Fake-Real-News-Detective-Model

October 10, 2021

[1]:
```
from bs4 import BeautifulSoup
import re,string,unicodedata
```

[3]:
```
class clean:
    def __init__(self,text):
        self.text = text

    def strip_html(self,text):
        soup = BeautifulSoup(self.text, "html.parser")
        return soup.get_text()

    # Removing the square brackets
    def remove_betweenn_square_brackets(self, text):
        return re.sub('\[[^]]*\]', '', self.text)

    # Removing URL's
    def remove_between_square_brackets(self, text):
        return re.sub(r'http\S+', '', self.text)

    # Removing the stopwords from text
    def remove_stopwords(self, text):
        final_text = []
        text = self.text
        for i in text.split():
            if i.strip().lower() not in stop:
                final_text.append(i.strip())
        return " ".join(final_text)

    # Removing the noisy text
    def denoise_text(self, text):
        #text = self.text
        text = self.strip_html(self.text)
        text = self.remove_between_square_brackets(text)
        text = self.remove_stopwords(text)
        return text
```

[1]:
```
import nltk
import clean
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import re,string,unicodedata
from collections import Counter
from wordcloud import WordCloud,STOPWORDS
from sklearn.feature_extraction.text import CountVectorizer
```

[2]:
```
def get_corpus(text):
    words = []
    for i in text:
        for j in i.split():
            words.append(j.strip())
    return words

def get_top_text_ngrams(corpus, n, g):
    vec = CountVectorizer(ngram_range=(g, g)).fit(corpus)
    bag_of_words = vec.transform(corpus)
    sum_words = bag_of_words.sum(axis=0)
    words_freq = [(word, sum_words[0, idx]) for word, idx in vec.vocabulary_.
 ↪items()]
    words_freq =sorted(words_freq, key = lambda x: x[1], reverse=True)
    return words_freq[:n]
```

[4]:
```
if __name__ == "__main__":
    # load the real news data and preview
    True_news = pd.read_csv('/Users/yuechenjiang/Desktop/project660/True.csv')
    print('==================== Real Data Preview ====================')
    print(True_news.head())
    print('==================== Real Data Describe ====================')
    True_news.describe()
    print('Real Dataset Shape:','\n',True_news.shape)
    print('Real Columns name','\n',True_news.columns)
    print('Real Subject count','\n',True_news['subject'].value_counts())

    # load the fake news data and preview
    Fake_news = pd.read_csv('/Users/yuechenjiang/Desktop/project660/Fake.csv')
    print('==================== Fake Data Preview ====================')
    print(Fake_news.head())
    print('==================== Fake Data Describe ====================')
    Fake_news.describe()
    print('Fake Dataset Shape:','\n',Fake_news.shape)
    print('Fake Columns name','\n',Fake_news.columns)
    print('Fake Subject count','\n',Fake_news['subject'].value_counts())
```

```
    # combine the datasets and data visualization
    True_news['category'] = 1
    Fake_news['category'] = 0
    df = pd.concat([True_news,Fake_news])
    print('========== Comparie the Number of Real and Fake News =========')
    sns.set_style("darkgrid")
    sns.countplot(df.category)
    print('Check whether the data set has null values','\n',df.isna().sum())
    print('Check news subjects','\n',df.subject.value_counts())

    plt.figure(figsize = (12,8))
    plt.title('Real and Fake News subjects')
    sns.set(style = "whitegrid",font_scale = 1.2)
    chart = sns.countplot(x = "subject", hue = "category" , data = df)
    chart.set_xticklabels(chart.get_xticklabels(),rotation=90)

    df['text'] = df['text'] + " " + df['title']
    del df['title']
    del df['subject']
    del df['date']

    print('============= Real News World Cloud Before Cleaning =============')
    plt.figure(figsize = (20,20)) # Text that is not Fake
    wc = WordCloud(max_words = 2000 , width = 1600 , height = 800 , stopwords =␣
↪STOPWORDS).generate(" ".join(df[df.category == 1].text))
    plt.imshow(wc , interpolation = 'bilinear')
    print('============= Fake News World Cloud Before Cleaning =============')
    plt.figure(figsize = (20,20)) # Text that is Fake
    wc = WordCloud(max_words = 2000 , width = 1600 , height = 800 , stopwords =␣
↪STOPWORDS).generate(" ".join(df[df.category == 0].text))
    plt.imshow(wc , interpolation = 'bilinear')

    clean_text = []
    for i in df['text']:
        data_cleaning = clean.clean(text = i)
        clean_text.append(data_cleaning.denoise_text(i))
    del df['text']
    df = pd.DataFrame({'text':clean_text,'category':df['category']})
    # df.head()
    # data_cleaning = clean()
    # df['text'] = df['text'].apply(data_cleaning.denoise_text)
    # WHEN I USE CLASS I'M UNABLE TO USE 'apply' FUNCTION, STILL NEED TO FIND␣
↪OUT WHY, USING LOOPS ARE SLOW
    print('============== Real News World Cloud After Cleaning =============')
    plt.figure(figsize = (20,20)) # Text that is not Fake
```

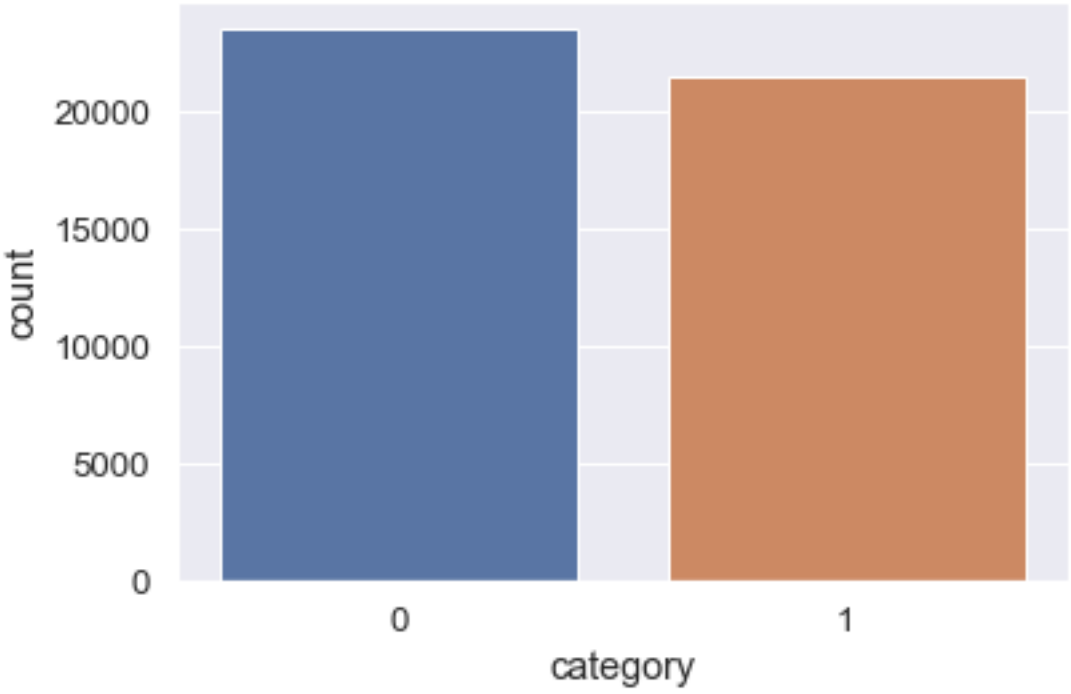
```
   wc = WordCloud(max_words = 2000 , width = 1600 , height = 800 , stopwords =␣
↪STOPWORDS).generate(" ".join(df[df.category == 1].text))
   plt.imshow(wc , interpolation = 'bilinear')
   print('============== Fake News World Cloud After Cleaning =============')
   plt.figure(figsize = (20,20)) # Text that is Fake
   wc = WordCloud(max_words = 2000 , width = 1600 , height = 800 , stopwords =␣
↪STOPWORDS).generate(" ".join(df[df.category == 0].text))
   plt.imshow(wc , interpolation = 'bilinear')
   # Number of characters in texts
   fig,(ax1,ax2)=plt.subplots(1,2,figsize=(12,8))
   text_len=df[df['category']==1]['text'].str.len()
   ax1.hist(text_len,color='red')
   ax1.set_title('Original text')
   text_len=df[df['category']==0]['text'].str.len()
   ax2.hist(text_len,color='green')
   ax2.set_title('Fake text')
   fig.suptitle('Characters in texts')
   plt.show()
   print('The distribution of both seems to be a bit different.','\n',
         '2500 characters in text is the most common in original text␣
↪category', '\n',
         'while around 5000 characters in text are most common in fake text␣
↪category.')

   # Number of words in each text
   fig,(ax1,ax2)=plt.subplots(1,2,figsize=(12,8))
   text_len=df[df['category']==1]['text'].str.split().map(lambda x: len(x))
   ax1.hist(text_len,color='red')
   ax1.set_title('Original text')
   text_len=df[df['category']==0]['text'].str.split().map(lambda x: len(x))
   ax2.hist(text_len,color='green')
   ax2.set_title('Fake text')
   fig.suptitle('Words in texts')
   plt.show()

   # Average word length in a text
   fig,(ax1,ax2)=plt.subplots(1,2,figsize=(20,10))
   word=df[df['category']==1]['text'].str.split().apply(lambda x : [len(i) for␣
↪i in x])
   sns.distplot(word.map(lambda x: np.mean(x)),ax=ax1,color='red')
   ax1.set_title('Original text')
   word=df[df['category']==0]['text'].str.split().apply(lambda x : [len(i) for␣
↪i in x])
   sns.distplot(word.map(lambda x: np.mean(x)),ax=ax2,color='green')
   ax2.set_title('Fake text')
   fig.suptitle('Average word length in each text')
```

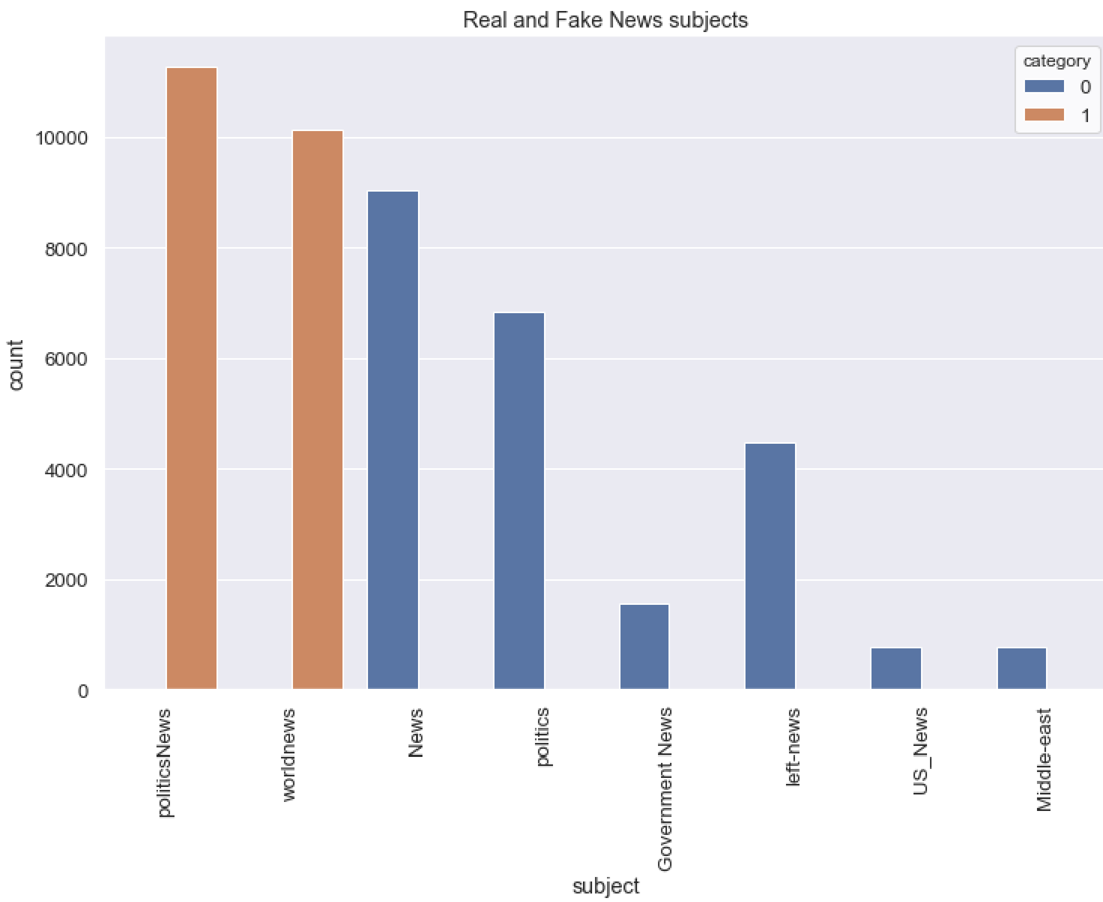
```
    corpus = get_corpus(df.text)
    print('Top 5 Words','\n',corpus[:5])

    counter = Counter(corpus)
    most_common = counter.most_common(10)
    most_common = dict(most_common)
    print('Numbers of most common words','\n',most_common)

    # Unigram Analysis
    plt.figure(figsize = (16,9))
    most_common_uni = get_top_text_ngrams(df.text,10,1)
    most_common_uni = dict(most_common_uni)
    sns.barplot(x=list(most_common_uni.values()),y=list(most_common_uni.keys()))

    # Bigram Analysis
    plt.figure(figsize = (16,9))
    most_common_bi = get_top_text_ngrams(df.text,10,2)
    most_common_bi = dict(most_common_bi)
    sns.barplot(x=list(most_common_bi.values()),y=list(most_common_bi.keys()))

    # Trigram Analysis
    plt.figure(figsize = (16,9))
    most_common_tri = get_top_text_ngrams(df.text,10,3)
    most_common_tri = dict(most_common_tri)
    sns.barplot(x=list(most_common_tri.values()),y=list(most_common_tri.keys()))
```

