In [117…

```
#Import all of the packages we will need for this project
#Jupyter Lab 3.44, Python 3
import json
import pandas as pd
import gzip
import numpy as np
import pandas as pd
import matplotlib.pyplot as mpl
import matplotlib.image as mpimg
%matplotlib inline
import seaborn as sb
#This next line was ran in the commmand line
# pip install tensorflow
import tensorflow as tf
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from keras import callbacks
```

In [118…

```
#Parse for json gzip file downloaded from the links provided
def parse(path):
  g = gzip.open(path, 'rb')
  for l in g:
    yield json.loads(l)
```

In [119…

```
# Function to turn json into df
def getDF(path):
  i = 0
  df = {}
  for d in parse(path):
    df[i] = d
    i += 1
  return pd.DataFrame.from_dict(df, orient='index')
```

In [120…

```
#Importing data
df = getDF('Software.json.gz')
#View the dataset
df.head()
```

Out[120]:

	overall	verified	reviewTime	reviewerID	asin	style	reviewerName	reviewText
0	4.0	True	03 11, 2014	A240ORQ2LF9LUI	0077613252	{'Format:': ' Loose Leaf'}	Michelle W	The materials arrived early and were in excell...
1	4.0	True	02 23, 2014	A1YCCU0YRLS0FE	0077613252	{'Format:': ' Loose Leaf'}	Rosalind White Ames	I am really enjoying this book with the worksh...
2	1.0	True	02 17, 2014	A1BJHRQDYVAY2J	0077613252	{'Format:': ' Loose Leaf'}	Allan R. Baker	IF YOU ARE TAKING THIS CLASS DON"T WASTE YOUR ...
3	3.0	True	02 17, 2014	APRDVZ6QBIQXT	0077613252	{'Format:': ' Loose Leaf'}	Lucy	This book was missing pages!!! Important pages...
4	5.0	False	10 14, 2013	A2JZTTBSLS1QXV	0077775473	NaN	Albert V.	I have used LearnSmart and can officially say ...

In [121…

```
#New data frame with the new selected columns we need
df = df[['overall','reviewText']]
df.head()
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 459436 entries, 0 to 459435
Data columns (total 2 columns):
 #   Column      Non-Null Count   Dtype  
---  ------      --------------   -----  
 0   overall     459436 non-null  float64
 1   reviewText  459370 non-null  object 
dtypes: float64(1), object(1)
memory usage: 10.5+ MB
```

In [122…

```
# Select the special characters
special_char = ["!",'"',"#","%","&","'","(",")",
 "*","+",",","-",".","/",":",";","<",
 "=",">","?","@","[","\\","]","^","_",
 "`","{","|","}","~","-"]
```

In [123…

```
# Rename Columns
df = df.rename(columns={'overall': 'Score', 'reviewText': 'Review'})
df.head()
```

Out[123]:

	Score	Review
0	4.0	The materials arrived early and were in excell...
1	4.0	I am really enjoying this book with the worksh...
2	1.0	IF YOU ARE TAKING THIS CLASS DON"T WASTE YOUR ...
3	3.0	This book was missing pages!!! Important pages...
4	5.0	I have used LearnSmart and can officially say ...

In [124…

```
# Check for nulls
df.isna().any()
```

Out[124]:

```
Score      False
Review      True
dtype: bool
```

In [125…

```
# Remove nulls from where it says “True” above this cell
df = df.dropna(subset=['Review'])
```

In [126…

```
# Verify we do not have any nulls
df.isna().any()
```

Out[126]:

```
Score      False
Review     False
dtype: bool
```

In [127…

```
# replace the special characters with spaces
for char in special_char:
 df['Review'] = df['Review'].str.replace(char, ' ',regex=True)
```

In [128…

```
# Replace capitals with lowercase letters
df['Review'] = df['Review'].str.lower()
df.head()
```

Out[128]:

	Score	Review
0	4.0	the materials arrived early and were in excell...
1	4.0	i am really enjoying this book with the worksh...
2	1.0	if you are taking this class don t waste your ...
3	3.0	this book was missing pages important pages...
4	5.0	i have used learnsmart and can officially say ...

