

# **BUILDING A SMARTER AI-POWERED SPAM CLASSIFIER**

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## **PHASE 2- DOCUMENTATION**

### **Project: Building a Smarter AI-Powered Spam Classifier**

**Abstract:-** Spam Classification using Artificial Intelligence – For business purposes, email is the most widely utilized mode of official communication. Despite the availability of other forms of communication, email usage continues to rise. In today's world, automated email management is critical since the volume of emails grows by the day. More than 55 percent of all emails have been recognized as spam. This demonstrates that spammers waste email users' time and resources while producing no meaningful results. Spammers employ sophisticated and inventive strategies to carry out their criminal actions via spam emails. As a result, it is critical to comprehend the many spam email classification tactics and mechanisms. The main focus of this paper is on spam classification using machine learning algorithms. Furthermore, this research includes a thorough examination and evaluation of research on several machine learning methodologies and email properties used in various Machine Learning approaches. Future study goals and obstacles in the subject of spam classification are also discussed, which may be valuable to future researchers.

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**Objective: –**

Machine learning algorithms use statistical models to classify data. In the case of spam detection, a trained machine learning model must be able to determine whether the sequence of words found in an email is closer to those found in spam emails or safe ones.

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Introduction: –

For the majority of internet users, email has become the most often utilized formal communication channel. In recent years, there has been a surge in email usage, which has exacerbated the problems presented by spam emails. Spam, often known as junk email, is the act of sending unsolicited mass messages to a large number of people. ‘Ham’ refers to emails that are meaningful but of a different type. Every day, the average email user receives roughly 40-50 emails. Spammers earn roughly 3.5 million dollars per year from spam, resulting in financial damages on both a personal and institutional level. As a result, consumers devote a large amount of their working time to these emails. Spam is said to account for more than half of all email server traffic, sending out a vast volume of undesired and uninvited bulk emails.

They squander user resources on useless output, lowering productivity. Spammers use spam for marketing goals to spread malicious criminal acts such as identity theft, financial disruptions, stealing sensitive information, and reputational damage.

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The existing model of the system: –

Spam refers to the term, which is related to undesired content with low-quality information, Spam referred to the major drawback of mobile business. When comes to spam detection in the campus network they did the analysis using Incremental Learning. For Collecting Spam detection on web pages. Moreover Sending out a Spam message was also analyzed. Data Collection was done privately by a limited company. From the data Collection. There also anti-spam filter system was evolved. Many parallel and distributed computing system has also processed this spam system. Machine learning algorithm provides accurate result. Text Mining analysis done separates ham and spam separately.

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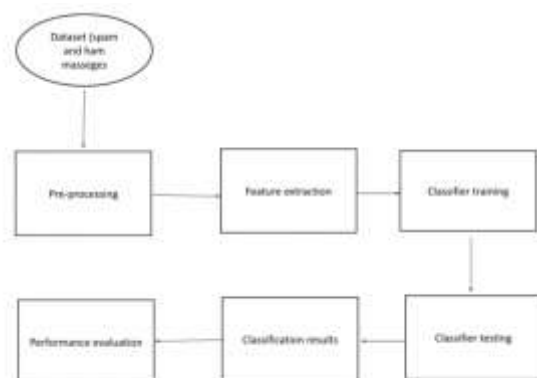
Proposed model of the system: –

As we look at spam detection systems that use Machine Learning (ML) techniques, it's vital to take a look at the history of ML in the field as well as the many methods that are now used to identify spam. Researchers have discovered that the content of spam emails, as well as their operational procedures, evolve with time. As a result, the tactics that are currently effective may become obsolete in the near future. The conceptual drift [8] is a term used to describe this occurrence. Machine Learning is an engineering approach that allows computational instruments to behave without being explicitly programmed. Because of the ML system's ability to evolve, limiting concept drift, this strategy is a significant help in detecting and combating spam.

In the next section, we'll go through a variety of machine learning techniques, approaches, and algorithms, as well as the benefits of each, using Supervised, Unsupervised, and Semi-Supervised Machine Learning algorithms Approaches.