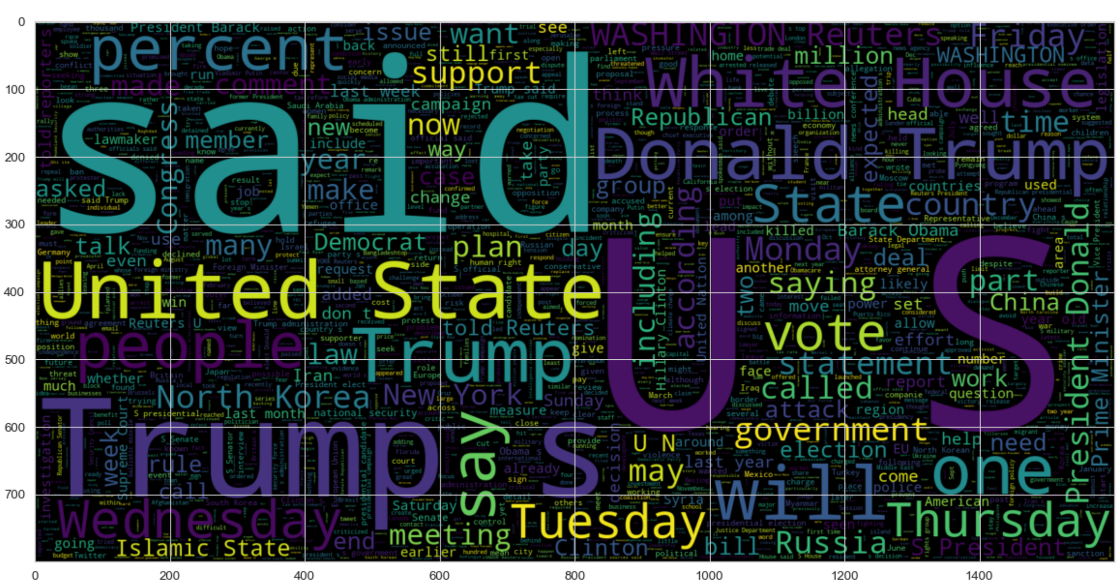
```
====================== Real Data Preview ====================
                                                 title  \
0  As U.S. budget fight looms, Republicans flip t…
1  U.S. military to accept transgender recruits o…
2  Senior U.S. Republican senator: 'Let Mr. Muell…
3  FBI Russia probe helped by Australian diplomat…
4  Trump wants Postal Service to charge 'much mor…

                                                text       subject  \
0  WASHINGTON (Reuters) - The head of a conservat…  politicsNews
1  WASHINGTON (Reuters) - Transgender people will…  politicsNews
2  WASHINGTON (Reuters) - The special counsel inv…  politicsNews
3  WASHINGTON (Reuters) - Trump campaign adviser …  politicsNews
4  SEATTLE/WASHINGTON (Reuters) - President Donal…  politicsNews

                date
0  December 31, 2017
1  December 29, 2017
2  December 31, 2017
3  December 30, 2017
```

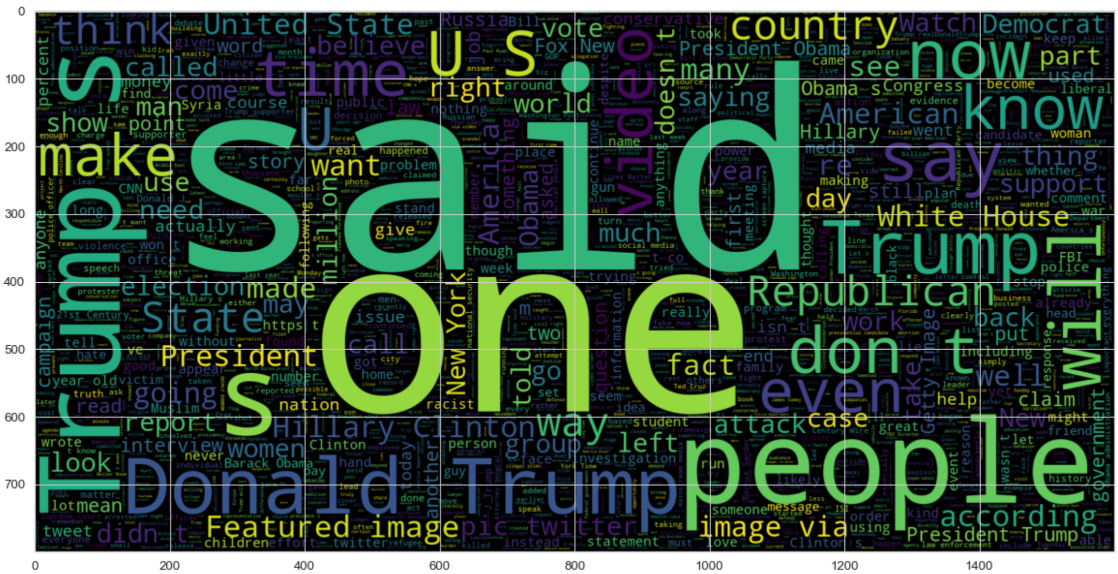
```
4  December 29, 2017
==================== Real Data Describe ====================
Real Dataset Shape:
 (21417, 4)
Real Columns name
 Index(['title', 'text', 'subject', 'date'], dtype='object')
Real Subject count
 politicsNews    11272
worldnews       10145
Name: subject, dtype: int64
==================== Fake Data Preview ====================
                                                   title  \
0   Donald Trump Sends Out Embarrassing New Year'…
1   Drunk Bragging Trump Staffer Started Russian …
2   Sheriff David Clarke Becomes An Internet Joke…
3   Trump Is So Obsessed He Even Has Obama's Name…
4   Pope Francis Just Called Out Donald Trump Dur…

                                                 text subject  \
0  Donald Trump just couldn t wish all Americans …    News
1  House Intelligence Committee Chairman Devin Nu…    News
2  On Friday, it was revealed that former Milwauk…    News
3  On Christmas day, Donald Trump announced that …    News
4  Pope Francis used his annual Christmas Day mes…    News

               date
0  December 31, 2017
1  December 31, 2017
2  December 30, 2017
3  December 29, 2017
4  December 25, 2017
==================== Fake Data Describe ====================
Fake Dataset Shape:
 (23481, 4)
Fake Columns name
 Index(['title', 'text', 'subject', 'date'], dtype='object')
Fake Subject count
 News               9050
politics           6841
left-news          4459
Government News    1570
US_News             783
Middle-east         778
Name: subject, dtype: int64
========== Comparie the Number of Real and Fake News =========
Check whether the data set has null values
 title       0
text        0
```

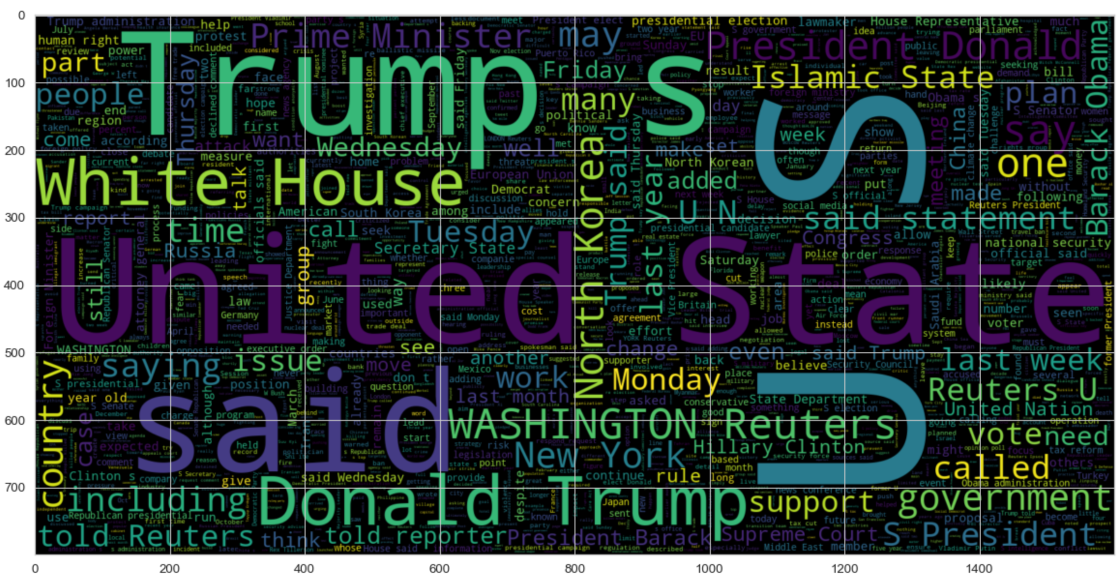
```
subject     0
date        0
category    0
dtype: int64
Check news subjects
 politicsNews       11272
worldnews          10145
News                9050
politics            6841
left-news           4459
Government News     1570
US_News               783
Middle-east           778
Name: subject, dtype: int64
============= Real News World Cloud Before Cleaning =============
============= Fake News World Cloud Before Cleaning =============
============== Real News World Cloud After Cleaning =============
============== Fake News World Cloud After Cleaning =============
```