In [129…

```
# Create sentiments column from the dataset (Changing numeric review answers to positi
# 0 = negative, 1 = positive
df['Sentiments'] = df.Score.apply(lambda x: 0 if x in [1, 2] else 1)
df.head()
```

Out[129]:

	Score	Review	Sentiments
0	4.0	the materials arrived early and were in excell...	1
1	4.0	i am really enjoying this book with the worksh...	1
2	1.0	if you are taking this class don t waste your ...	0
3	3.0	this book was missing pages important pages...	1
4	5.0	i have used learnsmart and can officially say ...	1

In [130…

```
# export the prepared data
df.to_csv('D213_Task2_cleaned.csv', index = False)
```

In [131…

```
# Split data into 80/20 training and testing, standard for testing datasets and lookir
split = round(len(df)*0.8)
train_reviews = df['Review'][:split]
train_label = df['Sentiments'][:split]
test_reviews = df['Review'][split:]
test_label = df['Sentiments'][split:]
```

In [132…

```
#Changing each review into a string after tokenization
training_sentences = []
training_labels = []
testing_sentences = []
testing_labels = []
for row in train_reviews:
    training_sentences.append(str(row))
for row in train_label:
    training_labels.append(row)
for row in test_reviews:
    testing_sentences.append(str(row))
for row in test_label:
    testing_labels.append(row)
```

In [133…

```
#View the max vocab
tokenizer = Tokenizer()
tokenizer.fit_on_texts(df['Review'])
print(len(tokenizer.word_index) + 1)
```

```
130085
```

In [134…

```
# Getting the word index (vocabulary size)
word_index = tokenizer.word_index
word_index
```

```
Out[134]: {'the': 1,
           'i': 2,
           'to': 3,
           'and': 4,
           'it': 5,
           'a': 6,
           'of': 7,
           'is': 8,
           'for': 9,
           'this': 10,
           'you': 11,
           'that': 12,
           'my': 13,
           'in': 14,
           'with': 15,
           'have': 16,
           'on': 17,
           'not': 18,
           'was': 19,
           'but': 20,
           't': 21,
           'as': 22,
           'software': 23,
           's': 24,
           'so': 25,
           'be': 26,
           'are': 27,
           'can': 28,
           'product': 29,
           'if': 30,
           'use': 31,
           'all': 32,
           'from': 33,
           'program': 34,
           'or': 35,
           'me': 36,
           'they': 37,
           'had': 38,
           'your': 39,
           'do': 40,
           'an': 41,
           'will': 42,
           'version': 43,
           'very': 44,
           'no': 45,
           'one': 46,
           'at': 47,
           'get': 48,
           'just': 49,
           'would': 50,
           'up': 51,
           'has': 52,
           'time': 53,
           'like': 54,
           'windows': 55,
           'when': 56,
           'there': 57,
           'more': 58,
           'computer': 59,
           'what': 60,
           'great': 61,
           'out': 62,
           'been': 63,
           'work': 64,
           'good': 65,
           'used': 66,
           'new': 67,
           'only': 68,
           'years': 69,
           'using': 70,
           'easy': 71,
           'some': 72,
           'which': 73,
           'than': 74,
           'other': 75,
           'about': 76,
           'after': 77,
           'don': 78,
           'am': 79,
           'now': 80,
           'by': 81,
           'their': 82,
           'any': 83,
           'then': 84,
           'well': 85,
           'even': 86,
           'year': 87,
           've': 88,
           'does': 89,
           'also': 90,
           'because': 91,
           'much': 92,
           'them': 93,
           'did': 94,
           'support': 95,
           'quicken': 96,
           'm': 97,
           'works': 98,
           'really': 99,
           'need': 100,
           'many': 101,
           'could': 102,
           'how': 103,
           'we': 104,
           'install': 105,
           'back': 106,
           'tax': 107,
           'still': 108,
           'over': 109,
           'way': 110,
           'want': 111,
           'buy': 112,
           'better': 113,
           'download': 114,
           'money': 115,
           'problem': 116,
           'first': 117,
           'find': 118,
           'make': 119,
           'mac': 120,
           'since': 121,
           'system': 122,
           '2': 123,
           'user': 124,
           'amazon': 125,
           'go': 126,
           'pc': 127,
           'upgrade': 128,
           'microsoft': 129,
           'were': 130,
           'norton': 131,
           'problems': 132,
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           'price': 134,
           'old': 135,
           '3': 136,
           'never': 137,
           'into': 138,
           'bought': 139,
           'file': 140,
           'got': 141,
           '7': 142,
           'help': 143,
           'its': 144,
           'free': 145,
           'again': 146,
           'able': 147,
           'most': 148,
           'know': 149,
           'before': 150,
           '10': 151,
           'found': 152,
           'features': 153,
           'who': 154,
           'same': 155,
           'installed': 156,
           'every': 157,
           '5': 158,
           'tried': 159,
           'without': 160,
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           'too': 162,
           '8': 163,
           'love': 164,
           'best': 165,
           'recommend': 166,
           'through': 167,
           'lot': 168,
           'should': 169,
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           'game': 178,
           'two': 179,
           'think': 180,
           'doesn': 181,
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           'turbotax': 186,
           'far': 187,
           'everything': 188,
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           'run': 190,
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           'these': 195,
           'while': 196,
           'down': 197,
           'business': 198,
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           'state': 230,
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           'actually': 305,
           'number': 306,
           'yet': 307,
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           'pretty': 310,
           'around': 311,
           'bad': 312,
           'previous': 313,
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           'until': 317,
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           'win': 568,
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           'non': 609,
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           'value': 617,
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           'sound': 705,
           '2008': 706,
           'c': 707,
           'solution': 708,
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           'ordered': 725,
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           'clear': 727,
           'choose': 728,
           'returns': 729,
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           'switched': 965,
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           'whether': 969,
           '95': 970,
           'qb': 971,
           'luck': 972,
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           'turned': 976,
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           'arrived': 978,
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           'trust': 986,
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           'art': 988,
           'stopped': 989,
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           'spending': 992,
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           'upgrades': 994,
           'consider': 995,
           'favorite': 996,
           'brand': 997,
           'wife': 998,
           '2004': 999,
           'hook': 1000,
           ...}
```

