```
#importing the necessary libraries
import numpy as np
import pandas as pd

from sklearn.preprocessing import LabelEncoder

import matplotlib.pyplot as plt

import nltk

import seaborn as sns

from nltk.corpus import stopwords

import string

from nltk.stem import PorterStemmer

from wordcloud import WordCloud

from collections import Counter

from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer

from sklearn.model_selection import train_test_split

from sklearn.naive_bayes import GaussianNB, MultinomialNB, BernoulliNB

from sklearn.metrics import accuracy_score, precision_score, confusion_matrix


#reading the CSV file
x = pd.read_csv("sms-spam.csv")

#displaying the dataframe
x
```

	v1	v2	Unnamed: 2	Unnamed: 3	Unnamed: 4
0	ham	Go until jurong point, crazy.. Available only ...	NaN	NaN	NaN
1	ham	Ok lar... Joking wif u oni...	NaN	NaN	NaN
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...	NaN	NaN	NaN
3	ham	U dun say so early hor... U c already then say...	NaN	NaN	NaN
4	ham	Nah I don't think he goes to usf, he lives aro...	NaN	NaN	NaN
...	...	...	...	...	...
5567	spam	This is the 2nd time we have tried 2 contact u...	NaN	NaN	NaN
5568	ham	Will Ì_ b going to esplanade fr home?	NaN	NaN	NaN
5569	ham	Pity, * was in mood for that. So...any other s...	NaN	NaN	NaN
5570	ham	The guy did some bitching but I acted like i'd...	NaN	NaN	NaN
5571	ham	Rofl. Its true to its name	NaN	NaN	NaN

5572 rows × 5 columns

```
#dataset size - 5572 rows x 5 columns
x.shape
```

```
(5572, 5)
```

Data Cleaning

```
#printing the concise summary of the dataset
x.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5572 entries, 0 to 5571
Data columns (total 5 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   v1          5572 non-null   object
 1   v2          5572 non-null   object
 2   Unnamed: 2  50 non-null     object
 3   Unnamed: 3  12 non-null     object
 4   Unnamed: 4  6 non-null      object
```

```
dtypes: object(5)
memory usage: 217.8+ KB
```

```
#column 2, 3, 4 have majority missing values, so it is better to drop them.
x.drop(columns=['Unnamed: 2', 'Unnamed: 3', 'Unnamed: 4'], inplace = True)

#displaying the edited dataframe
x
```

	v1	v2
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...
...	...	...
5567	spam	This is the 2nd time we have tried 2 contact u...
5568	ham	Will Ì_ b going to esplanade fr home?
5569	ham	Pity, * was in mood for that. So...any other s...
5570	ham	The guy did some bitching but I acted like i'd...
5571	ham	Rofl. Its true to its name

5572 rows × 2 columns

```
#renaming the column names to a better and meaningful column name
x.rename(columns = {'v1':'result', 'v2':'input'}, inplace=True)

#displaying the edited dataframe
x
```

	result	input
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...
...	...	...
5567	spam	This is the 2nd time we have tried 2 contact u...
5568	ham	Will Ì_ b going to esplanade fr home?
5569	ham	Pity, * was in mood for that. So...any other s...
5570	ham	The guy did some bitching but I acted like i'd...
5571	ham	Rofl. Its true to its name

5572 rows × 2 columns

```
#result has categorical labels, we need to convert it into numerical values - enbcoding
#for that we will be using 'LabelEncoder' from sklearn


encoder = LabelEncoder()
x['result'] = encoder.fit_transform(x['result'])

#displaying the edited dataframe
x.head()
```

	result	input
0	0	Go until jurong point, crazy.. Available only ...
1	0	Ok lar... Joking wif u oni...
2	1	Free entry in 2 a wkly comp to win FA Cup fina...
3	0	U dun say so early hor... U c already then say...
4	0	Nah I don't think he goes to usf, he lives aro...

```
#so 0 means no SPAM, 1 means SPAM


#check if there is any NULL value
x.isnull().sum()
```

```
result    0
input     0
dtype: int64
```

```
#the dataset has NO null values, so don't need to handle them


#check if there is any DUPLICATE values
x.duplicated().sum()
```

```
403
```

```
#the dataset has DUPLICATE values, so we will have to REMOVE them
x = x.drop_duplicates(keep='first')

#displaying the edited dataframe
x
```

	result	input
0	0	Go until jurong point, crazy.. Available only ...
1	0	Ok lar... Joking wif u oni...
2	1	Free entry in 2 a wkly comp to win FA Cup fina...
3	0	U dun say so early hor... U c already then say...
4	0	Nah I don't think he goes to usf, he lives aro...
...	...	...
5567	1	This is the 2nd time we have tried 2 contact u...
5568	0	Will Ì_ b going to esplanade fr home?
5569	0	Pity, * was in mood for that. So...any other s...
5570	0	The guy did some bitching but I acted like i'd...
5571	0	Rofl. Its true to its name