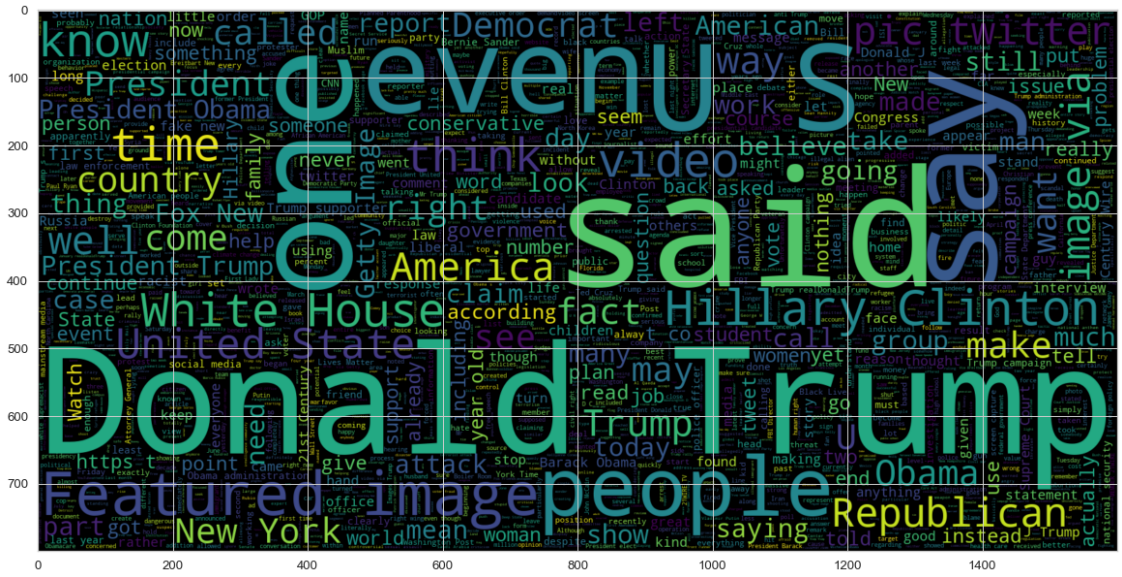


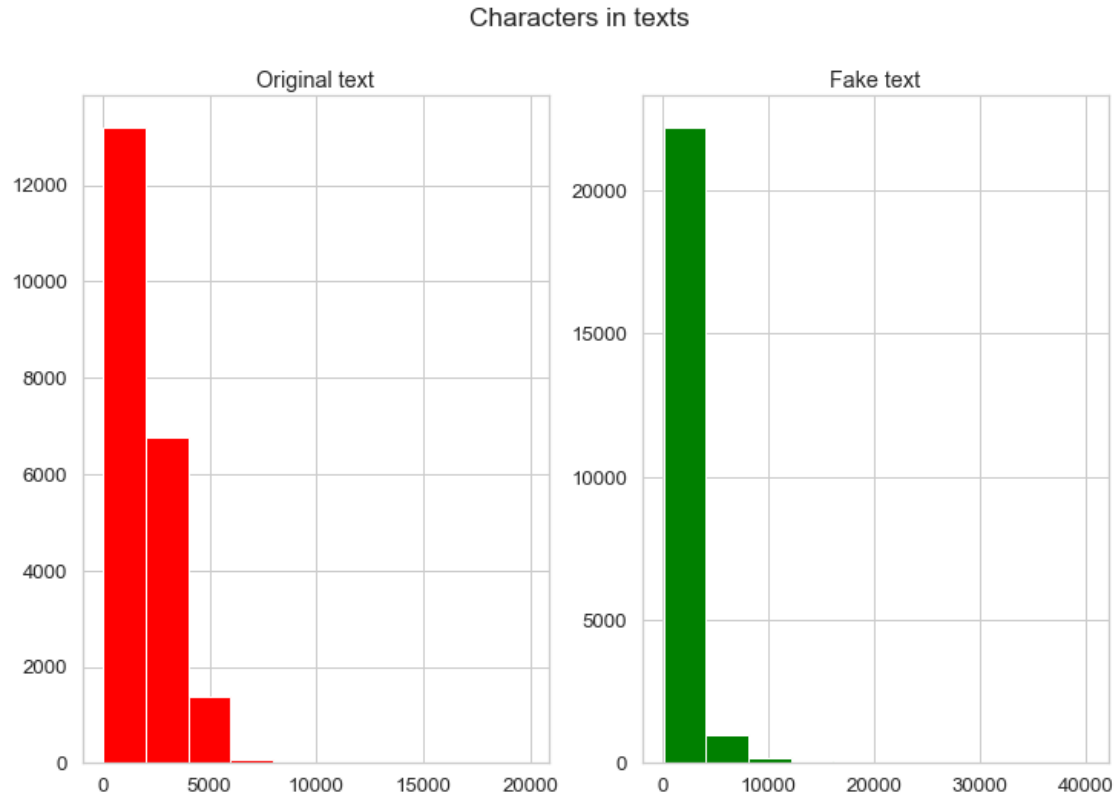

Real and Fake News subjects
category
0
1
count
0
2000
4000
6000
8000
10000
politicsNews
worldnews
News
politics
Government News
left-news
US_News
Middle-east
subject


0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200
1400
said
US
Trump
United State
Donald Trump
White House
percent
people
Trump
State
vote
government
one
will
Tuesday
Thursday
Wednesday
North Korea
New York
Republican
country
Monday
say
statement
called
Russia
Islamic State
President Donald
Prime Minister
WASHINGTON Reuters
Friday
support
Democrat
plan
many
law
may
meeting
Clinton
million
time
China
part
saying


said
one
people
Trump
Donald Trump
Trump s
time
U S
video
know
now
country
Republican
don t
even
will
make
say
Hillary Clinton
Featured image
image via
according
White House
United State
think
Democrat
Watch
President
State
election
going
report
look
American
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200
1400

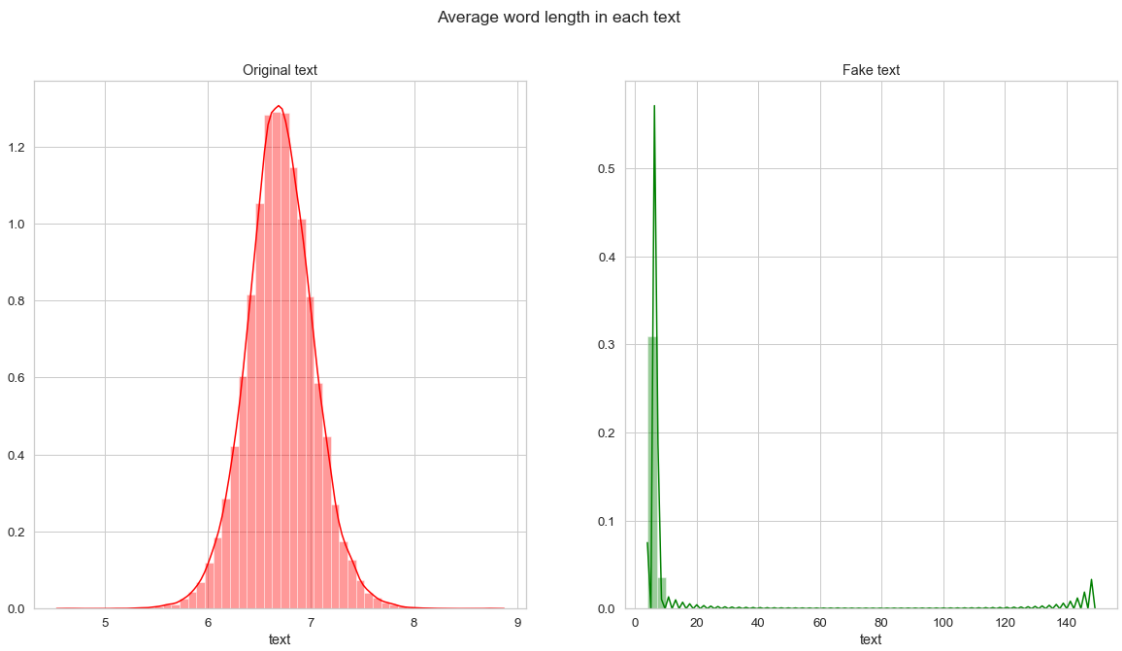

United State
Trump s
said
U S
Donald Trump
White House
President Donald
Prime Minister may
Islamic State
North Korea
WASHINGTON Reuters
New York
Monday
Tuesday
Wednesday
Thursday
Friday
last year
last week
said statement
government
including
told Reuters
told reporter
Reuters U
called
vote
need
one
Barack Obama
country
people
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200
1400

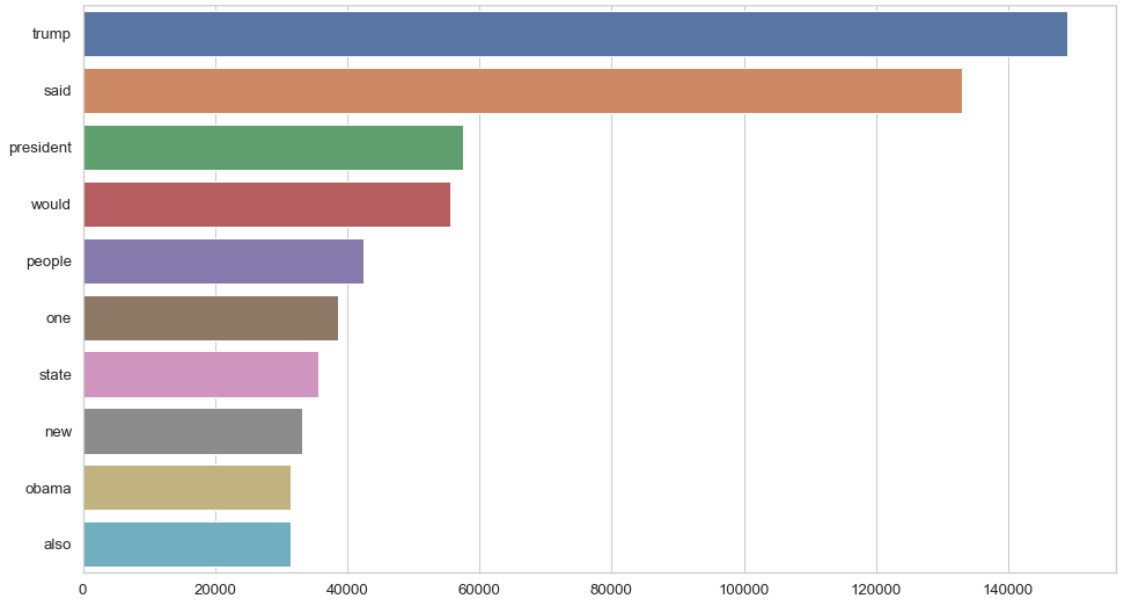


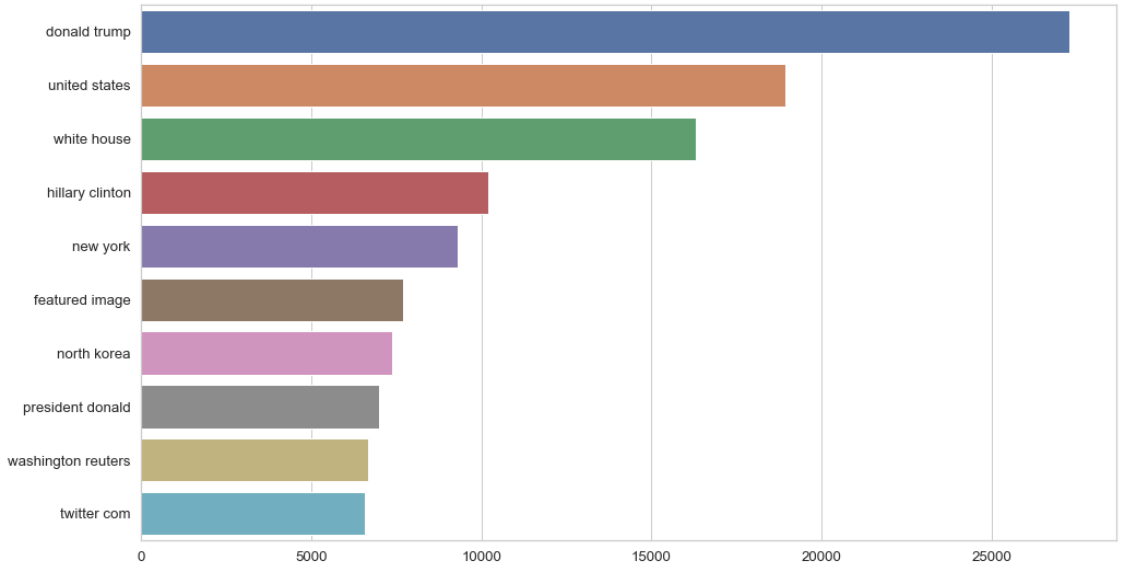


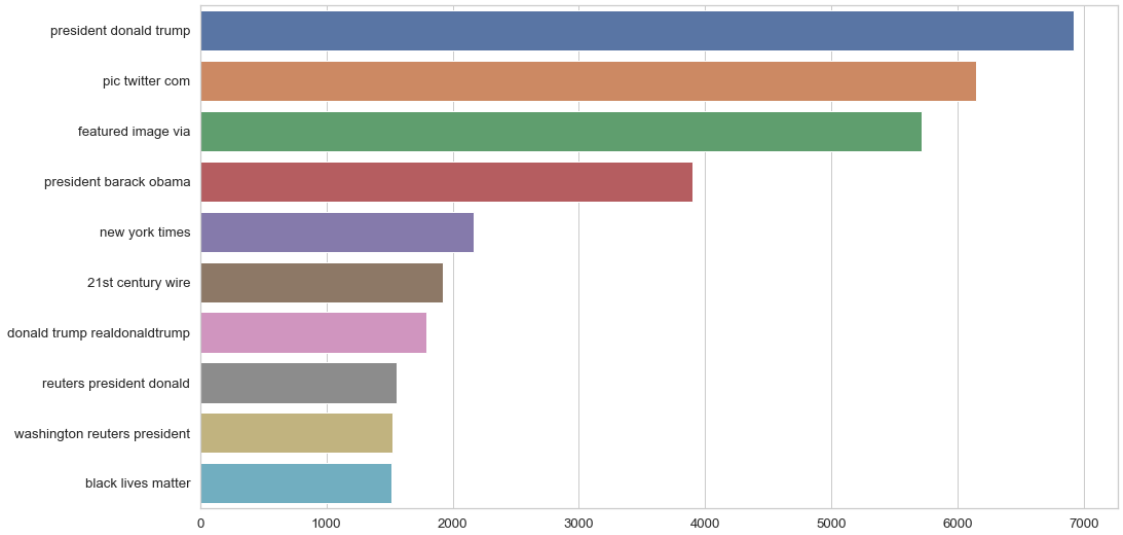
The distribution of both seems to be a bit different.
2500 characters in text is the most common in original text category
while around 5000 characters in text are most common in fake text category.


```
Top 5 Words
 ['WASHINGTON', '(Reuters)', 'head', 'conservative', 'Republican']
Numbers of most common words {'Trump': 111503, 'said': 93162, 'would': 54613,
'U.S.': 50441, 'President': 33180, 'people': 33115, 'also': 30325, 'one': 29370,
'Donald': 27795, 'said.': 26190}
```