In [135…

```
#Setting vocab size to 130086, aka taking 130086 words to train
vocab_size = 130086
# View the embedding length
max_sequence_embedding = int(round(np.sqrt(np.sqrt(vocab_size)), 0))
max_sequence_embedding
```

Out[135]:

```
19
```

In [136…

```
# Embedding to 19 dimensions, given from the above code
embedding_dim = 19
# Max length of 150 words per review as a cut off
max_length = 150
#If review is bigger than 150 words, it will be truncated "post" or after the 150th wo
trunc_type = 'post'
oov_tok = '<OOV>'
# Padding type "post" meaning each word will receive padding after, not before
padding_type = 'post'
```

In [137…

```
#Starting the tokenizer
tokenizer = Tokenizer(num_words=vocab_size, oov_token=oov_tok)
# Fitting the tokenizer
tokenizer.fit_on_texts(training_sentences)
```

In [138…

```
#Setting the sequences
sequences = tokenizer.texts_to_sequences(training_sentences)
#Setting the padding
padded = pad_sequences(sequences, maxlen=max_length, truncating=trunc_type)
testing_sentences = tokenizer.texts_to_sequences(testing_sentences)
testing_padded = pad_sequences(testing_sentences, maxlen=max_length)
```

In [139…

```
# Let’s check out the padded array
padded
print(df)
```

```
        Score                                             Review  Sentiments
0         4.0  the materials arrived early and were in excell...           1
1         4.0  i am really enjoying this book with the worksh...           1
2         1.0  if you are taking this class don t waste your ...           0
3         3.0  this book was missing pages    important pages...           1
4         5.0  i have used learnsmart and can officially say ...           1
...       ...                                                ...         ...
459431    2.0  no instructions     no help unless you want to...           0
459432    1.0                                        it s a joke           0
459433    5.0  i have multiple licenses of the antivirus  i h...           1
459434    5.0                                         good value           1
459435    5.0                     very nice designs easy to use            1

[459370 rows x 3 columns]
```

In [140…

```
#Time to create the model
model = tf.keras.Sequential([
    tf.keras.layers.Embedding(vocab_size, embedding_dim, input_length=max_length),
    tf.keras.layers.GlobalAveragePooling1D(),
    tf.keras.layers.Dense(10, activation='relu'),
    tf.keras.layers.Dense(6, activation='relu'),
    tf.keras.layers.Dense(1, activation='relu')
])
```