5169 rows × 2 columns

```
#rows reduced from 5572 to 5169 after DUPLICATED values have been deleted
```

EDA - Exploratory Data Analysis

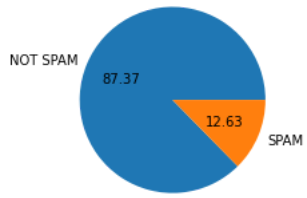
```
#the given problem is a classification problem, so we need to understand the data first by performing EDA.
#the dataset has only 2 columns, so less analysis required.


#checking the number of SPAM vs not SPAM messages
x['result'].value_counts()
```

```
0    4516
1     653
Name: result, dtype: int64
```

```
#out of 5169 datavalues, 653 are SPAM


653*100.0/5169
```

```
12.633004449603405
```

```
#12.63% is SPAM and 87.37% is not SPAM


#for better representation, we can use PIE CHART to represent it.
#PIE CHARTS can be created using matplotlib library

plt.pie(x['result'].value_counts(),  labels = ['NOT SPAM', 'SPAM'], autopct = '%0.2f', radius = 0.8)
plt.show()
```




```
#hence, highly IMBALANCED DATA


#now we will be analysing the number of alphabets/words/sentences being used in the TEXT
#for this, will create 3 new columns: (1) no. of characters (2) no. of words (3) no. of sentences in SMS

#using 'nltk' library for this.
#Natural Language Toolkit for text processing
#(pip install nltk)


#downloading the dependencies
#punkt package includes pre-trained models for tokenizing text in many languages

nltk.download('punkt')
```

```
[nltk_data] Error loading punkt: <urlopen error [WinError 10061] No
[nltk_data]     connection could be made because the target machine
[nltk_data]     actively refused it>
False
```

```
#creating a new column with count of characters
x['countCharacters'] = x['input'].apply(len)

#creating a new column with count of words
x['countWords'] = x['input'].apply(lambda i:len(nltk.word_tokenize(i)))
#'word_tokenize' function takes a string of text as input and returns a list of words

#creating a new column with count of sentences
x['countSentences'] = x['input'].apply(lambda i:len(nltk.sent_tokenize(i)))
#'sent_tokenize' function takes a string of text as input and returns a list of sentences
```

```
C:\Users\codes\AppData\Local\Temp\ipykernel_37516\3785843795.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  x['countCharacters'] = x['input'].apply(len)
C:\Users\codes\AppData\Local\Temp\ipykernel_37516\3785843795.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  x['countWords'] = x['input'].apply(lambda i:len(nltk.word_tokenize(i)))
C:\Users\codes\AppData\Local\Temp\ipykernel_37516\3785843795.py:9: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  x['countSentences'] = x['input'].apply(lambda i:len(nltk.sent_tokenize(i)))
```

```
#displaying the edited dataframe with the 3 new columns added
x.head()
```

	result	input	countCharacters	countWords	countSentences
0	0	Go until jurong point, crazy.. Available only ...	111	24	2
1	0	Ok lar... Joking wif u oni...	29	8	2
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	37	2
3	0	U dun say so early hor... U c already then say...	49	13	1
4	0	Nah I don't think he goes to usf, he lives aro...	61	15	1

```
#extracting the 5 number summary of the 3 new column values
x[['countCharacters', 'countWords', 'countSentences']].describe()
```

	countCharacters	countWords	countSentences
count	5169.000000	5169.000000	5169.000000
mean	78.977945	18.453279	1.947185
std	58.236293	13.324793	1.362406
min	2.000000	1.000000	1.000000
25%	36.000000	9.000000	1.000000
50%	60.000000	15.000000	1.000000
75%	117.000000	26.000000	2.000000
max	910.000000	220.000000	28.000000

```
#extracting the same summaries, classified on the basis of SPAM and not SPAM


#for not SPAM
x[x['result'] == 0][['countCharacters', 'countWords', 'countSentences']].describe()
```