Average word length in each text
Original text
Fake text
text
text


trump
said
president
would
people
one
state
new
obama
also





[7]:
```
stop = set(stopwords.words('english'))
punctuation = list(string.punctuation)
stop.update(punctuation)
```

[38]:
```
def strip_html(text):
    soup = BeautifulSoup(text, "html.parser")
    return soup.get_text()

#Removing the square brackets
def remove_between_square_brackets(text):
```

```
    return re.sub('\[[^]]*\]', '', text)
# Removing URL's
def remove_between_square_brackets(text):
    return re.sub(r'http\S+', '', text)
#Removing the stopwords from text
def remove_stopwords(text):
    final_text = []
    for i in text.split():
        if i.strip().lower() not in stop:
            final_text.append(i.strip())
    return " ".join(final_text)
#Removing the noisy text
def denoise_text(text):
    text = strip_html(text)
    text = remove_between_square_brackets(text)
    text = remove_stopwords(text)
    return text
```

[2]:
```
True_news = pd.read_csv('/Users/yuechenjiang/Desktop/project660/True.csv')
Fake_news = pd.read_csv('/Users/yuechenjiang/Desktop/project660/Fake.csv')
True_news['category'] = 1
Fake_news['category'] = 0
df = pd.concat([True_news,Fake_news])
df['text']=df['text'].apply(denoise_text)
```

[5]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.metrics import␣
 ↪classification_report,confusion_matrix,accuracy_score
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn import model_selection
from sklearn import preprocessing
from sklearn.tree import DecisionTreeClassifier
from sklearn.neural_network import MLPClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB
from sklearn.ensemble import RandomForestClassifier
from sklearn import metrics
```

[6]:
```
True_news = pd.read_csv('/Users/yuechenjiang/Desktop/project660/True.csv')
Fake_news = pd.read_csv('/Users/yuechenjiang/Desktop/project660/Fake.csv')
True_news['category'] = 1
Fake_news['category'] = 0
df = pd.concat([True_news,Fake_news])
df['text'] = df['text'] + " " + df['title']
del df['title']
del df['subject']
del df['date']
clean_text = []
for i in df['text']:
    data_cleaning = clean.clean(text = i)
    clean_text.append(data_cleaning.denoise_text(i))
del df['text']
df = pd.DataFrame({'text':clean_text,'category':df['category']})
```

[7]:
```
models = [LogisticRegression(solver='lbfgs'),          # Logistic regression
          RandomForestClassifier(n_estimators=100),    # Random forest
          DecisionTreeClassifier(),                    # Decision tree
          MLPClassifier(max_iter=100),                 # Multilayer perceptron
          AdaBoostClassifier(),                        # Adaptive gradient boost
          BaggingClassifier(),                         # Bagging algorithm
          GradientBoostingClassifier(),                # Gradient Boosting␣
 ↪Algorithm
          SVC(kernel = 'linear')]
          #GaussianNB()]

model_name = ['LogisticRegression',
              'RandomForestClassifier',
              'DecisionTreeClassifier',
              'MLPClassifier',
              'AdaBoostClassifier',
              'BaggingClassifier',
              'GradientBoostingClassifier',
              'SVMClassifier']
```

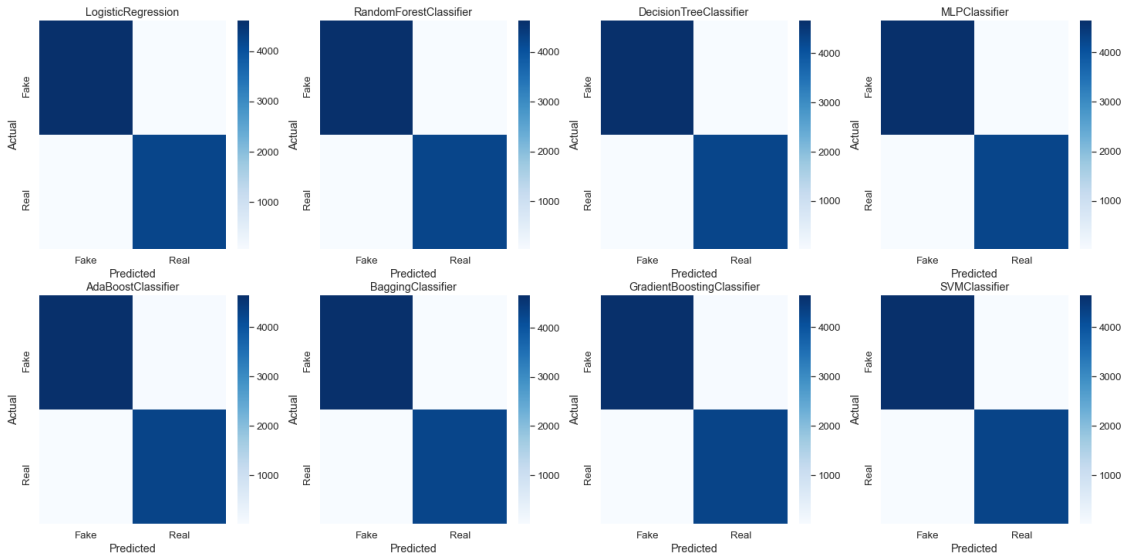
[8]:
```
tfidf_vectorizer = TfidfVectorizer(use_idf=True, stop_words='english')
X = tfidf_vectorizer.fit_transform(df['text'])
Y = df['category']
x_train, x_test, y_train, y_test = model_selection.train_test_split(X, Y ,␣
 ↪train_size=0.8,test_size=0.2, random_state=1)
```

[18]:
```
#fig,(ax1,ax2)=plt.subplots(figsize=(20,8))
acc = []
cms = []
for model in models:
    model.fit(x_train,y_train)
```

```
    # model_acc = model.score(x_test, y_test)*100
    acc.append(model.score(x_test, y_test))
    y_pred = model.predict(x_test)
    cm = confusion_matrix(y_test,y_pred)
    cms.append(cm)
    print(model,'\n',cm)
    #sns.heatmap(cm,cmap= "Blues", linecolor = 'black' , linewidth = 1 , annot␣
↪= True, fmt='' , xticklabels = ['Fake','Original'] , yticklabels =␣
↪['Fake','Original'])
    #plt.xlabel("Predicted")
    #plt.ylabel("Actual")
```

```
LogisticRegression()
 [[4607   71]
 [  56 4246]]
RandomForestClassifier()
 [[4629   49]
 [  37 4265]]
DecisionTreeClassifier()
 [[4660   18]
 [  18 4284]]
MLPClassifier(max_iter=100)
 [[4642   36]
 [  23 4279]]
AdaBoostClassifier()
 [[4648   30]
 [   8 4294]]
BaggingClassifier()
 [[4661   17]
 [   9 4293]]
GradientBoostingClassifier()
 [[4644   34]
 [  10 4292]]
SVC(kernel='linear')
 [[4646   32]
 [  15 4287]]
```

[28]:
```
fig,ax=plt.subplots(2,4,figsize=(25,12))
for i in range(len(cms)):
    plt.subplot(2, 4, i+1)
    sns.heatmap(np.array(cms[i]),cmap= "Blues", linecolor = 'black' ,␣
↪xticklabels = ['Fake','Real'] , yticklabels = ['Fake','Real'])
    plt.xlabel("Predicted")
    plt.ylabel("Actual")
    plt.title(model_name[i])
```



[20]:
```
a = pd.DataFrame({"name": model_name, "acc": acc})
a
```

[20]:

	name	acc
0	LogisticRegression	0.985857
1	RandomForestClassifier	0.990423
2	DecisionTreeClassifier	0.995991
3	MLPClassifier	0.993430
4	AdaBoostClassifier	0.995768
5	BaggingClassifier	0.997105
6	GradientBoostingClassifier	0.995100
7	SVMClassifier	0.994766

[1]:
```
import os
import clean
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import nltk
from sklearn.preprocessing import LabelBinarizer
from nltk.corpus import stopwords
from nltk.stem.porter import PorterStemmer
from wordcloud import WordCloud,STOPWORDS
from nltk.stem import WordNetLemmatizer
from nltk.tokenize import word_tokenize,sent_tokenize
from bs4 import BeautifulSoup
import re,string,unicodedata
```

```
from keras.preprocessing import text, sequence
from sklearn.metrics import␣
↪classification_report,confusion_matrix,accuracy_score
from sklearn.model_selection import train_test_split
from string import punctuation
from nltk import pos_tag
from nltk.corpus import wordnet
from tensorflow import keras
from tensorflow.keras import layers
import keras
from keras.models import Sequential
from keras.layers import Dense,Embedding,LSTM,Dropout
from keras.callbacks import ReduceLROnPlateau
import tensorflow as tf
from collections import Counter
from sklearn.feature_extraction.text import CountVectorizer
```

[3]:
```
True_news = pd.read_csv('/Users/yuechenjiang/Desktop/project660/code&data/True.
↪csv')
Fake_news = pd.read_csv('/Users/yuechenjiang/Desktop/project660/code&data/Fake.
↪csv')
True_news['category'] = 1
Fake_news['category'] = 0
df = pd.concat([True_news,Fake_news])
df['text'] = df['text'] + " " + df['title']
del df['title']
del df['subject']
del df['date']
clean_text = []
for i in df['text']:
    data_cleaning = clean.clean(text = i)
    clean_text.append(data_cleaning.denoise_text(i))
del df['text']
df = pd.DataFrame({'text':clean_text,'category':df['category']})
```

[4]:
```
df.to_csv("combined.csv",index=False)
```

[2]:
```
df = pd.read_csv('/Users/yuechenjiang/Desktop/project660/code&data/combined.
↪csv')
```

[17]:
```
x_train,x_test,y_train,y_test = train_test_split(df.text,df.
↪category,random_state = 0)

max_features = 10000
maxlen = 101

# Tokenizing Text -> Repsesenting each word by a number
```

```
# Mapping of orginal word to number is preserved in word_index property of␣
 ↪tokenizer
# Tokenized applies basic processing like changing it to lower case,␣
 ↪explicitely setting that as False
# Lets keep all news to 300, add padding to news with less than 300 words and␣
 ↪truncating long ones
tokenizer = text.Tokenizer(num_words=max_features)
tokenizer.fit_on_texts(x_train)
tokenized_train = tokenizer.texts_to_sequences(x_train)
x_train = sequence.pad_sequences(tokenized_train, maxlen=maxlen)

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

[18]:
```
np.savetxt('train.txt', x_train)
```

[19]:
```
EMBEDDING_FILE = '/Users/yuechenjiang/Desktop/project660/code&data/train.txt'
```

[20]:
```
def get_coefs(word, *arr):
    return word, np.asarray(arr, dtype='float32')
embeddings_index = dict(get_coefs(*o.rstrip().rsplit(' ')) for o in␣
 ↪open(EMBEDDING_FILE))
```

[21]:
```
all_embs = np.stack(embeddings_index.values())
emb_mean,emb_std = all_embs.mean(), all_embs.std()
embed_size = all_embs.shape[1]
```