In [141…

```
#Compile the model
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
model.summary()
```

```
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 embedding_6 (Embedding)     (None, 150, 19)           2471634   
                                                                 
 global_average_pooling1d_6   (None, 19)               0         
 (GlobalAveragePooling1D)                                        
                                                                 
 dense_17 (Dense)            (None, 10)                200       
                                                                 
 dense_18 (Dense)            (None, 6)                 66        
                                                                 
 dense_19 (Dense)            (None, 1)                 7         
                                                                 
=================================================================
Total params: 2,471,907
Trainable params: 2,471,907
Non-trainable params: 0
_________________________________________________________________
```

In [142…

```
#Train the model
training_final = np.array(training_labels)
testing_final = np.array(testing_labels)
# Run the model for 25 epochs
model1 = model.fit(padded, training_final, epochs=25, validation_data=(testing_padded,
testing_final))
# We need to stop the model Early to prevent overfitting of the model
earlystopping = callbacks.EarlyStopping(monitor ="val_loss",
                                        mode ="min", patience = 2,
                                        restore_best_weights = True)
```

```
Epoch 1/25
11485/11485 [==============================] - 333s 29ms/step - loss: 0.3631 - accura
cy: 0.8483 - val_loss: 0.3563 - val_accuracy: 0.8652
Epoch 2/25
11485/11485 [==============================] - 332s 29ms/step - loss: 0.2890 - accura
cy: 0.8870 - val_loss: 0.3501 - val_accuracy: 0.8645
Epoch 3/25
11485/11485 [==============================] - 333s 29ms/step - loss: 0.3462 - accura
cy: 0.8606 - val_loss: 0.3660 - val_accuracy: 0.8699
Epoch 4/25
11485/11485 [==============================] - 335s 29ms/step - loss: 0.3162 - accura
cy: 0.8705 - val_loss: 0.3476 - val_accuracy: 0.8701
Epoch 5/25
11485/11485 [==============================] - 333s 29ms/step - loss: 0.2852 - accura
cy: 0.8905 - val_loss: 0.3577 - val_accuracy: 0.8763
Epoch 6/25
11485/11485 [==============================] - 333s 29ms/step - loss: 0.2901 - accura
cy: 0.8869 - val_loss: 0.3408 - val_accuracy: 0.8718
Epoch 7/25
11485/11485 [==============================] - 332s 29ms/step - loss: 0.2922 - accura
cy: 0.8905 - val_loss: 0.3554 - val_accuracy: 0.8757
Epoch 8/25
11485/11485 [==============================] - 335s 29ms/step - loss: 0.2653 - accura
cy: 0.8990 - val_loss: 0.3866 - val_accuracy: 0.8716
Epoch 9/25
11485/11485 [==============================] - 335s 29ms/step - loss: 0.2991 - accura
cy: 0.8880 - val_loss: 0.3708 - val_accuracy: 0.8694
Epoch 10/25
11485/11485 [==============================] - 337s 29ms/step - loss: 0.2531 - accura
cy: 0.9062 - val_loss: 0.3382 - val_accuracy: 0.8712
Epoch 11/25
11485/11485 [==============================] - 339s 30ms/step - loss: 0.3060 - accura
cy: 0.8821 - val_loss: 0.3430 - val_accuracy: 0.8733
Epoch 12/25
11485/11485 [==============================] - 336s 29ms/step - loss: 0.2589 - accura
cy: 0.9029 - val_loss: 0.3516 - val_accuracy: 0.8683
Epoch 13/25
11485/11485 [==============================] - 338s 29ms/step - loss: 0.2593 - accura
cy: 0.9029 - val_loss: 0.3505 - val_accuracy: 0.8719
Epoch 14/25
11485/11485 [==============================] - 340s 30ms/step - loss: 0.2513 - accura
cy: 0.9087 - val_loss: 0.3589 - val_accuracy: 0.8688
Epoch 15/25
11485/11485 [==============================] - 341s 30ms/step - loss: 0.2468 - accura
cy: 0.9100 - val_loss: 0.3671 - val_accuracy: 0.8650
Epoch 16/25
11485/11485 [==============================] - 341s 30ms/step - loss: 0.2368 - accura
cy: 0.9113 - val_loss: 0.4051 - val_accuracy: 0.8535
Epoch 17/25
11485/11485 [==============================] - 340s 30ms/step - loss: 0.2350 - accura
cy: 0.9111 - val_loss: 0.4411 - val_accuracy: 0.8644
Epoch 18/25
11485/11485 [==============================] - 339s 30ms/step - loss: 0.2387 - accura
cy: 0.9106 - val_loss: 0.3927 - val_accuracy: 0.8723
Epoch 19/25
11485/11485 [==============================] - 332s 29ms/step - loss: 0.2628 - accura
cy: 0.8968 - val_loss: 0.3807 - val_accuracy: 0.8689
Epoch 20/25
11485/11485 [==============================] - 337s 29ms/step - loss: 0.2334 - accura
cy: 0.9137 - val_loss: 0.3791 - val_accuracy: 0.8715
```

```
Epoch 21/25
11485/11485 [==============================] - 338s 29ms/step - loss: 0.3121 - accura
cy: 0.8522 - val_loss: 0.5409 - val_accuracy: 0.7144
Epoch 22/25
11485/11485 [==============================] - 337s 29ms/step - loss: 0.2870 - accura
cy: 0.8977 - val_loss: 0.4150 - val_accuracy: 0.8668
Epoch 23/25
11485/11485 [==============================] - 337s 29ms/step - loss: 0.2521 - accura
cy: 0.9124 - val_loss: 0.3855 - val_accuracy: 0.8716
Epoch 24/25
11485/11485 [==============================] - 339s 30ms/step - loss: 0.2347 - accura
cy: 0.9150 - val_loss: 0.4049 - val_accuracy: 0.8637
Epoch 25/25
11485/11485 [==============================] - 341s 30ms/step - loss: 0.2338 - accura
cy: 0.9148 - val_loss: 0.3883 - val_accuracy: 0.8663
```