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System Architecture: –



Spam classification using Artificial Intelligence

---

[illegible]

CODE:

```
import numpy as np
import pandas as pd
df = pd.read_csv('spam.csv')
df.sample(5)
```

```
Out[4]:
```

	v1	v2	Unnamed: 2	Unnamed: 3	Unnamed: 4
2464	ham	They will pick up and drop in car:so no problem..	NaN	NaN	NaN
1248	ham	HI HUN! IM NOT COMIN 2NITE-TELL EVERY1 IM SORR...	NaN	NaN	NaN
1413	spam	Dear U've been invited to XCHAT. This is our f...	NaN	NaN	NaN
2995	ham	They released vday shirts and when u put it on...	NaN	NaN	NaN
4458	spam	Welcome to UK-mobile-date this msg is FREE giv...	NaN	NaN	NaN

```
df.shape
(5572, 5)
```

# 1. Data Cleaning

```
In [6]: df.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
```

```
In [7]: # drop last 3 cols
df.drop(columns=['Unnamed: 2', 'Unnamed: 3', 'Unnamed: 4'], inplace=True)
```

```
In [8]: df.sample(5)
```

```
Out[8]:
```

	v1	v2
1947	ham	The battery is for mr adewale my uncle. Aka Egbon
2712	ham	Hey you still want to go for yogasana? Coz if ...
4428	ham	Hey they r not watching movie tonight so i'll ...
3944	ham	I will be gentle princess! We will make sweet ...
49	ham	U don't know how stubborn I am, I didn't even ...

```
In [9]: # renaming the cols
df.rename(columns={'v1':'target','v2':'text'},inplace=True)
df.sample(5)
```

```
Out[9]:
```

	target	text
1418	ham	Lmao. Take a pic and send it to me.
2338	ham	Alright, see you in a bit
88	ham	I'm really not up to it still tonight babe
3735	ham	How's the street where the end of library walk is?
3859	ham	Yep. I do like the pink furniture tho.

```
In [10]: from sklearn.preprocessing import LabelEncoder
encoder = LabelEncoder()
```

```
In [12]: df['target'] = encoder.fit_transform(df['target'])
```

```
In [13]: df.head()
```

```
Out[13]:
```

	target	text
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...

```
In [14]: # missing values  
df.isnull().sum()
```

```
Out[14]: target    0  
text          0  
dtype: int64
```

```
In [15]: # check for duplicate values  
df.duplicated().sum()
```

```
Out[15]: 403
```

```
In [17]: # remove duplicates  
df = df.drop_duplicates(keep='first')
```

```
In [18]: df.duplicated().sum()
```

```
Out[18]: 0
```

```
In [19]: df.shape
```

```
Out[19]: (5169, 2)
```



## 2.EDA

```
In [29]: df.head()
```

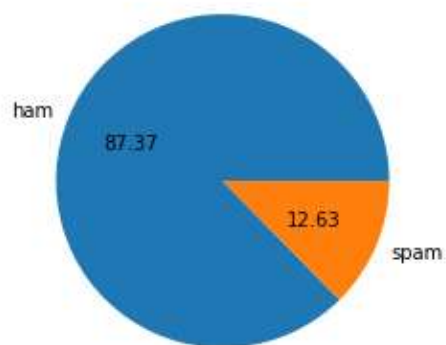
```
Out[29]:
```

	target	text
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...

```
In [31]: df['target'].value_counts()
```

```
Out[31]: 0    4516
         1     653
         Name: target, dtype: int64
```

```
In [33]: import matplotlib.pyplot as plt
plt.pie(df['target'].value_counts(), labels=['ham', 'spam'], autopct="%0.2f")
plt.show()
```



```
In [34]: # Data is imbalanced
```

```
In [35]: import nltk
```

```
In [ ]: !pip install nltk
```

```
In [37]: nltk.download('punkt')
```

```
[nltk_data] Downloading package punkt to  
[nltk_data] C:\Users\91842\AppData\Roaming\nltk_data...  
[nltk_data] Unzipping tokenizers\punkt.zip.
```

```
Out[37]: True
```

```
In [45]: df['num_characters'] = df['text'].apply(len)
```

```
In [46]: df.head()
```

```
Out[46]:
```

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

```
In [50]: # num of words
df['num_words'] = df['text'].apply(lambda x:len(nltk.word_tokenize(x)))
```

```
In [51]: df.head()
```

```
Out[51]:
```