[22]:
```
word_index = tokenizer.word_index
nb_words = min(max_features, len(word_index))
# change below line if computing normal stats is too slow
embedding_matrix = np.random.normal(emb_mean, emb_std, (nb_words, embed_size))
for word, i in word_index.items():
    if i >= max_features: continue
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None: embedding_matrix[i] = embedding_vector
```

[23]:
```
embed_size
```

[23]:
```
100
```

[24]:
```
embedding_matrix.shape
```

[24]:
```
(10000, 100)
```

[25]:
```
emb_mean
```

[25]:
```
1615.2051
```

[30]:
```
# Model Parameters
batch_size = 256
epochs = 12
embed_size = 100
```

[27]:
```
learning_rate_reduction = ReduceLROnPlateau(monitor='val_accuracy', patience =␣
↪2, verbose=1,factor=0.5, min_lr=0.00001)
```

[28]:
```
from tensorflow import keras
from tensorflow.keras import layers
#Defining Neural Network
model = Sequential()
#Non-trainable embeddidng layer
model.add(Embedding(max_features, output_dim=embed_size,␣
↪weights=[embedding_matrix], input_length=300, trainable=False))
#LSTM
model.add(LSTM(units=128 , return_sequences = True , recurrent_dropout = 0.25 ,␣
↪dropout = 0.25))
model.add(LSTM(units=64 , recurrent_dropout = 0.1 , dropout = 0.1))
model.add(Dense(units = 32 , activation = 'relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(optimizer=keras.optimizers.Adam(learning_rate = 0.01),␣
↪loss='binary_crossentropy', metrics=['accuracy'])
```

[29]:
```
model.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_1 (Embedding)      (None, 300, 100)          1000000
_________________________________________________________________
lstm (LSTM)                  (None, 300, 128)          117248
_________________________________________________________________
lstm_1 (LSTM)                (None, 64)                49408
_________________________________________________________________
dense (Dense)                (None, 32)                2080
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 33
=================================================================
Total params: 1,168,769
Trainable params: 168,769
Non-trainable params: 1,000,000
_________________________________________________________________
```

[31]:
```
history = model.fit(x_train, y_train, batch_size = batch_size , validation_data␣
↪= (X_test,y_test) , epochs = epochs , callbacks = [learning_rate_reduction])
```

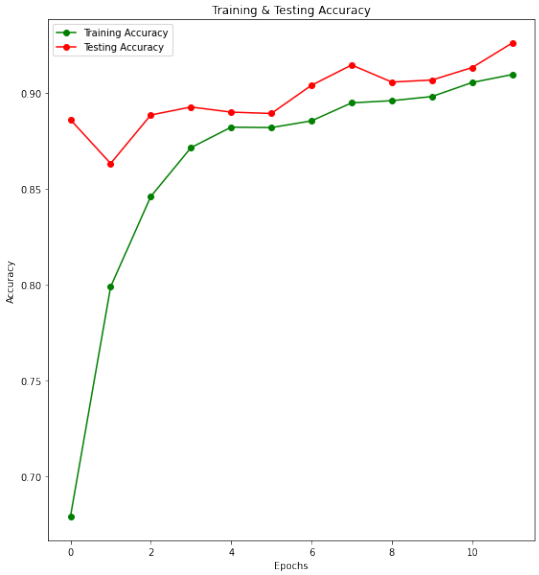
```
Epoch 1/12
WARNING:tensorflow:Model was constructed with shape (None, 300) for input
KerasTensor(type_spec=TensorSpec(shape=(None, 300), dtype=tf.float32,
name='embedding_1_input'), name='embedding_1_input', description="created by
layer 'embedding_1_input'"), but it was called on an input with incompatible
shape (None, 101).
WARNING:tensorflow:Model was constructed with shape (None, 300) for input
KerasTensor(type_spec=TensorSpec(shape=(None, 300), dtype=tf.float32,
name='embedding_1_input'), name='embedding_1_input', description="created by
layer 'embedding_1_input'"), but it was called on an input with incompatible
shape (None, 101).
132/132 [==============================] - ETA: 0s - loss: 0.5488 - accuracy:
0.6789WARNING:tensorflow:Model was constructed with shape (None, 300) for input
KerasTensor(type_spec=TensorSpec(shape=(None, 300), dtype=tf.float32,
name='embedding_1_input'), name='embedding_1_input', description="created by
layer 'embedding_1_input'"), but it was called on an input with incompatible
shape (None, 101).
132/132 [==============================] - 101s 740ms/step - loss: 0.5488 -
accuracy: 0.6789 - val_loss: 0.2801 - val_accuracy: 0.8861
Epoch 2/12
132/132 [==============================] - 118s 894ms/step - loss: 0.4190 -
accuracy: 0.7988 - val_loss: 0.3402 - val_accuracy: 0.8632
Epoch 3/12
132/132 [==============================] - 113s 855ms/step - loss: 0.3375 -
accuracy: 0.8459 - val_loss: 0.2524 - val_accuracy: 0.8885
Epoch 4/12
132/132 [==============================] - 137s 1s/step - loss: 0.2912 -
accuracy: 0.8714 - val_loss: 0.2506 - val_accuracy: 0.8927
Epoch 5/12
132/132 [==============================] - 147s 1s/step - loss: 0.2707 -
accuracy: 0.8821 - val_loss: 0.2542 - val_accuracy: 0.8900
Epoch 6/12
132/132 [==============================] - 176s 1s/step - loss: 0.2739 -
accuracy: 0.8819 - val_loss: 0.2597 - val_accuracy: 0.8893

Epoch 00006: ReduceLROnPlateau reducing learning rate to 0.004999999888241291.
Epoch 7/12
132/132 [==============================] - 160s 1s/step - loss: 0.2613 -
accuracy: 0.8854 - val_loss: 0.2323 - val_accuracy: 0.9040
Epoch 8/12
132/132 [==============================] - 142s 1s/step - loss: 0.2442 -
accuracy: 0.8948 - val_loss: 0.2034 - val_accuracy: 0.9146
Epoch 9/12
132/132 [==============================] - 138s 1s/step - loss: 0.2432 -
accuracy: 0.8959 - val_loss: 0.2294 - val_accuracy: 0.9057
Epoch 10/12
132/132 [==============================] - 139s 1s/step - loss: 0.2349 -
accuracy: 0.8981 - val_loss: 0.2230 - val_accuracy: 0.9067
```

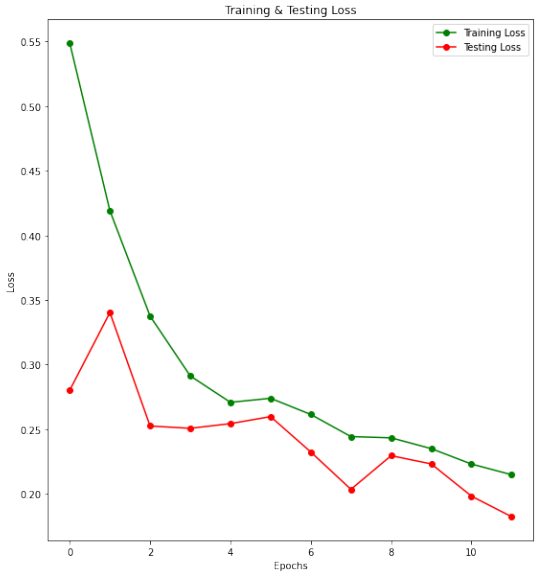
```
Epoch 00010: ReduceLROnPlateau reducing learning rate to 0.0024999999441206455.
Epoch 11/12
132/132 [==============================] - 132s 999ms/step - loss: 0.2230 -
accuracy: 0.9054 - val_loss: 0.1981 - val_accuracy: 0.9132
Epoch 12/12
132/132 [==============================] - 152s 1s/step - loss: 0.2147 -
accuracy: 0.9096 - val_loss: 0.1822 - val_accuracy: 0.9261
```

[32]:
```
# Model Analysis
print("Accuracy of the model on Training Data is - " , model.
 ↪evaluate(x_train,y_train)[1]*100 , "%")
print("Accuracy of the model on Testing Data is - " , model.
 ↪evaluate(X_test,y_test)[1]*100 , "%")
```

```
1053/1053 [==============================] - 44s 42ms/step - loss: 0.1856 -
accuracy: 0.9272
Accuracy of the model on Training Data is -  92.72413849830627 %
351/351 [==============================] - 15s 44ms/step - loss: 0.1822 -
accuracy: 0.9261
Accuracy of the model on Testing Data is -  92.60579347610474 %
```

[33]:
```
epochs = [i for i in range(12)]
fig , ax = plt.subplots(1,2)
train_acc = history.history['accuracy']
train_loss = history.history['loss']
val_acc = history.history['val_accuracy']
val_loss = history.history['val_loss']

fig.set_size_inches(20,10)

ax[0].plot(epochs , train_acc , 'go-' , label = 'Training Accuracy')
ax[0].plot(epochs , val_acc , 'ro-' , label = 'Testing Accuracy')
ax[0].set_title('Training & Testing Accuracy')
ax[0].legend()
ax[0].set_xlabel("Epochs")
ax[0].set_ylabel("Accuracy")

ax[1].plot(epochs , train_loss , 'go-' , label = 'Training Loss')
ax[1].plot(epochs , val_loss , 'ro-' , label = 'Testing Loss')
ax[1].set_title('Training & Testing Loss')
ax[1].legend()
ax[1].set_xlabel("Epochs")
ax[1].set_ylabel("Loss")
plt.show()
```





[34]:
```
pred = model.predict(X_test)
pred[:5]
```

```
WARNING:tensorflow:Model was constructed with shape (None, 300) for input
KerasTensor(type_spec=TensorSpec(shape=(None, 300), dtype=tf.float32,
name='embedding_1_input'), name='embedding_1_input', description="created by
layer 'embedding_1_input'"), but it was called on an input with incompatible
shape (None, 101).
```

[34]:
```
array([[1.6572118e-02],
       [1.2124286e-05],
       [7.2982348e-06],
       [1.0700109e-04],
       [9.8854536e-01]], dtype=float32)
```

[35]:
```
pred = list(pred)
test_result = []
for i in range(len(pred)):
    test_result.append(pred[i][0])
```

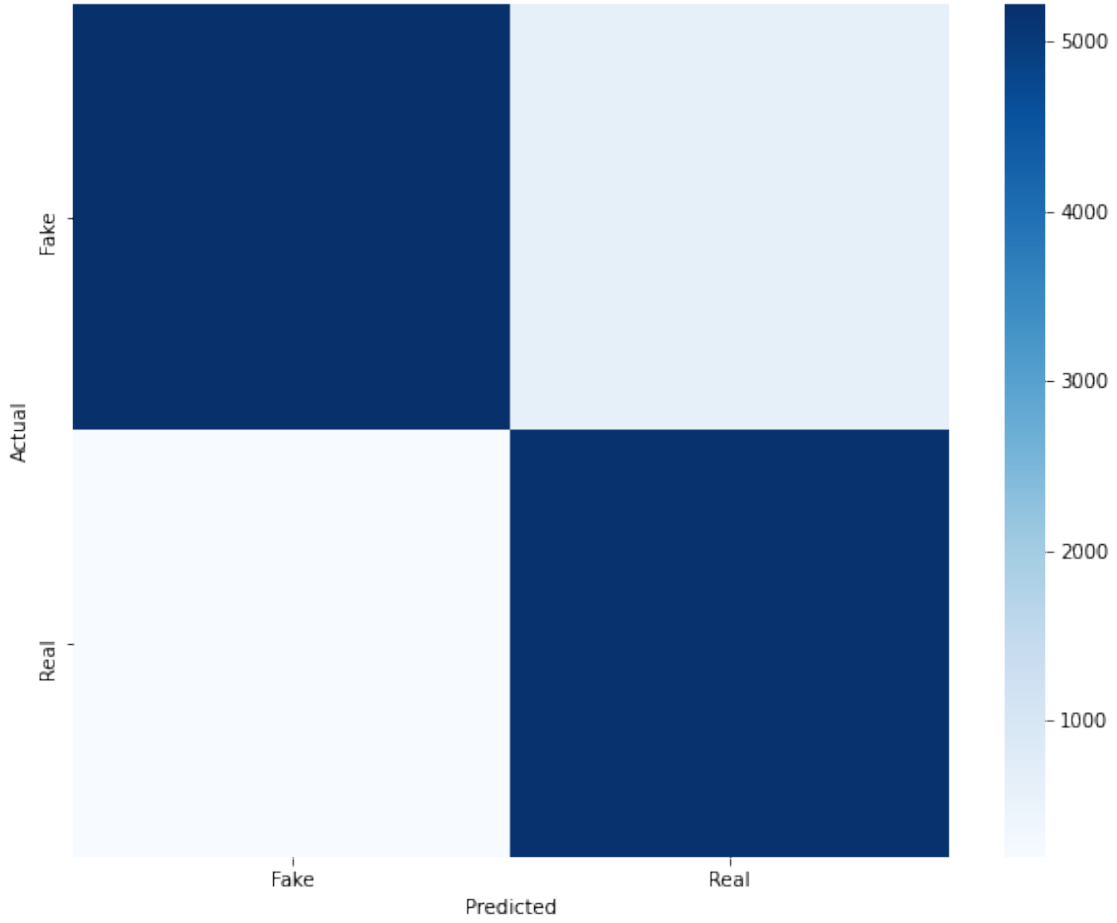
[36]:
```
confusion = pd.DataFrame({'Pred':test_result, 'Truth':list(y_test)})
confusion['binary_pred'] = (confusion['Pred'] > 0.5).astype(int)
```

