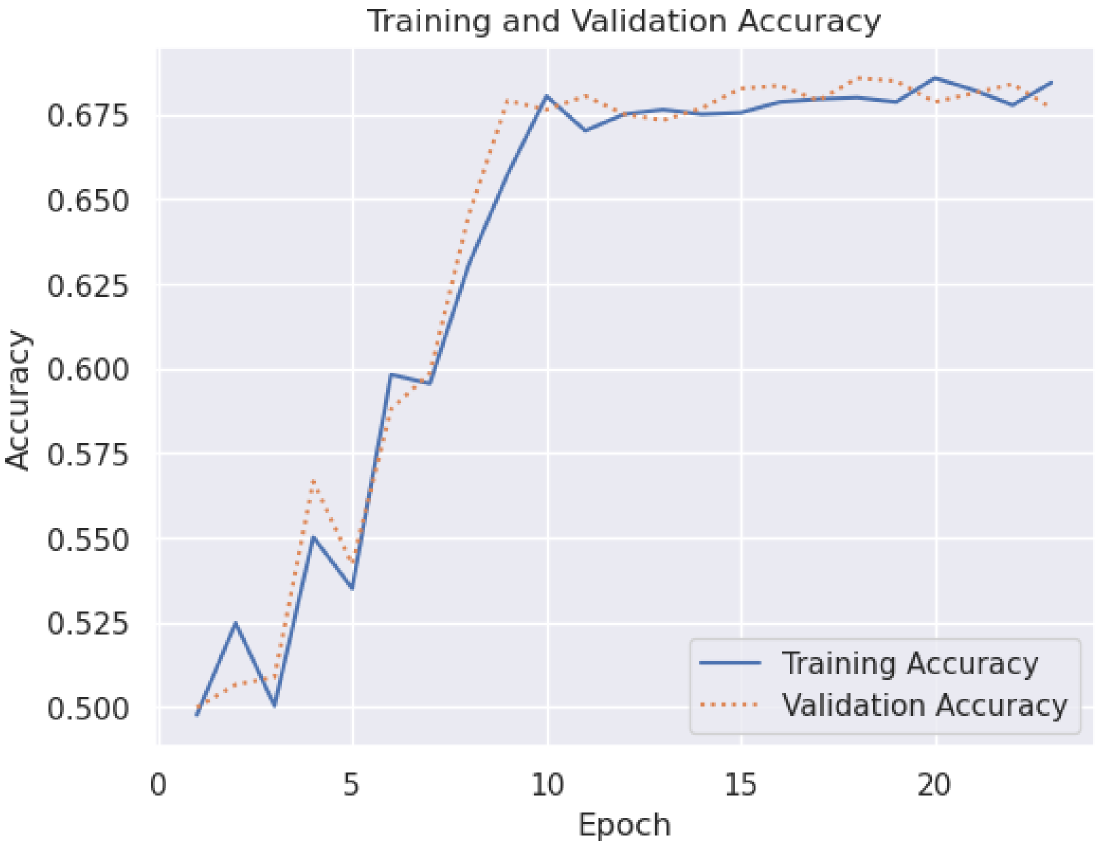
[99]:

```
# Plot Training/Validation Accuracy
sns.set()
acc = fitmodel.history['accuracy']
val = fitmodel.history['val_accuracy']
epochs = range = range(1, len(acc)+1)

plt.plot(epochs, acc, '-', label = "Training Accuracy")
plt.plot(epochs, val, ':', label = "Validation Accuracy")
plt.title('Training and Validation Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend(loc = 'lower right')
plt.plot()
```

[99]:

```
[]
```



[101]:

```
# Save model
model.save('model.h5')
model = keras.models.load_model('model.h5')
model
```

```
/home/7d515a27-500e-49a7-accc-3e4f4339db24/.local/lib/python3.11/site-
packages/keras/src/engine/training.py:3000: UserWarning: You are saving your
model as an HDF5 file via `model.save()`. This file format is considered legacy.
We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')`.
  saving_api.save_model(
```

```
[101]: <keras.src.engine.sequential.Sequential at 0x7fd6b7a75250>
```

```
[ ]:
```