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

```
In [53]: df['num_sentences'] = df['text'].apply(lambda x:len(nltk.sent_tokenize(x)))
```

```
In [54]: df.head()
```

```
Out[54]:
```

	target	text	num_characters	num_words	num_sentences
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

```
In [55]: df[['num_characters', 'num_words', 'num_sentences']].describe()
```

```
Out[55]:
```

	num_characters	num_words	num_sentences
count	5169.000000	5169.000000	5169.000000
mean	78.923776	18.456375	1.962275
std	58.174846	13.323322	1.433892
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	38.000000

```
In [58]: # ham
df[df['target'] == 0][['num_characters', 'num_words', 'num_sentences']].describe()
```

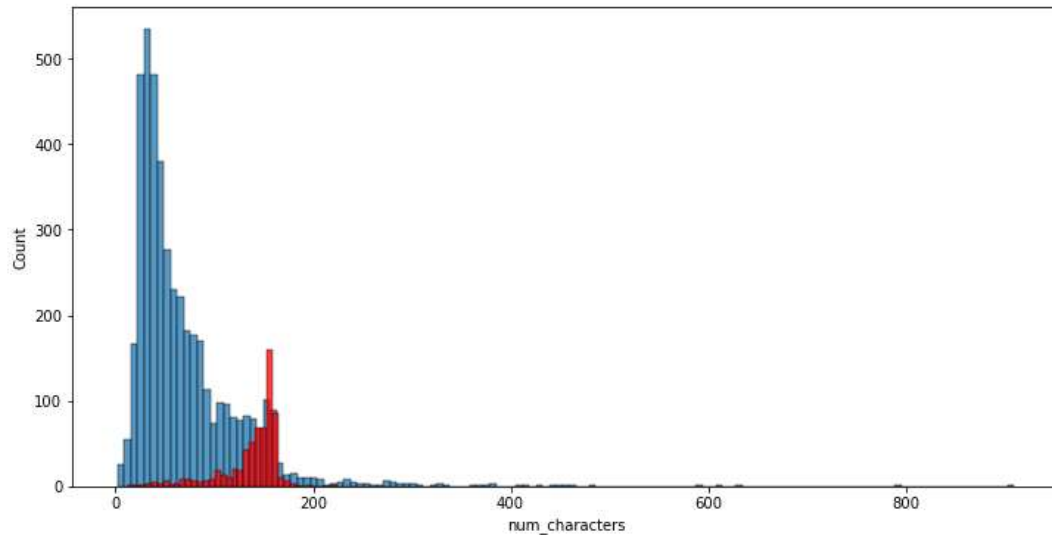
```
Out[58]:
```

	num_characters	num_words	num_sentences
count	4516.000000	4516.000000	4516.000000
mean	70.456820	17.123339	1.815545
std	56.356802	13.491315	1.364098
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	38.000000

```
In [78]: import seaborn as sns
```

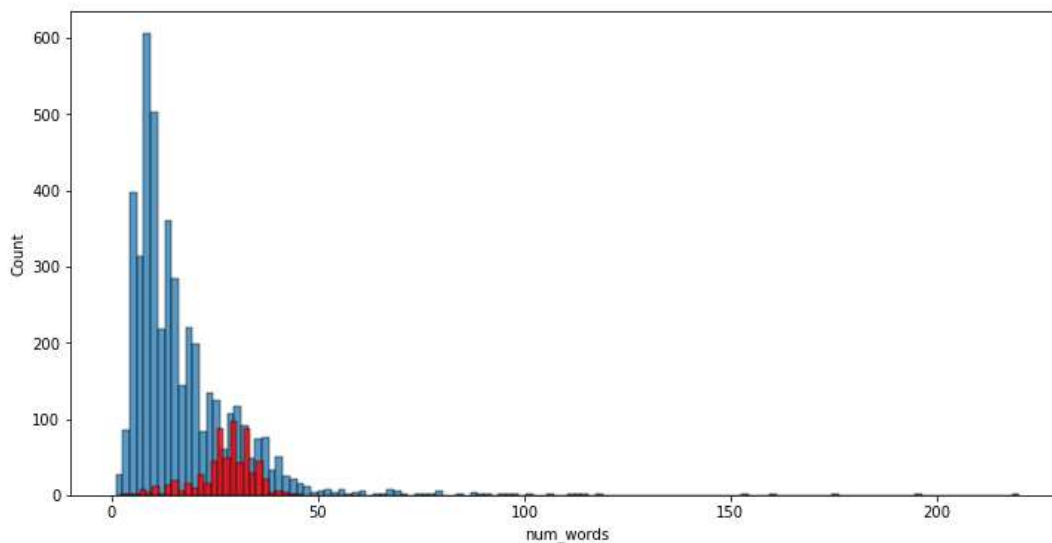
```
In [84]: plt.figure(figsize=(12,6))
sns.histplot(df[df['target'] == 0]['num_characters'])
sns.histplot(df[df['target'] == 1]['num_characters'],color='red')
```

```
Out[84]: <AxesSubplot:xlabel='num_characters', ylabel='Count'>
```