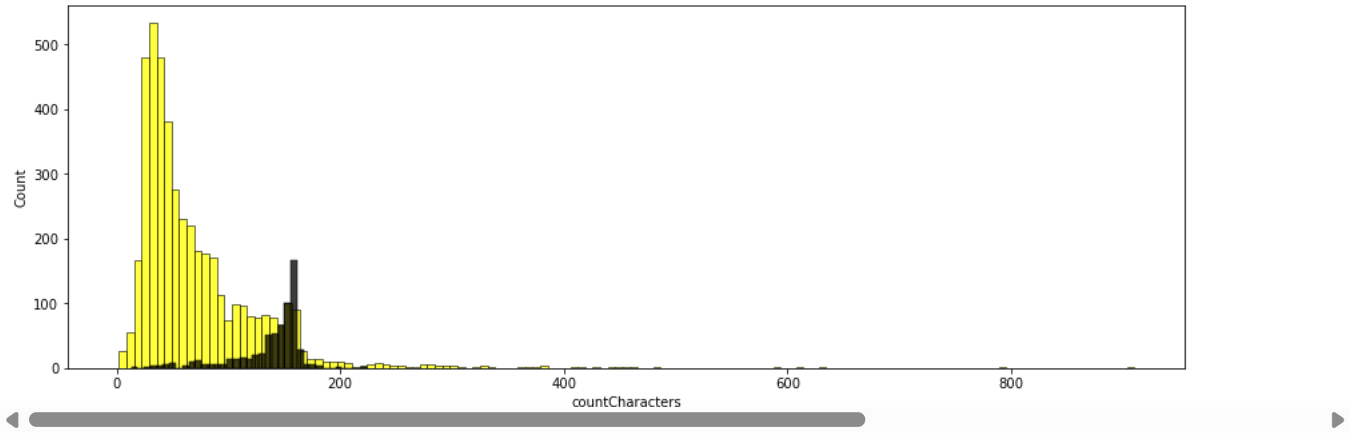
	countCharacters	countWords	countSentences
count	4516.000000	4516.000000	4516.000000
mean	70.459256	17.120903	1.799601
std	56.358207	13.493725	1.278465
min	2.000000	1.000000	1.000000
25%	34.000000	8.000000	1.000000
50%	52.000000	13.000000	1.000000
75%	90.000000	22.000000	2.000000
max	910.000000	220.000000	28.000000

```
#for SPAM
x[x['result'] == 1][['countCharacters', 'countWords', 'countSentences']].describe()
```

	countCharacters	countWords	countSentences
count	653.000000	653.000000	653.000000
mean	137.891271	27.667688	2.967841
std	30.137753	7.008418	1.483201
min	13.000000	2.000000	1.000000
25%	132.000000	25.000000	2.000000
50%	149.000000	29.000000	3.000000
75%	157.000000	32.000000	4.000000
max	224.000000	46.000000	8.000000

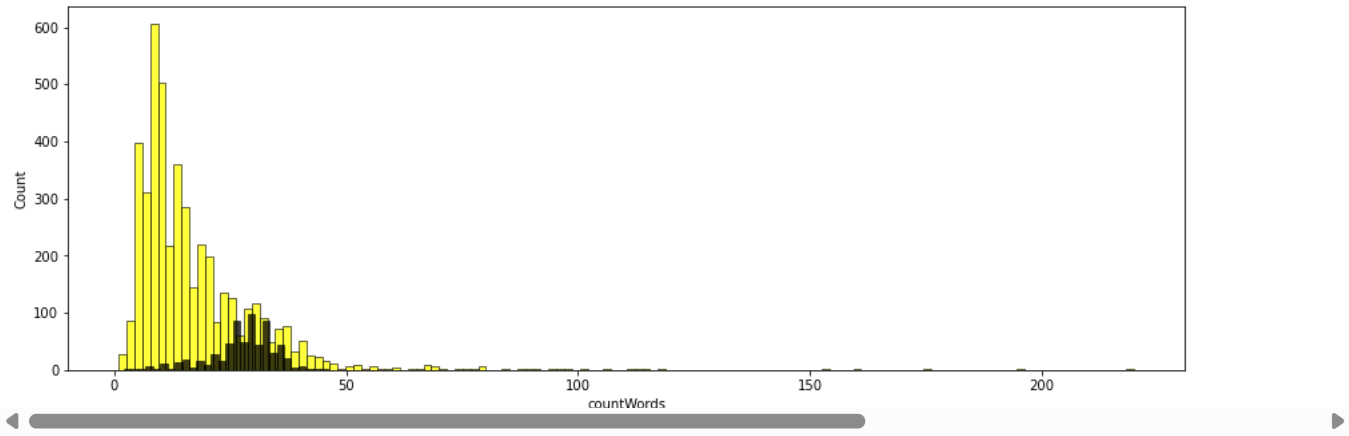
```
#for better visualization, we will plot a histogram using 'seaborn'
plt.figure(figsize = (15, 5))
sns.histplot(x[x['result'] == 0]['countCharacters'], color = "yellow")
sns.histplot(x[x['result'] == 1]['countCharacters'], color = "black")

#black -> SPAM, yellow -> not SPAM
```

```
<AxesSubplot:xlabel='countCharacters', ylabel='Count'>
```