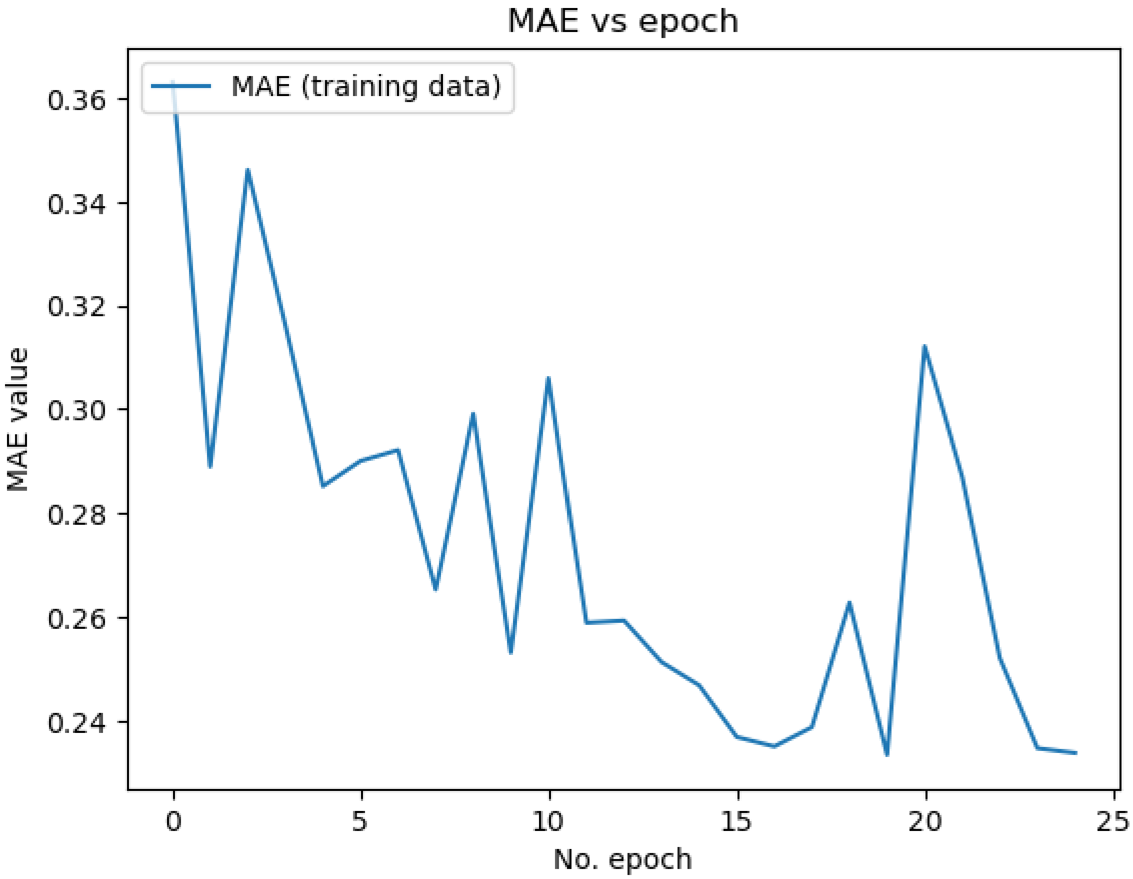
In [143…

```
# Time to run the model again and see our accuracy
model2 = model.fit(padded, training_final, epochs=25, validation_data=(testing_padded,
                                                                       testing_final),
                                                                       callbacks = [ea
```

```
Epoch 1/25
11485/11485 [==============================] - 327s 28ms/step - loss: 0.2312 - accura
cy: 0.9153 - val_loss: 0.3715 - val_accuracy: 0.8639
Epoch 2/25
11485/11485 [==============================] - 327s 28ms/step - loss: 0.2261 - accura
cy: 0.9165 - val_loss: 0.3883 - val_accuracy: 0.8708
Epoch 3/25
11485/11485 [==============================] - 327s 28ms/step - loss: 0.2349 - accura
cy: 0.9138 - val_loss: 0.3749 - val_accuracy: 0.8652
```