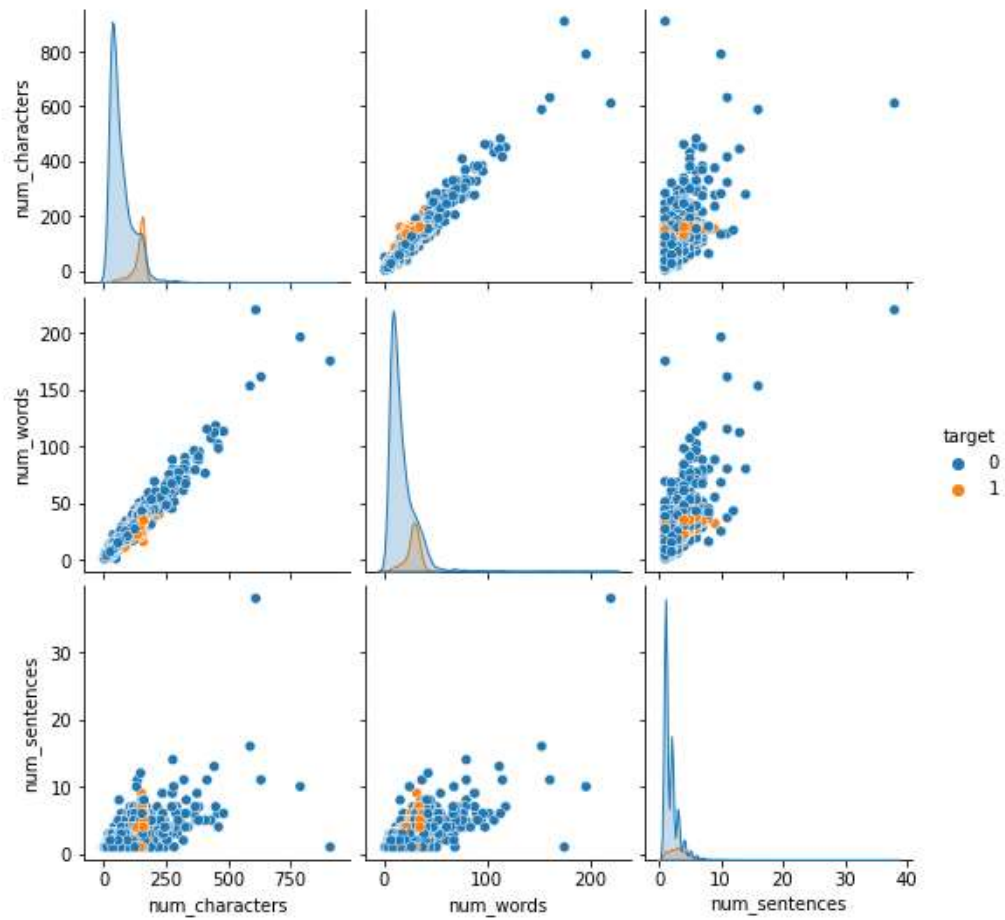
```
In [85]: plt.figure(figsize=(12,6))
sns.histplot(df[df['target'] == 0]['num_words'])
sns.histplot(df[df['target'] == 1]['num_words'],color='red')
```

```
Out[85]: <AxesSubplot:xlabel='num_words', ylabel='Count'>
```