[37]:
```
cm_DL = confusion_matrix(confusion['Truth'],confusion['binary_pred'])
cm_DL
```

[37]:
```
array([[5221,  637],
       [ 193, 5174]])
```

[38]:
```
plt.figure(figsize = (10,8))
sns.heatmap(cm_DL,cmap= "Blues", linecolor = 'black' , xticklabels =␣
↪['Fake','Real'] , yticklabels = ['Fake','Real'])
plt.xlabel("Predicted")
plt.ylabel("Actual")
```

[38]:
```
Text(69.0, 0.5, 'Actual')
```



[ ]:
```
from tensorflow import keras
from tensorflow.keras import layers
#Defining Neural Network
model = Sequential()
#Non-trainable embeddidng layer
model.add(Embedding(max_features, output_dim=embed_size,␣
↪weights=[embedding_matrix], input_length=100, trainable=False))
#LSTM
model.add(LSTM(units=128 , return_sequences = True , recurrent_dropout = 0.25 ,␣
↪dropout = 0.25))
```

```
model.add(LSTM(units=64 , recurrent_dropout = 0.1 , dropout = 0.1))
model.add(Dense(units = 32 , activation = 'relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(optimizer=keras.optimizers.Adam(learning_rate = 0.01),␣
↪loss='binary_crossentropy', metrics=['accuracy'])
```

[16]:
```
history = model.fit(x_train, y_train, batch_size = batch_size , validation_data␣
↪= (X_test,y_test) , epochs = epochs , callbacks = [learning_rate_reduction])
```

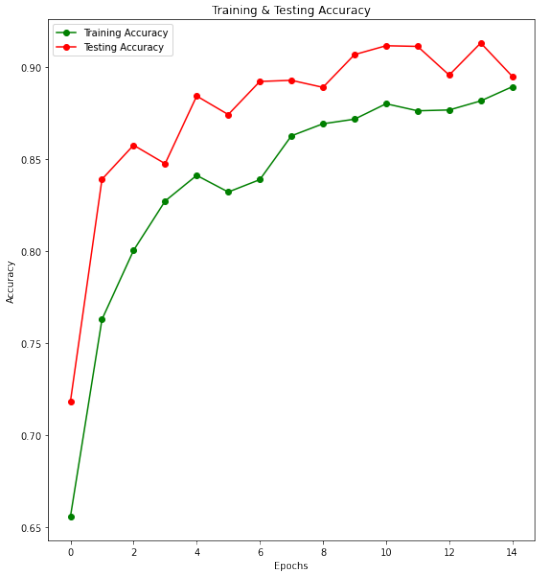
```
Epoch 1/15
132/132 [==============================] - 158s 1s/step - loss: 0.5791 -
accuracy: 0.6556 - val_loss: 0.5158 - val_accuracy: 0.7183
Epoch 2/15
132/132 [==============================] - 122s 924ms/step - loss: 0.4687 -
accuracy: 0.7630 - val_loss: 0.3673 - val_accuracy: 0.8392
Epoch 3/15
132/132 [==============================] - 127s 962ms/step - loss: 0.4201 -
accuracy: 0.8005 - val_loss: 0.3459 - val_accuracy: 0.8577
Epoch 4/15
132/132 [==============================] - 125s 941ms/step - loss: 0.3738 -
accuracy: 0.8273 - val_loss: 0.3302 - val_accuracy: 0.8477
Epoch 5/15
132/132 [==============================] - 125s 947ms/step - loss: 0.3471 -
accuracy: 0.8413 - val_loss: 0.2792 - val_accuracy: 0.8845
Epoch 6/15
132/132 [==============================] - 129s 976ms/step - loss: 0.3673 -
accuracy: 0.8322 - val_loss: 0.3263 - val_accuracy: 0.8744
Epoch 7/15
132/132 [==============================] - 123s 923ms/step - loss: 0.3494 -
accuracy: 0.8390 - val_loss: 0.2641 - val_accuracy: 0.8924
Epoch 8/15
132/132 [==============================] - 157s 1s/step - loss: 0.3034 -
accuracy: 0.8628 - val_loss: 0.2489 - val_accuracy: 0.8930
Epoch 9/15
132/132 [==============================] - 164s 1s/step - loss: 0.2839 -
accuracy: 0.8694 - val_loss: 0.2425 - val_accuracy: 0.8892
Epoch 10/15
132/132 [==============================] - 162s 1s/step - loss: 0.2828 -
accuracy: 0.8719 - val_loss: 0.2071 - val_accuracy: 0.9070
Epoch 11/15
132/132 [==============================] - 230s 2s/step - loss: 0.2639 -
accuracy: 0.8803 - val_loss: 0.1999 - val_accuracy: 0.9118
Epoch 12/15
132/132 [==============================] - 139s 1s/step - loss: 0.2688 -
accuracy: 0.8764 - val_loss: 0.2166 - val_accuracy: 0.9114
Epoch 13/15
132/132 [==============================] - 158s 1s/step - loss: 0.2638 -
```

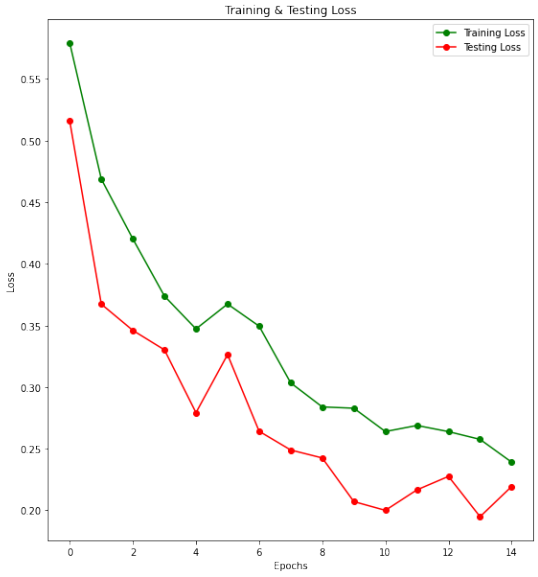
```
accuracy: 0.8769 - val_loss: 0.2275 - val_accuracy: 0.8959

Epoch 00013: ReduceLROnPlateau reducing learning rate to 0.004999999888241291.
Epoch 14/15
132/132 [==============================] - 126s 950ms/step - loss: 0.2575 -
accuracy: 0.8818 - val_loss: 0.1948 - val_accuracy: 0.9133
Epoch 15/15
132/132 [==============================] - 125s 950ms/step - loss: 0.2390 -
accuracy: 0.8895 - val_loss: 0.2193 - val_accuracy: 0.8951
```

[17]:
```
# Model Analysis
print("Accuracy of the model on Training Data is - " , model.
 ↪evaluate(x_train,y_train)[1]*100 , "%")
print("Accuracy of the model on Testing Data is - " , model.
 ↪evaluate(X_test,y_test)[1]*100 , "%")
```

```
1053/1053 [==============================] - 43s 41ms/step - loss: 0.2183 -
accuracy: 0.8983
Accuracy of the model on Training Data is -  89.82864618301392 %
351/351 [==============================] - 14s 40ms/step - loss: 0.2193 -
accuracy: 0.8951
Accuracy of the model on Testing Data is -  89.51447606086731 %
```

[18]:
```
epochs = [i for i in range(15)]
fig , ax = plt.subplots(1,2)
train_acc = history.history['accuracy']
train_loss = history.history['loss']
val_acc = history.history['val_accuracy']
val_loss = history.history['val_loss']

fig.set_size_inches(20,10)

ax[0].plot(epochs , train_acc , 'go-' , label = 'Training Accuracy')
ax[0].plot(epochs , val_acc , 'ro-' , label = 'Testing Accuracy')
ax[0].set_title('Training & Testing Accuracy')
ax[0].legend()
ax[0].set_xlabel("Epochs")
ax[0].set_ylabel("Accuracy")

ax[1].plot(epochs , train_loss , 'go-' , label = 'Training Loss')
ax[1].plot(epochs , val_loss , 'ro-' , label = 'Testing Loss')
ax[1].set_title('Training & Testing Loss')
ax[1].legend()
ax[1].set_xlabel("Epochs")
ax[1].set_ylabel("Loss")
plt.show()
```





[19]:
```
pred = model.predict(X_test)
pred[:5]
```

[19]:
```
array([[8.5334843e-01],
       [6.8051787e-07],
       [3.1262412e-06],
       [5.1984191e-04],
       [9.9682760e-01]], dtype=float32)
```

[20]:
```
pred = list(pred)
test_result = []
for i in range(len(pred)):
    test_result.append(pred[i][0])
```

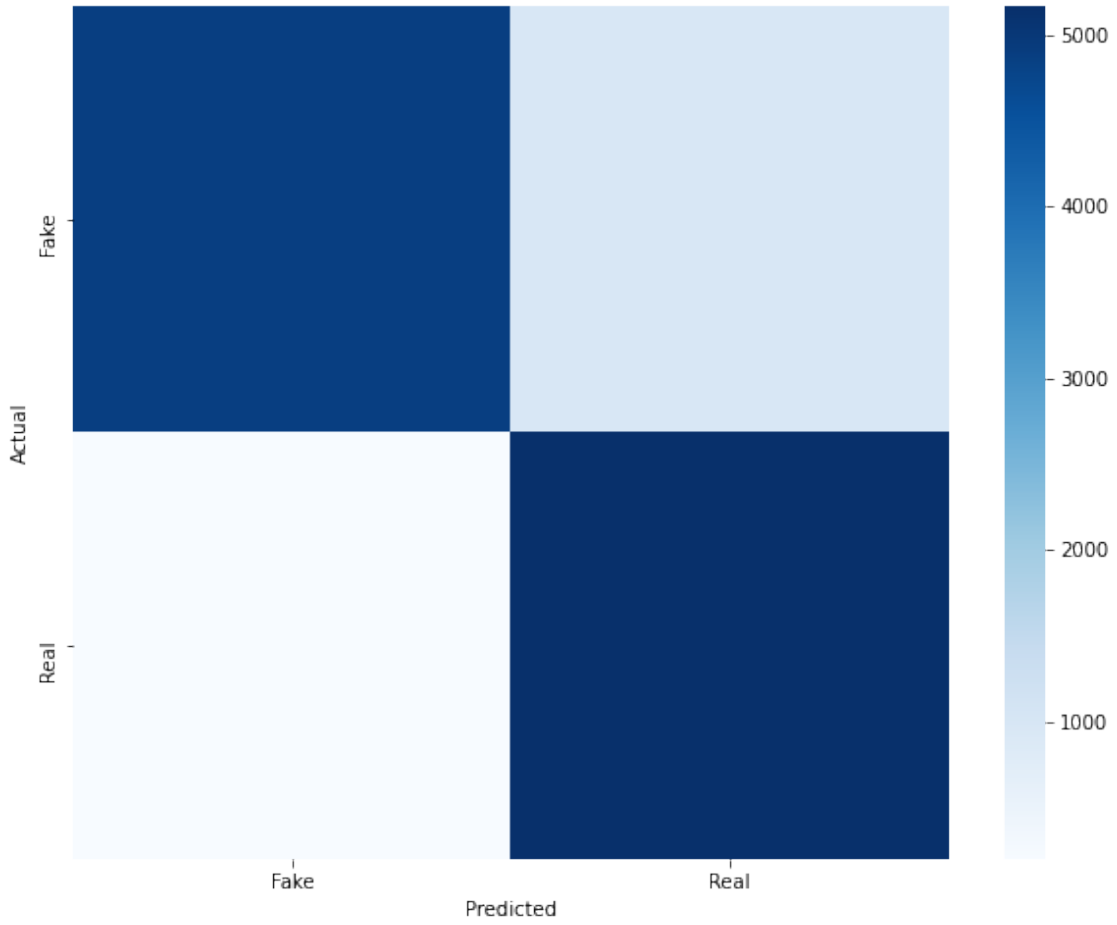
[21]:
```
confusion = pd.DataFrame({'Pred':test_result, 'Truth':list(y_test)})
confusion['binary_pred'] = (confusion['Pred'] > 0.5).astype(int)
```