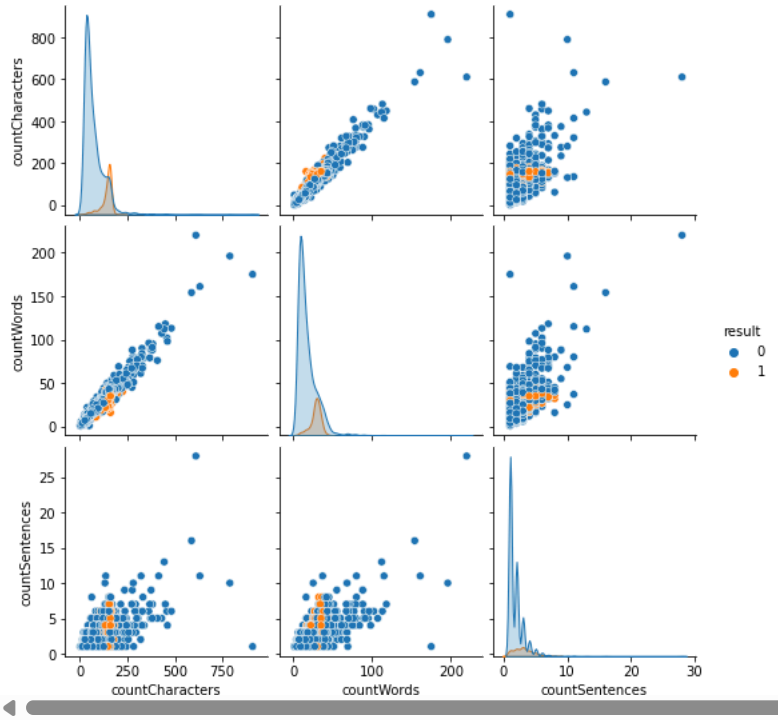

```
plt.figure(figsize = (15, 5))
sns.histplot(x[x['result'] == 0]['countWords'], color = "yellow")
sns.histplot(x[x['result'] == 1]['countWords'], color = "black")

#black -> SPAM, yellow -> not SPAM
```

```
<AxesSubplot:xlabel='countWords', ylabel='Count'>
```




```
#observation : SPAM messages have more no of characters used, mean is 137.89 for SPAM and 70.45 for not SPAM


#finding relationship between the columns
sns.pairplot(x, hue='result')
```

```
<seaborn.axisgrid.PairGrid at 0x22e85fb2f70>
```

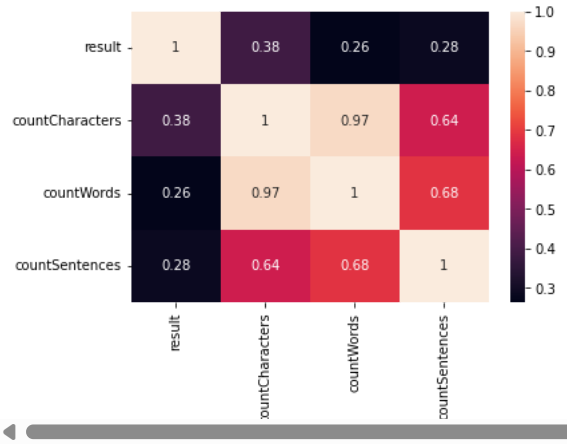



```
#find pearson's correlation coefficient
x.corr()
```

	result	countCharacters	countWords	countSentences
result	1.000000	0.384717	0.262984	0.284901
countCharacters	0.384717	1.000000	0.965770	0.638143
countWords	0.262984	0.965770	1.000000	0.684541
countSentences	0.284901	0.638143	0.684541	1.000000

```
#converting it into a heatmap
sns.heatmap(x.corr(), annot=True)
```

```
<AxesSubplot:>
```



```
#multi-collinearity in the dataset
#all new 3 columns are highly correlated with each other but countCharacters is correlated more with the 'result' than any other column
```