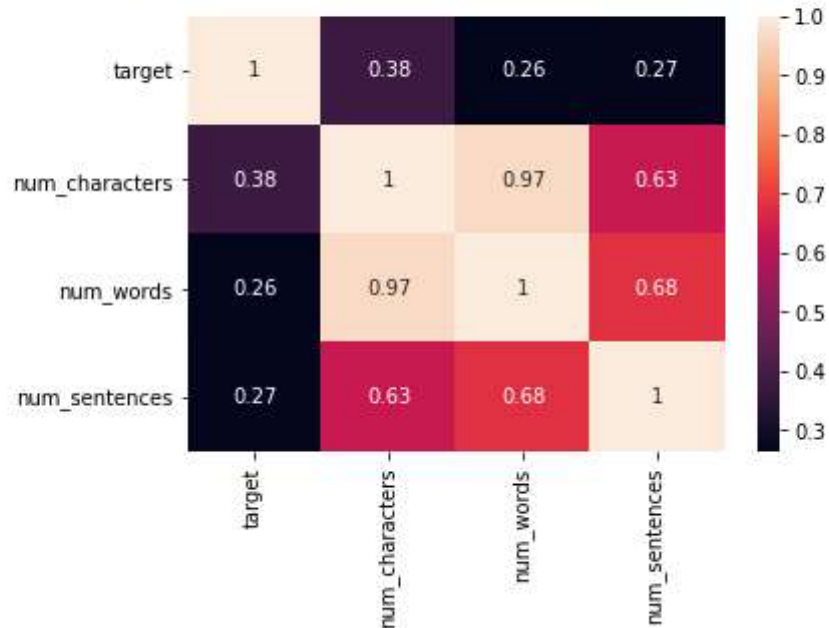
```
In [86]: sns.pairplot(df,hue='target')
```

```
Out[86]: <seaborn.axisgrid.PairGrid at 0x16f88c4a4f0>
```



```
In [89]: sns.heatmap(df.corr(),annot=True)
```

```
Out[89]: <AxesSubplot:>
```



### 3. Data Preprocessing

- Lower case
- Tokenization
- Removing special characters
- Removing stop words and punctuation
- Stemming

```
def transform_text(text):  
    text = text.lower()  
    text = nltk.word_tokenize(text)
```

```
    y = []  
    for i in text:  
        if i.isalnum():  
            y.append(i)
```

```
    text = y[:]  
    y.clear()
```

```
    for i in text:
```

```

if i not in stopwords.words('english') and i not in string.punctuation:
    y.append(i)

```

```

text = y[:]
y.clear()

```

```

for i in text:
    y.append(ps.stem(i))

```

```

return " ".join(y)

```

```

transform_text("I'm gonna be home soon and i don't want to talk about this stuff anymore tonight,
k? I've cried enough today.")

```

```

'gon na home soon want talk stuff anymor tonight k cri enough today'

```

```

df['text'][10]

```

```

"I'm gonna be home soon and i don't want to talk about this stuff anymore tonight, k? I've cried
enough today."

```

```

from nltk.stem.porter import PorterStemmer
ps = PorterStemmer()
ps.stem('loving')

```

```

'love'

```

```

In [194... df['transformed_text'] = df['text'].apply(transform_text)

```

```

In [195... df.head()

```

```

Out[195...

```

	target	text	num_characters	num_words	num_sentences	transformed_text
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...
3	0	U dun say so early hor... U c already then say...	49	13	1	u dun say earli hor u c already say
4	0	Nah I don't think he goes to usf, he lives aro...	61	15	1	nah think goe usf live around though

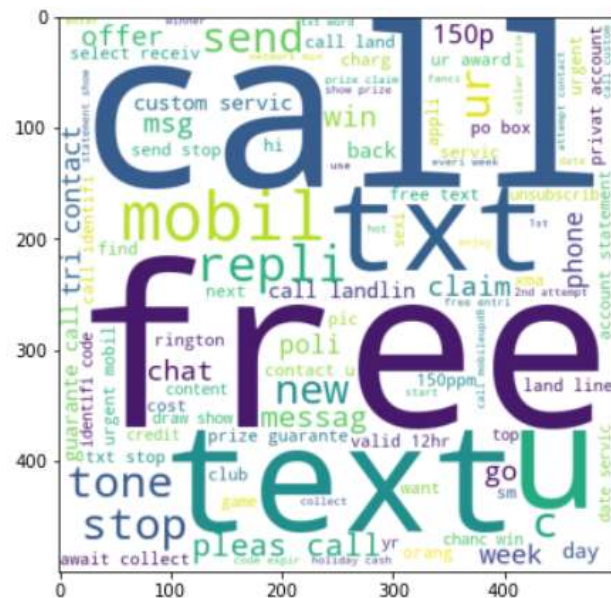


```
In [232... from wordcloud import WordCloud
wc = WordCloud(width=500,height=500,min_font_size=10,background_color='white')
```

```
In [233... spam_wc = wc.generate(df[df['target'] == 1]['transformed_text'], str.cat(sep=" "))
```

```
In [236... plt.figure(figsize=(15,6))
plt.imshow(spam_wc)
```

```
Out[236]: <matplotlib.image.AxesImage at 0x16f87ea8cd0>
```