[22]:
```
cm_DL = confusion_matrix(confusion['Truth'],confusion['binary_pred'])
cm_DL
```

[22]:
```
array([[4881,  977],
       [ 200, 5167]])
```

[23]:
```
plt.figure(figsize = (10,8))
sns.heatmap(cm_DL,cmap= "Blues", linecolor = 'black' , xticklabels =␣
 ↪['Fake','Real'] , yticklabels = ['Fake','Real'])
plt.xlabel("Predicted")
plt.ylabel("Actual")
```

[23]: Text(69.0, 0.5, 'Actual')

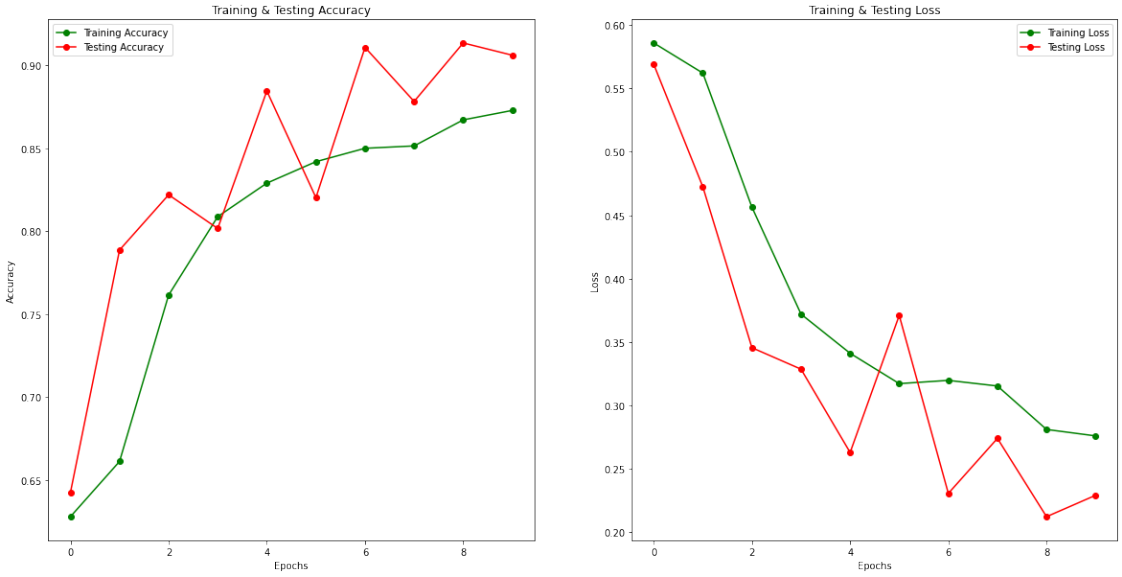


[ ]:
```
from tensorflow import keras
from tensorflow.keras import layers
#Defining Neural Network
model = Sequential()
#Non-trainable embeddidng layer
model.add(Embedding(max_features, output_dim=embed_size,␣
 ↪weights=[embedding_matrix], input_length=100, trainable=False))
#LSTM
model.add(LSTM(units=128 , return_sequences = True , recurrent_dropout = 0.25 ,␣
 ↪dropout = 0.25))
model.add(LSTM(units=64 , recurrent_dropout = 0.1 , dropout = 0.1))
model.add(Dense(units = 32 , activation = 'relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(optimizer=keras.optimizers.Adam(learning_rate = 0.01),␣
 ↪loss='binary_crossentropy', metrics=['accuracy'])
```

[17]:
```
# Model Analysis
print("Accuracy of the model on Training Data is - " , model.
 ↪evaluate(x_train,y_train)[1]*100 , "%")
print("Accuracy of the model on Testing Data is - " , model.
 ↪evaluate(X_test,y_test)[1]*100 , "%")
```

```
1053/1053 [==============================] - 29s 28ms/step - loss: 0.2320 -
accuracy: 0.9086
Accuracy of the model on Training Data is -  90.85617661476135 %
351/351 [==============================] - 14s 41ms/step - loss: 0.2291 -
accuracy: 0.9061
Accuracy of the model on Testing Data is -  90.61024785041809 %
```

[23]:
```
epochs = [i for i in range(10)]
fig , ax = plt.subplots(1,2)
train_acc = history.history['accuracy']
train_loss = history.history['loss']
val_acc = history.history['val_accuracy']
val_loss = history.history['val_loss']

fig.set_size_inches(20,10)

ax[0].plot(epochs , train_acc , 'go-' , label = 'Training Accuracy')
ax[0].plot(epochs , val_acc , 'ro-' , label = 'Testing Accuracy')
ax[0].set_title('Training & Testing Accuracy')
ax[0].legend()
ax[0].set_xlabel("Epochs")
ax[0].set_ylabel("Accuracy")

ax[1].plot(epochs , train_loss , 'go-' , label = 'Training Loss')
ax[1].plot(epochs , val_loss , 'ro-' , label = 'Testing Loss')
ax[1].set_title('Training & Testing Loss')
ax[1].legend()
ax[1].set_xlabel("Epochs")
ax[1].set_ylabel("Loss")
plt.show()
```



[48]:
```
pred = model.predict(X_test)
pred[:5]
```

[48]:
```
array([[5.1491559e-02],
       [7.5027813e-08],
       [6.7804095e-08],
       [1.5647142e-06],
       [9.8565006e-01]], dtype=float32)
```

[49]:
```
pred = list(pred)
test_result = []
for i in range(len(pred)):
    test_result.append(pred[i][0])
```

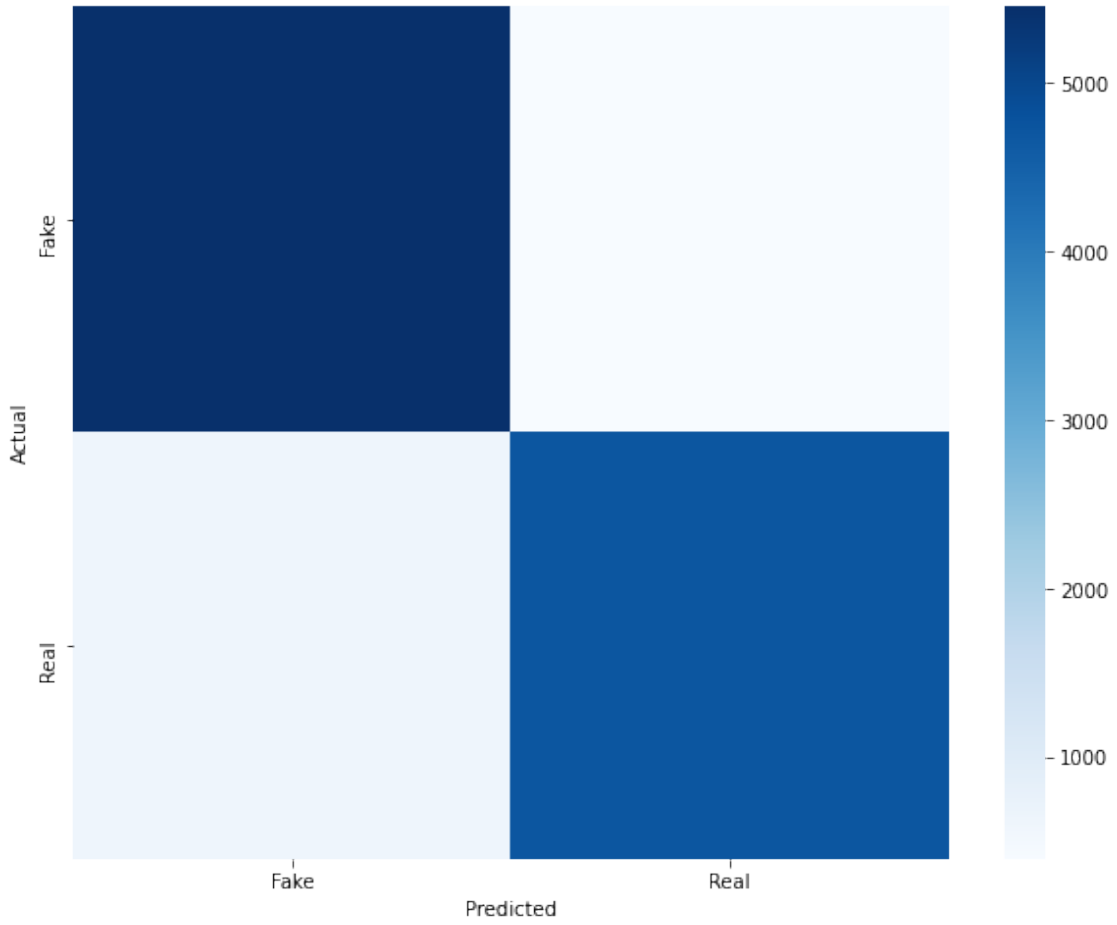
[50]:
```
confusion = pd.DataFrame({'Pred':test_result, 'Truth':list(y_test)})
confusion['binary_pred'] = (confusion['Pred'] > 0.5).astype(int)
```

[63]:
```
cm_DL = confusion_matrix(confusion['Truth'],confusion['binary_pred'])
cm_DL
```

[63]:
```
array([[5458,  400],
       [ 654, 4713]])
```

[64]:
```
plt.figure(figsize = (10,8))
sns.heatmap(cm_DL,cmap= "Blues", linecolor = 'black' , xticklabels =␣
↪['Fake','Real'] , yticklabels = ['Fake','Real'])
plt.xlabel("Predicted")
plt.ylabel("Actual")
```

[64]: Text(69.0, 0.5, 'Actual')



[28]:
```
pip install joblib
```

```
Requirement already satisfied: joblib in
/Users/yuechenjiang/opt/anaconda3/lib/python3.8/site-packages (0.16.0)
Note: you may need to restart the kernel to use updated packages.
```

[2]:
```
import os
import clean
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import nltk
from sklearn.preprocessing import LabelBinarizer
from nltk.corpus import stopwords
from nltk.stem.porter import PorterStemmer
```

```
from wordcloud import WordCloud,STOPWORDS
from nltk.stem import WordNetLemmatizer
from nltk.tokenize import word_tokenize,sent_tokenize
import re,string,unicodedata
from keras.preprocessing import text, sequence
from sklearn.metrics import␣
 ↪classification_report,confusion_matrix,accuracy_score
from sklearn.model_selection import train_test_split
import keras
from keras.models import Sequential
from keras.layers import Dense,Embedding,LSTM,Dropout
import tensorflow as tf
```

[3]:
```
df = pd.read_csv('/Users/yuechenjiang/Desktop/project660/code-data/combined.
 ↪csv')

# fix random seed for reproducibility
# load the dataset but only keep the top n words, zero the rest
top_words = 10000
# truncate and pad input sequences
max_review_length = 80
X_train,X_test,y_train,y_test = train_test_split(df.text,df.
 ↪category,random_state = 0)

print('Pad sequences (samples x time)')
tokenizer = text.Tokenizer(num_words=top_words)
tokenizer.fit_on_texts(X_train)
tokenized_train = tokenizer.texts_to_sequences(X_train)
X_train = sequence.pad_sequences(tokenized_train, max_review_length)

tokenized_test = tokenizer.texts_to_sequences(X_test)
X_test = sequence.pad_sequences(tokenized_test, max_review_length)

x_train = keras.preprocessing.sequence.pad_sequences(X_train,␣
 ↪maxlen=max_review_length)
x_test = keras.preprocessing.sequence.pad_sequences(X_test,␣
 ↪maxlen=max_review_length)
print('x_train shape:', x_train.shape)
print('x_test shape:', x_test.shape)
```

```
Pad sequences (samples x time)
x_train shape: (33673, 80)
x_test shape: (11225, 80)
```