Data Preprocessing

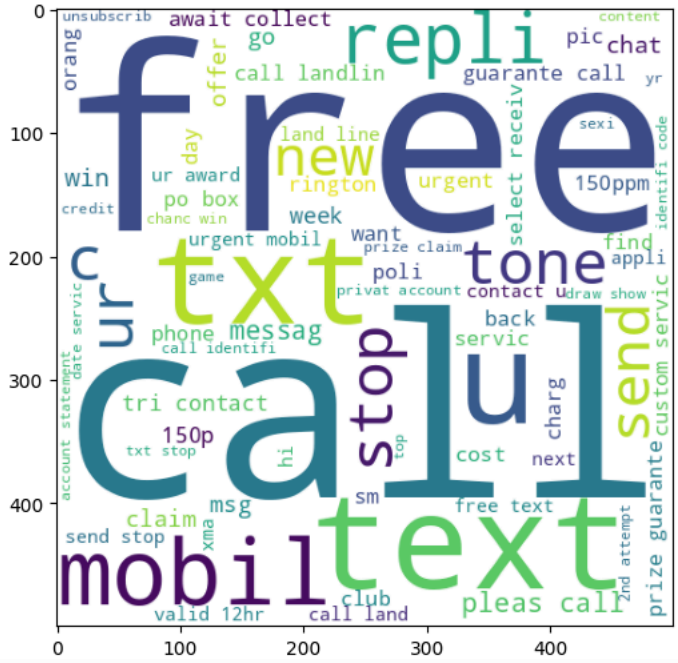
```
#peforming preprocessing such as tokenization (converting the text into tokens or words), removing special characters,
#removing stop words and punctuation and finallying stemming the data.
#also, converting to lower case first and then pre-processing the data


#downloading the package which contains the stopwords
nltk.download('stopwords')


def transform_text (text):

    #converting to lower case
    text = text.lower()

    #tokenization
    text = nltk.word_tokenize(text)

    #removing special characters
    removedSC = list()
    for i in text:
        if i.isalnum():
            removedSC.append(i)

    #updating the text after removed special characters
    text = removedSC[:]

    #removing stop words and punctuation characters
    removedSWPC = list()
    for i in text:
        #stopwords.words('english') is a function of 'nltk', returns list of english stop words
        #string.punctuation is a part of 'string' module, containing the ASCII punctuation characters
        if i not in stopwords.words('english') and i not in string.punctuation:
            removedSWPC.append(i)

    #updating the text after removed stop words and punctuation characters
    text = removedSWPC[:]

    #stemming the data using 'PorterStemmer' algorithm.
    #nltk module provides this class to use.
    ps = PorterStemmer()
    stemmed = list()
    for i in text:
        stemmed.append(ps.stem(i))

    text = stemmed[:]

    return " ".join(text)


#function for transforming the text is ready


#will create a new column to store the transformed text -> 'processed'
x['processed'] = x['input'].apply(transform_text)

#displaying the edited dataframe with a new column 'processed'
x.head()
```

```
C:\Users\codes\AppData\Local\Temp\ipykernel_37516\2432381459.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  x['processed'] = x['input'].apply(transform_text)
```