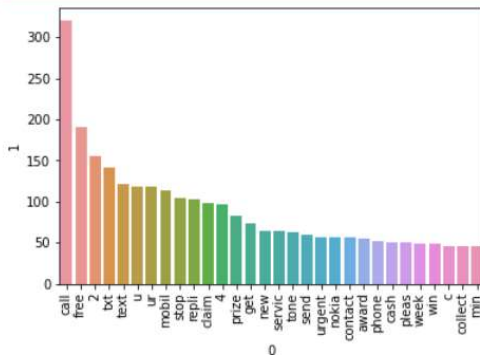


In [280...

```
from collections import Counter
sns.barplot(pd.DataFrame(Counter(spam_corpus).most_common(30))[0],pd.DataFrame(Counter(spam_corpus).most_common(30))[1])
plt.xticks(rotation='vertical')
plt.show()
```

C:\Users\91842\anaconda3\lib\site-packages\seaborn\decorators.py:36: FutureWarning: Pass the following variables as keyword arguments: x, y. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.

warnings.warn(



In [281...

```
ham_corpus = []
for msg in df[df['target'] == 0]['transformed_text'].tolist():
    for word in msg.split():
        ham_corpus.append(word)
```

In [282...

```
len(ham_corpus)
```

Out[282...

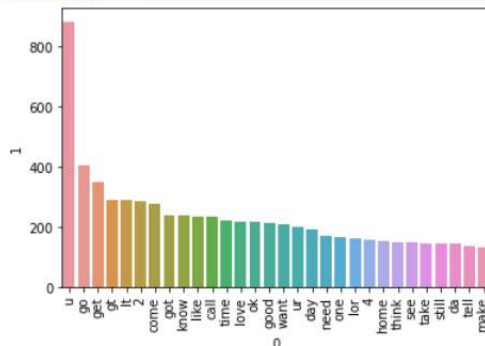
```
35303
```

In [284...

```
from collections import Counter
sns.barplot(pd.DataFrame(Counter(ham_corpus).most_common(30))[0],pd.DataFrame(Counter(ham_corpus).most_common(30))[1])
plt.xticks(rotation='vertical')
plt.show()
```

C:\Users\91842\anaconda3\lib\site-packages\seaborn\decorators.py:36: FutureWarning: Pass the following variables as keyword arguments: x, y. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.

warnings.warn(



```
df.head()
```

Out[285]:

	target	text	num_characters	num_words	num_sentences	transformed_text
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...
3	0	U dun say so early hor... U c already then say...	49	13	1	u dun say earli hor u c already say
4	0	Nah I don't think he goes to usf, he lives aro...	61	15	1	nah think goe usf live around though

```
from sklearn.feature_extraction.text import CountVectorizer,TfidfVectorizer
cv = CountVectorizer()
tfidf = TfidfVectorizer(max_features=3000)
X = tfidf.fit_transform(df['transformed_text']).toarray()
X.shape
(5169, 3000)
y = df['target'].values
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.2,random_state=2)
from sklearn.naive_bayes import GaussianNB,MultinomialNB,BernoulliNB
from sklearn.metrics import accuracy_score,confusion_matrix,precision_score
gnb = GaussianNB()
mnb = MultinomialNB()
bnb = BernoulliNB()
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))
0.8916827852998066
[[808 88]
 [ 24 114]]
0.5643564356435643
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))
0.971953578336557
[[896  0]
 [ 29 109]]
1.0
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))
0.9835589941972921
```

```

[[895  1]
 [ 16 122]]
0.991869918699187
# tfidf --> MNB
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
from xgboost import XGBClassifier
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)
xgb = XGBClassifier(n_estimators=50, random_state=2)
clfs = {
    'SVC' : svc,
    'KN' : knc,
    'NB': mnb,
    'DT': dtc,
    'LR': lrc,
    'RF': rfc,
    'AdaBoost': abc,
    'BgC': bc,
    'ETC': etc,
    'GBDT': gbdt,
    'xgb': xgb
}
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
train_classifier(svc, X_train, y_train, X_test, y_test)
(0.9729206963249516, 0.9741379310344828)
accuracy_scores = []
precision_scores = []