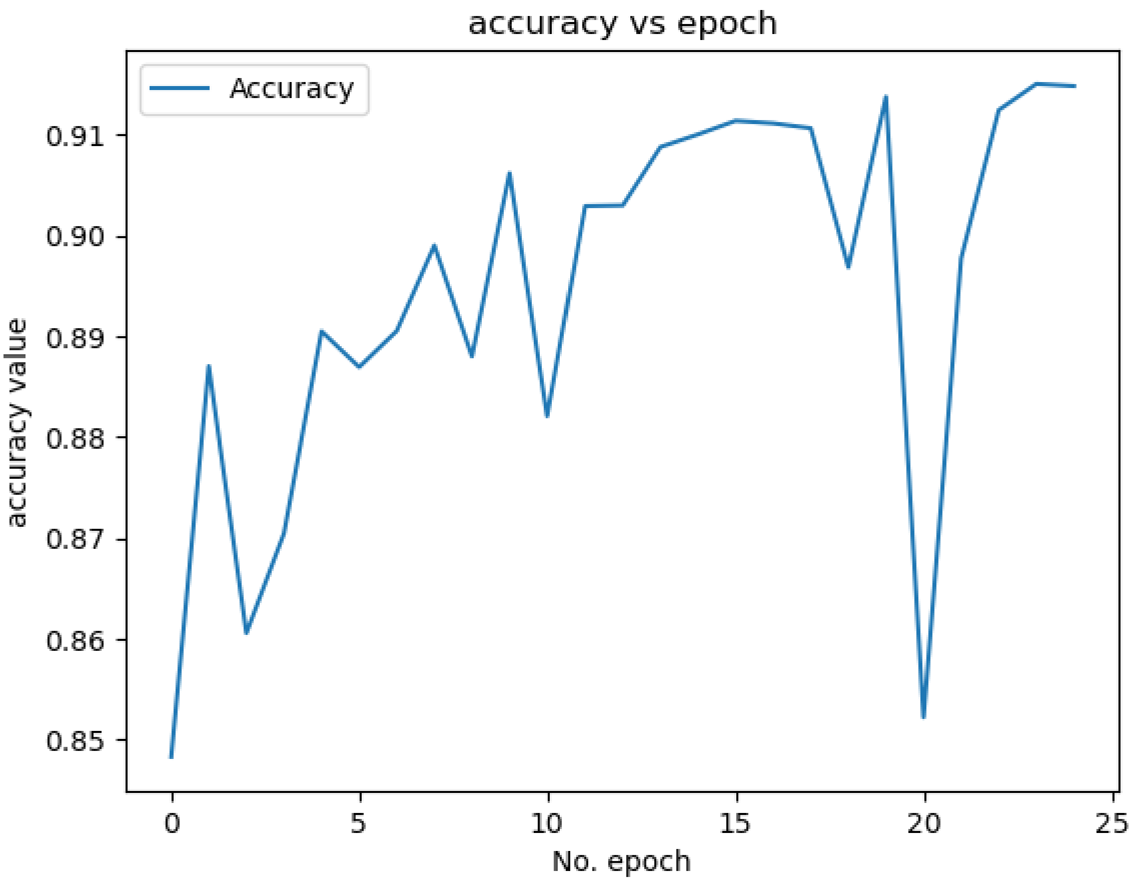
In [144…

```
# epoch vs Mean Absolute Error (MAE)
mpl.plot(model1.history['loss'], label='MAE (training data)')
mpl.title('MAE vs epoch')
mpl.ylabel('MAE value')
mpl.xlabel('No. epoch')
mpl.legend(loc="upper left")
mpl.show()
```