	result	input	countCharacters	countWords	countSentences	processed
0	0	Go until jurong point, crazy.. Available only ...	111	24	2	go jurong point crazi avail bugi n great world...
1	0	Ok lar... Joking wif u oni...	29	8	2	ok lar joke wif u oni
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	37	2	free entri 2 wkli comp win fa cup final tkt 21...
		U dun say so early hor... U c already then				

```
#will be creating word cloud for data visualization to display the most frequently occurring words in the processed dataset.
#using 'WordCloud' class

wc = WordCloud(width=500, height=500, min_font_size=10, background_color='white')


#creating a wordcloud for the SPAM messages
spamWC = wc.generate(x[x['result'] == 1]['processed'].str.cat(sep=" "))

#creating figure and displaying
plt.figure(figsize=(12, 6))
plt.imshow(spamWC)
```

```
<matplotlib.image.AxesImage at 0x7ff800663550>
```




```
#creating a wordcloud for the not SPAM messages
spamWC = wc.generate(x[x['result'] == 0]['processed'].str.cat(sep=" "))

#creating figure and displaying
plt.figure(figsize=(12, 6))
plt.imshow(spamWC)
```

```
<matplotlib.image.AxesImage at 0x7ff8005bc0d0>
```


```
#extracting the most common words used in both SPAM and not SPAM messages


#extracting all the words used in SPAM messages
spamWords = list()

for msg in x[x['result'] == 1]['processed'].tolist():
  for word in msg.split():
    spamWords.append(word)

spamWords
```

```
['free',
 'entri',
 '2',
 'wkli',
 'comp',
 'win',
 'fa',
 'cup',
 'final',
 'tkt',
 '21st',
 'may',
 'text',
 'fa',
 '87121',
 'receiv',
 'entri',
 'question',
 'std',
 'txt',
 'rate',
 'c',
 'appli',
 '08452810075over18',
 'freemsg',
 'hey',
 'darl',
 '3',
 'week',
 'word',
 'back',
 'like',
 'fun',
 'still',
 'tb',
 'ok',
 'xxx',
 'std',
 'chg',
 'send',
 'rcv',
 'winner',
 'valu',
 'network',
 'custom',
```

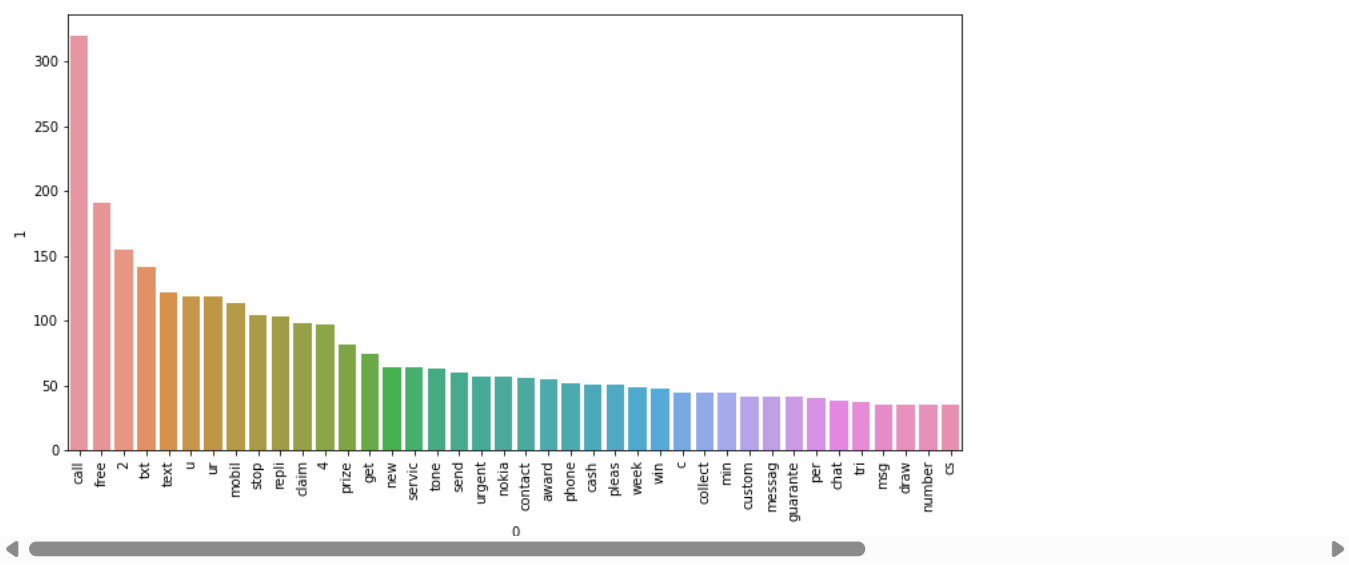
```
        'select',
        'receivea',
        'prize',
        'reward',
        'claim',
        'call',
        'claim',
        'code',
        'kl341',
        'valid',
        '12',
        'hour',
        'mobil',
```

```
#to count the frequency of the words, we will be using the Counter class to create a dictionary
spamWordsDictionary = Counter(spamWords)

#to extract the most common words
spamWordsDictionary.most_common(40)
```

```
[('call', 320),
 ('free', 191),
 ('2', 155),
 ('txt', 141),
 ('text', 122),
 ('u', 119),
 ('ur', 119),
 ('mobil', 114),
 ('stop', 104),
 ('repli', 103),
 ('claim', 98),
 ('4', 97),
 ('prize', 82),
 ('get', 74),
 ('new', 64),
 ('servic', 64),
 ('tone', 63),
 ('send', 60),
 ('urgent', 57),
 ('nokia', 57),
 ('contact', 56),
 ('award', 55),
 ('phone', 52),
 ('cash', 51),
 ('pleas', 51),
 ('week', 49),
 ('win', 48),
 ('c', 45),
 ('collect', 45),
 ('min', 45),
 ('custom', 42),
 ('messag', 42),
 ('guarante', 42),
 ('per', 41),
 ('chat', 38),
 ('tri', 37),
 ('msg', 35),
 ('draw', 35),
 ('number', 35),
 ('cs', 35)]
```

```
#converting this dictionary to a dataframe
mostCommonSPAM = pd.DataFrame(spamWordsDictionary.most_common(40))
```

```
#plotting a bar plot of the mostCommonSPAM dataframe
plt.figure(figsize=(12, 6))
sns.barplot(data = mostCommonSPAM, x=0, y=1)
plt.xticks(rotation='vertical')
plt.show()
```