```

```
for name,clf in clfs.items():

    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 - 0.8665377176015474**

**Precision - 0.0**

**For KN**

**Accuracy - 0.9284332688588007**

**Precision - 0.7711864406779662**

**For NB**

**Accuracy - 0.9400386847195358**

**Precision - 1.0**

**For DT**

**Accuracy - 0.9439071566731141**

**Precision - 0.8773584905660378**

**For LR**

**Accuracy - 0.9613152804642167**

**Precision - 0.9711538461538461**

**For RF**

**Accuracy - 0.9748549323017408**

**Precision - 0.9827586206896551**

**For AdaBoost**

**Accuracy - 0.971953578336557**

**Precision - 0.9504132231404959**

**For BgC**

**Accuracy - 0.9680851063829787**

**Precision - 0.9133858267716536**

**For ETC**

**Accuracy - 0.97678916827853**

**Precision - 0.975**

**For GBDT**

**Accuracy - 0.9487427466150871**

**Precision - 0.9292929292929293**

**C:\Users\91842\anaconda3\lib\site-packages\xgboost\sklearn.py:1146: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use\_label\_encoder=False when**

constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num\_class - 1].

warnings.warn(label\_encoder\_deprecation\_msg, UserWarning)

[14:16:02] WARNING:

C:/Users/Administrator/workspace/xgboost-win64\_release\_1.4.0/src/learner.cc:1095: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval\_metric if you'd like to restore the old behavior.

For xgb

Accuracy - 0.9700193423597679

Precision - 0.9421487603305785

```
In [386... performance_df = pd.DataFrame({'Algorithm':clfs.keys(),'Accuracy':accuracy_scores,'Precision':precision_scores}).sort_values
```

```
In [387... performance_df
```

```
Out[387... 
```

	Algorithm	Accuracy	Precision
1	KN	0.900387	1.000000
2	NB	0.959381	1.000000
8	ETC	0.977756	0.991453
5	RF	0.970019	0.990826
0	SVC	0.972921	0.974138
6	AdaBoost	0.962282	0.954128
10	xgb	0.971954	0.950413
4	LR	0.951644	0.940000
9	GBDT	0.951644	0.931373
7	BgC	0.957447	0.861538
3	DT	0.935203	0.838095

```
In [364... performance_df1 = pd.melt(performance_df, id_vars = "Algorithm")
```

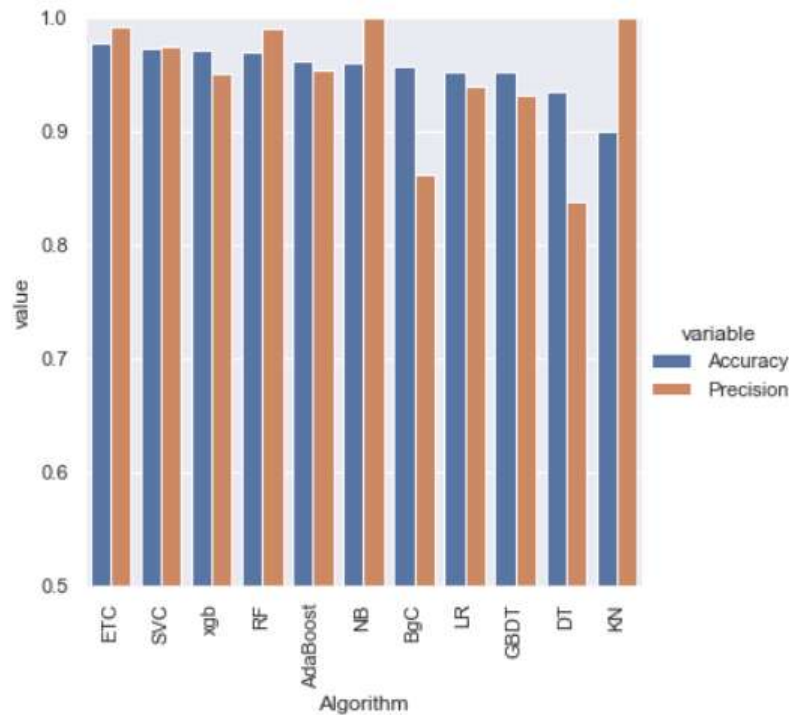
```
In [365... performance_df1
```