In [145…

```
#Check our accuracy per Epoch
mpl.plot(model1.history['accuracy'], label='Accuracy')
mpl.title('accuracy vs epoch')
mpl.ylabel('accuracy value')
mpl.xlabel('No. epoch')
mpl.legend(loc="upper left")
mpl.show()
```

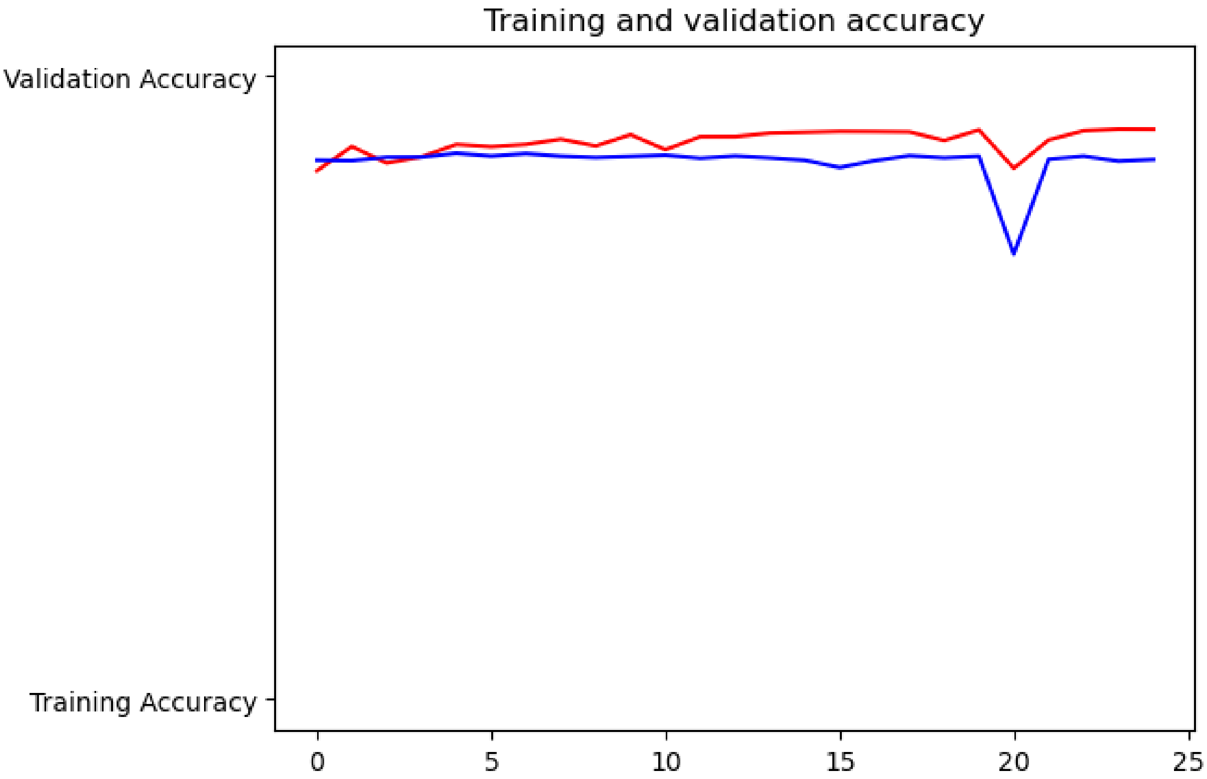


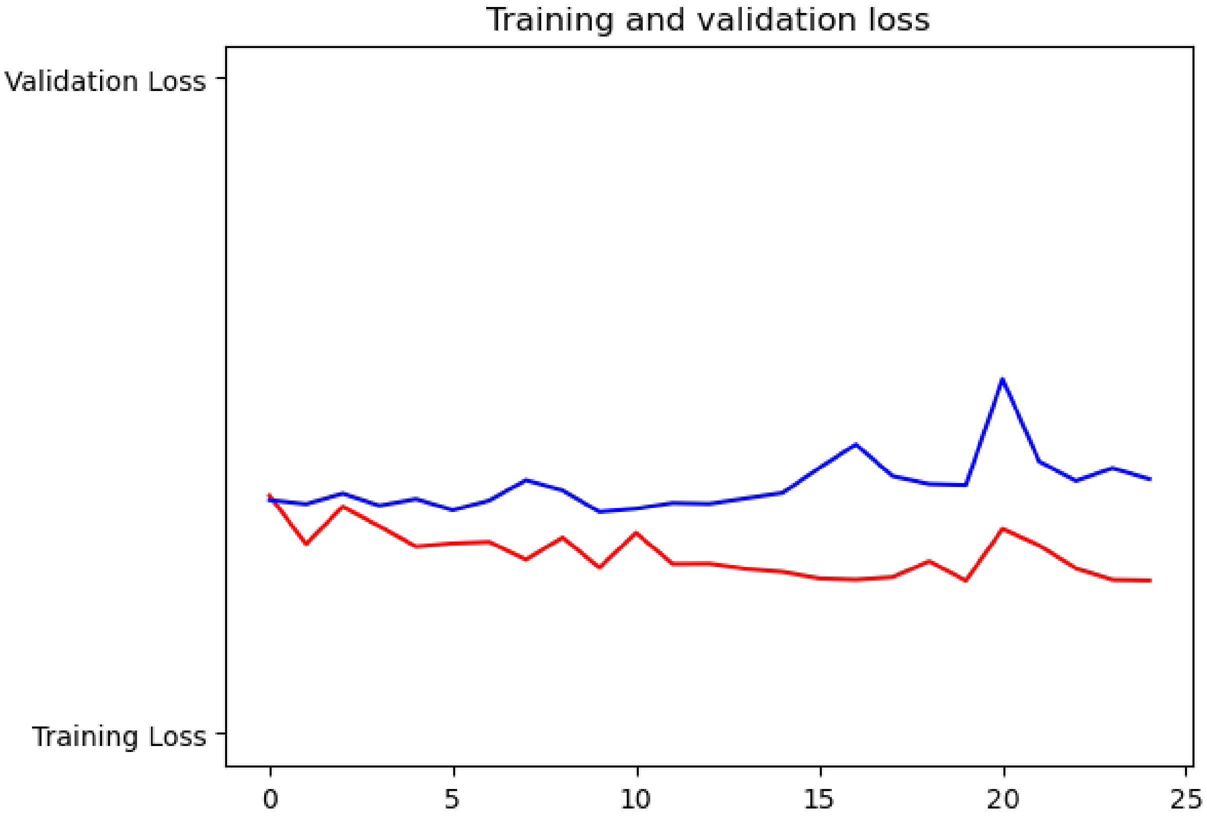
In [146…

```
#Training versus Accuracy
acc = model1.history['accuracy']
val_acc = model1.history['val_accuracy']
loss = model1.history['loss']
val_loss = model1.history['val_loss']
epochs=range(len(acc))
mpl.plot(epochs, acc, 'r', 'Training Accuracy')
mpl.plot(epochs, val_acc, 'b', 'Validation Accuracy')
mpl.title('Training and validation accuracy')
mpl.figure()
mpl.plot(epochs, loss, 'r', 'Training Loss')
mpl.plot(epochs, val_loss, 'b', 'Validation Loss')
mpl.title('Training and validation loss')
mpl.figure()
```

Out[146]:

```
<Figure size 640x480 with 0 Axes>
```





```
<Figure size 640x480 with 0 Axes>
```

In [152…

```
#Exports
train_reviews.to_csv('D213_Task2_train_reviews.csv', index = False)
train_label.to_csv('D213_Task2_train_label.csv', index = False)
test_reviews.to_csv('D213_Task2_test_reviews.csv', index = False)
test_label.to_csv('D213_Task2_test_label.csv', index = False)
```

In [153…

```
df.to_csv('D213_Task2_df_Ready_to_Run.csv', index = False)
```

In [154…

```
#Saving our model
model.save('D213_Task2_Model.h5')
```