#words like 'CALL', 'FREE', '2', 'TXT', 'TEXT', 'UR', 'MOBIL' are the most common words in SPAM texts

Model Building

#NaiveBayes classifier works BEST on textual data, so will firstly perform it on the dataset.

#we need to give numerical inputs to the classifier model, so will have to convert the 'processed' column into vectors.
#using 'bag of words'

#converting the collection of text into a matrix of token counts
cv = CountVectorizer()

#transforming the data of processed column
X = cv.fit_transform(x['processed']).toarray()

#printing size of X
X.shape

(5169, 6708)

#storing the values of the 'result' column
y = x['result'].values
y

array([0, 0, 1, ..., 0, 0, 0])

#splitting the training and testing dataset
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2, random_state = 49)

#creating the objects for the models
gnb = GaussianNB()
mnb = MultinomialNB()
bnb = BernoulliNB()

#training the dataset for GaussianNB
gnb.fit(X_train, y_train)
y_pred1 = gnb.predict(X_test)
print(accuracy_score(y_test, y_pred1))
print(confusion_matrix(y_test, y_pred1))
print(precision_score(y_test, y_pred1))

0.8617021276595744
[[774 125]

```
 [ 18 117]]
0.4834710743801653
```

```
#training the dataset for MultinomialnNB
mnb.fit(X_train, y_train)
y_pred2 = mnb.predict(X_test)
print(accuracy_score(y_test, y_pred2))
print(confusion_matrix(y_test, y_pred2))
print(precision_score(y_test, y_pred2))
```

```
0.9700193423597679
[[882  17]
 [ 14 121]]
0.8768115942028986
```

```
#training the dataset for BernoulliNB
bnb.fit(X_train, y_train)
y_pred3 = bnb.predict(X_test)
print(accuracy_score(y_test, y_pred3))
print(confusion_matrix(y_test, y_pred3))
print(precision_score(y_test, y_pred3))
```

```
0.9642166344294004
[[893   6]
 [ 31 104]]
0.9454545454545454
```

```
#we have to focus mainly on 'precision' value
#the max precision we got is 9.45 with 9.64 as accuracy
```

```
#using 'TfidfVectorizer' for vectorization
tf = TfidfVectorizer()

#transforming the data of processed column
X = tf.fit_transform(x['processed']).toarray()

#storing the values of the 'result' column
y = x['result'].values

#splitting the training and testing dataset
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2, random_state = 49)
```

```
#training the dataset for GaussianNB
gnb.fit(X_train, y_train)
y_pred1 = gnb.predict(X_test)
print(accuracy_score(y_test, y_pred1))
print(confusion_matrix(y_test, y_pred1))
print(precision_score(y_test, y_pred1))
```

```
0.8597678916827853
[[775 124]
 [ 21 114]]
0.4789915966386555
```

```
#training the dataset for MultinomialnNB
mnb.fit(X_train, y_train)
y_pred2 = mnb.predict(X_test)
print(accuracy_score(y_test, y_pred2))
print(confusion_matrix(y_test, y_pred2))
print(precision_score(y_test, y_pred2))
```

```
0.9574468085106383
[[899   0]
 [ 44  91]]
1.0
```

```
#training the dataset for BernoulliNB
bnb.fit(X_train, y_train)
y_pred3 = bnb.predict(X_test)
print(accuracy_score(y_test, y_pred3))
print(confusion_matrix(y_test, y_pred3))
print(precision_score(y_test, y_pred3))
```

```
0.9642166344294004
[[893   6]
 [ 31 104]]
0.9454545454545454
```

```
#as data is IMBALANCED, precision score matters more than accuracy.
#using TfidfVectorizer method, we get precision score = 1 for MultinomialNB
#so we will use this only


#trying out different CLASSIFIER model for the BEST predictions
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.naive_bayes import MultinomialNB
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import ExtraTreesClassifier