[4]:
```
class RNN(keras.Model):
    def __init__(self, units, num_classes, num_layers):
        super(RNN, self).__init__()
```

```
        self.rnn = keras.layers.LSTM(units,return_sequences = True)
        self.rnn2 = keras.layers.LSTM(units)

        # have 1000 words totally, every word will be embedding into 100 length␣
↪vector
        # the max sentence lenght is 80 words
        self.embedding = keras.layers.Embedding(top_words, 100,␣
↪input_length=max_review_length)
        self.fc = keras.layers.Dense(1)

    def call(self, inputs, training=None, mask=None):

        x = self.embedding(inputs)

        x = self.rnn(x)
        x = self.rnn2(x)

        x = self.fc(x)
        print(x.shape)

        return x
```

[16]:
```
from tensorflow import keras
from tensorflow.keras import layers
if __name__ == '__main__':
    units = 64
    num_classes = 2
    batch_size = 32
    epochs = 10

    model = RNN(units, num_classes, num_layers=2)


    model.compile(optimizer=keras.optimizers.Adam(0.001),
                  loss=keras.losses.BinaryCrossentropy(from_logits=True),
                  metrics=['accuracy'])

    learning_rate_reduction = ReduceLROnPlateau(monitor='val_accuracy',␣
↪patience = 2, verbose=1,factor=0.5, min_lr=0.00001)
    # train
    history = model.fit(x_train, y_train, batch_size=batch_size, epochs=epochs,
              validation_data=(x_test, y_test), verbose=1, callbacks =␣
↪[learning_rate_reduction])

    # evaluate on test set
    scores = model.evaluate(x_test, y_test, batch_size, verbose=1)
```

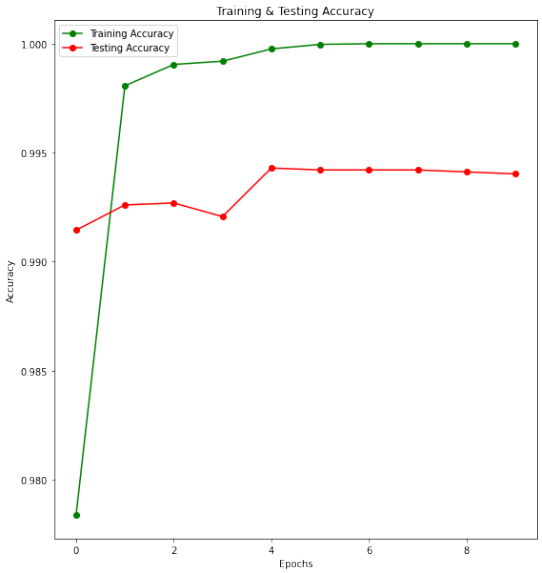
```
    print("Final test loss and accuracy :", scores)
```

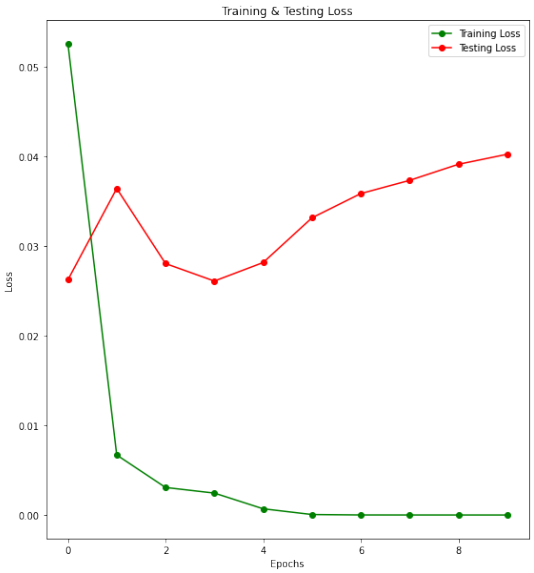
```
Epoch 1/10
(None, 1)
(None, 1)
1053/1053 [==============================] - ETA: 0s - loss: 0.0525 - accuracy:
0.9784(None, 1)
1053/1053 [==============================] - 67s 61ms/step - loss: 0.0525 -
accuracy: 0.9784 - val_loss: 0.0262 - val_accuracy: 0.9914
Epoch 2/10
1053/1053 [==============================] - 87s 83ms/step - loss: 0.0067 -
accuracy: 0.9981 - val_loss: 0.0364 - val_accuracy: 0.9926
Epoch 3/10
1053/1053 [==============================] - 78s 74ms/step - loss: 0.0031 -
accuracy: 0.9990 - val_loss: 0.0280 - val_accuracy: 0.9927
Epoch 4/10
1053/1053 [==============================] - 87s 83ms/step - loss: 0.0024 -
accuracy: 0.9992 - val_loss: 0.0261 - val_accuracy: 0.9921

Epoch 00004: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
Epoch 5/10
1053/1053 [==============================] - 83s 79ms/step - loss: 6.9677e-04 -
accuracy: 0.9998 - val_loss: 0.0281 - val_accuracy: 0.9943
Epoch 6/10
1053/1053 [==============================] - 85s 81ms/step - loss: 5.5685e-05 -
accuracy: 1.0000 - val_loss: 0.0331 - val_accuracy: 0.9942
Epoch 7/10
1053/1053 [==============================] - 96s 91ms/step - loss: 7.2388e-06 -
accuracy: 1.0000 - val_loss: 0.0358 - val_accuracy: 0.9942

Epoch 00007: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
Epoch 8/10
1053/1053 [==============================] - 91s 87ms/step - loss: 4.3196e-06 -
accuracy: 1.0000 - val_loss: 0.0373 - val_accuracy: 0.9942
Epoch 9/10
1053/1053 [==============================] - 102s 97ms/step - loss: 3.0631e-06 -
accuracy: 1.0000 - val_loss: 0.0391 - val_accuracy: 0.9941

Epoch 00009: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
Epoch 10/10
1053/1053 [==============================] - 91s 86ms/step - loss: 2.2539e-06 -
accuracy: 1.0000 - val_loss: 0.0402 - val_accuracy: 0.9940
351/351 [==============================] - 6s 17ms/step - loss: 0.0402 -
accuracy: 0.9940
Final test loss and accuracy : [0.04021625220775604, 0.9940311908721924]
```

[17]:
```
# Model Analysis
print("Accuracy of the model on Training Data is - " , model.
 ↪evaluate(x_train,y_train)[1]*100 , "%")
print("Accuracy of the model on Testing Data is - " , model.
 ↪evaluate(x_test,y_test)[1]*100 , "%")
```

```
1053/1053 [==============================] - 16s 15ms/step - loss: 1.9811e-06 -
accuracy: 1.0000
Accuracy of the model on Training Data is -  100.0 %
351/351 [==============================] - 5s 14ms/step - loss: 0.0402 -
accuracy: 0.9940
Accuracy of the model on Testing Data is -  99.40311908721924 %
```

[19]:
```
# visualiz training and testing accuracy and loss
epochs = [i for i in range(10)]
fig , ax = plt.subplots(1,2)
train_acc = history.history['accuracy']
train_loss = history.history['loss']
val_acc = history.history['val_accuracy']
val_loss = history.history['val_loss']

fig.set_size_inches(20,10)

ax[0].plot(epochs , train_acc , 'go-' , label = 'Training Accuracy')
ax[0].plot(epochs , val_acc , 'ro-' , label = 'Testing Accuracy')
ax[0].set_title('Training & Testing Accuracy')
ax[0].legend()
ax[0].set_xlabel("Epochs")
ax[0].set_ylabel("Accuracy")

ax[1].plot(epochs , train_loss , 'go-' , label = 'Training Loss')
ax[1].plot(epochs , val_loss , 'ro-' , label = 'Testing Loss')
ax[1].set_title('Training & Testing Loss')
ax[1].legend()
ax[1].set_xlabel("Epochs")
ax[1].set_ylabel("Loss")
plt.show()
```





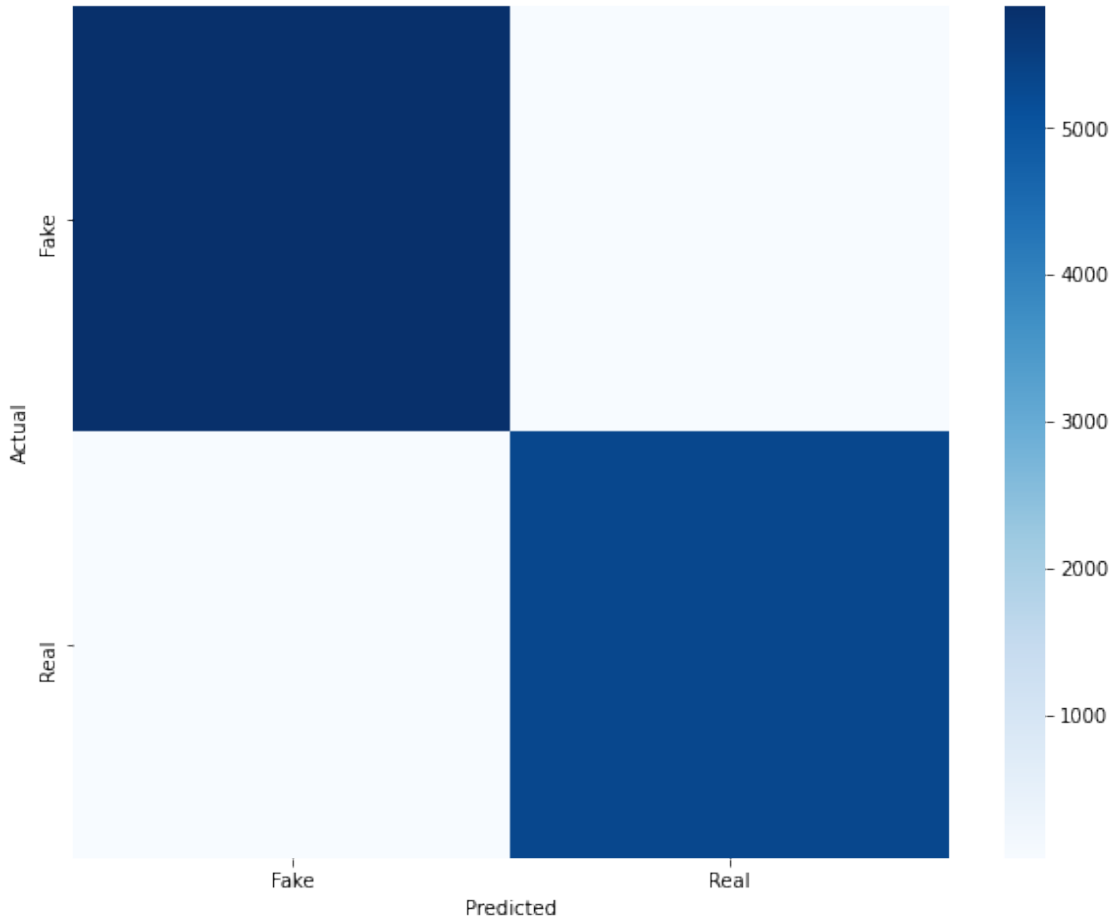
[20]:
```
pred = model.predict(x_test)
pred[:5]
```

```
(None, 1)
```

[20]:
```
array([[ -9.85934 ],
       [-14.818675],
       [-15.005421],
       [-14.802459],
       [ 13.948413]], dtype=float32)
```

[21]:
```
pred = list(pred)
test_result = []
for i in range(len(pred)):
    test_result.append(pred[i][0])

confusion = pd.DataFrame({'Pred':test_result, 'Truth':list(y_test)})
confusion['binary_pred'] = (confusion['Pred'] > 0.5).astype(int)

cm_DL = confusion_matrix(confusion['Truth'],confusion['binary_pred'])

plt.figure(figsize = (10,8))
sns.heatmap(cm_DL,cmap= "Blues", linecolor = 'black' , xticklabels =␣
 ↪['Fake','Real'] , yticklabels = ['Fake','Real'])
plt.xlabel("Predicted")
plt.ylabel("Actual")
```

[21]:
```
Text(69.0, 0.5, 'Actual')
```



[22]:
```
cm_DL
```

[22]:
```
array([[5834,   24],
       [  43, 5324]])
```