```
Out[365... 
```

	Algorithm	variable	value
0	ETC	Accuracy	0.977756
1	SVC	Accuracy	0.972921
2	xgb	Accuracy	0.971954
3	RF	Accuracy	0.970019
4	AdaBoost	Accuracy	0.962282
5	NB	Accuracy	0.959381
6	BgC	Accuracy	0.957447
7	LR	Accuracy	0.951644
8	GBDT	Accuracy	0.951644
9	DT	Accuracy	0.935203
10	KN	Accuracy	0.900387
11	ETC	Precision	0.991453
12	SVC	Precision	0.974138
13	xgb	Precision	0.950413
14	RF	Precision	0.990826
15	AdaBoost	Precision	0.954128
16	NB	Precision	1.000000

In [385...

```
sns.catplot(x = 'Algorithm', y='value',
            hue = 'variable',data=performance_df1, kind='bar',height=5)
plt.ylim(0.5,1.0)
plt.xticks(rotation='vertical')
plt.show()
```



```
In [454.. temp_df = pd.DataFrame({'Algorithm':clfs.keys(),'Accuracy_scaling':accuracy_scores,'Precision_scaling':precision_scores}).sc
```

```
In [452.. new_df = performance_df.merge(temp_df,on='Algorithm')
```

```
In [456.. new_df_scaled = new_df.merge(temp_df,on='Algorithm')
```

```
In [499.. temp_df = pd.DataFrame({'Algorithm':clfs.keys(),'Accuracy_num_chars':accuracy_scores,'Precision_num_chars':precision_scores}).sc
```

```
In [501.. new_df_scaled.merge(temp_df,on='Algorithm')
```

```
Out[501..
```

	Algorithm	Accuracy	Precision	Accuracy_max_ft_3000	Precision_max_ft_3000	Accuracy_scaling	Precision_scaling	Accuracy_num_cha
0	KN	0.900387	1.000000	0.905222	1.000000	0.905222	0.976190	0.92843
1	NB	0.959381	1.000000	0.971954	1.000000	0.978723	0.946154	0.94000
2	ETC	0.977756	0.991453	0.979691	0.975610	0.979691	0.975610	0.97678
3	RF	0.970019	0.990826	0.975822	0.982906	0.975822	0.982906	0.97488
4	SVC	0.972921	0.974138	0.974855	0.974576	0.971954	0.943089	0.86653
5	AdaBoost	0.962282	0.954128	0.961315	0.945455	0.961315	0.945455	0.97195
6	xgb	0.971954	0.950413	0.968085	0.933884	0.968085	0.933884	0.97001
7	LR	0.951644	0.940000	0.956480	0.969697	0.967118	0.964286	0.96131
8	GBDT	0.951644	0.931373	0.946809	0.927835	0.946809	0.927835	0.94874
9	BgC	0.957447	0.861538	0.959381	0.869231	0.959381	0.869231	0.96808
10	DT	0.935203	0.838095	0.931335	0.831683	0.932302	0.840000	0.94396

**svc = SVC(kernel='sigmoid', gamma=1.0,probability=True)**  
**mnb = MultinomialNB()**



```

etc = ExtraTreesClassifier(n_estimators=50, random_state=2)

from sklearn.ensemble import VotingClassifier
voting = VotingClassifier(estimators=[('svm', svc), ('nb', mnb), ('et', etc)], voting='soft')
voting.fit(X_train, y_train)
VotingClassifier(estimators=[('svm',
                             SVC(gamma=1.0, kernel='sigmoid',
                                probability=True)),
                             ('nb', MultinomialNB()),
                             ('et',
                              ExtraTreesClassifier(n_estimators=50,
                                                    random_state=2))],
                  voting='soft')
y_pred = voting.predict(X_test)
print("Accuracy", accuracy_score(y_test, y_pred))
print("Precision", precision_score(y_test, y_pred))
Accuracy 0.9816247582205029
Precision 0.9917355371900827
# Applying stacking
estimators=[('svm', svc), ('nb', mnb), ('et', etc)]
final_estimator=RandomForestClassifier()
from sklearn.ensemble import StackingClassifier
clf = StackingClassifier(estimators=estimators, final_estimator=final_estimator)
clf.fit(X_train, y_train)
y_pred = clf.predict(X_test)
print("Accuracy", accuracy_score(y_test, y_pred))
print("Precision", precision_score(y_test, y_pred))
Accuracy 0.9787234042553191
Precision 0.9328358208955224

```