from sklearn.ensemble import GradientBoostingClassifier


#creating objects of the classifier models
svc = SVC(kernel='sigmoid', gamma=1.0)
knc = KNeighborsClassifier()
mnb = MultinomialNB()
dtc = DecisionTreeClassifier(max_depth=5)
lrc = LogisticRegression(solver='liblinear', penalty='l1')
rfc = RandomForestClassifier(n_estimators=50, random_state=2)
abc = AdaBoostClassifier(n_estimators=50, random_state=2)
bc = BaggingClassifier(n_estimators=50, random_state=2)
etc = ExtraTreesClassifier(n_estimators=50, random_state=2)
gbdt = GradientBoostingClassifier(n_estimators=50,random_state=2)


#creating a dictionary that maps short names to the corresponding classification models.
clfs = {
    'SVC' : svc,
    'KN' : knc,
    'NB': mnb,
    'DT': dtc,
    'LR': lrc,
    'RF': rfc,
    'AdaBoost': abc,
    'BgC': bc,
    'ETC': etc,
    'GBDT':gbdt,
}


#creating a function which uses train test split data and performing on model and returning the scores
def train_classifier(clf,X_train,y_train,X_test,y_test):
    clf.fit(X_train,y_train)
    y_pred = clf.predict(X_test)
    accuracy = accuracy_score(y_test,y_pred)
    precision = precision_score(y_test,y_pred)

    return accuracy,precision


#taking each classifier algorithm, training and testing data, storing the score values and then printing for each
accuracy_scores = []
precision_scores = []

for name,clf in clfs.items():

    #calling the previously defined function
    current_accuracy,current_precision = train_classifier(clf, X_train,y_train,X_test,y_test)

    print("For ",name)
    print("Accuracy - ",current_accuracy)
    print("Precision - ",current_precision)

    accuracy_scores.append(current_accuracy)
    precision_scores.append(current_precision)
```

```
For  SVC
Accuracy -  0.960348162475822
Precision -  0.9519230769230769
For  KN
Accuracy -  0.8974854932301741
Precision -  1.0
For  NB
Accuracy -  0.9574468085106383
Precision -  1.0
For  DT
Accuracy -  0.9410058027079303
Precision -  0.8245614035087719
For  LR
```

```
Accuracy -  0.9458413926499033
Precision -  0.9072164948453608
For  RF
Accuracy -  0.9642166344294004
Precision -  1.0
For  AdaBoost
Accuracy -  0.9545454545454546
Precision -  0.9
For  BgC
Accuracy -  0.960348162475822
Precision -  0.873015873015873
For  ETC
Accuracy -  0.9709864603481625
Precision -  1.0
For  GBDT
Accuracy -  0.9497098646034816
Precision -  0.9191919191919192
```

```
#converting the accuracy and precision score values to a dataframe
#sorting on the basis of precision value
performance = pd.DataFrame({'Algorithm':clfs.keys(),'Accuracy':accuracy_scores,'Precision':precision_scores}).sort_values('Precision',as
performance
```

	Algorithm	Accuracy	Precision
1	KN	0.897485	1.000000
2	NB	0.957447	1.000000
5	RF	0.964217	1.000000
8	ETC	0.970986	1.000000
0	SVC	0.960348	0.951923
9	GBDT	0.949710	0.919192
4	LR	0.945841	0.907216
6	AdaBoost	0.954545	0.900000
7	BgC	0.960348	0.873016
3	DT	0.941006	0.824561

```
#precision is 1, we need to maximize the accuracy score.
#try using the Voting classifier


#Voting classifier of NB, RF and ETC

#creating the objects for the classifier classes
mnb = MultinomialNB()
etc = ExtraTreesClassifier(n_estimators=50, random_state=2)
rfc = RandomForestClassifier(n_estimators=50, random_state=2)


#creating voting object
from sklearn.ensemble import VotingClassifier
voting = VotingClassifier(estimators=[('rf', rfc), ('nb', mnb), ('et', etc)],voting='soft')


#training the data
voting.fit(X_train,y_train)
```