PROJECT NAME : EMAIL SPAM CLASSIFICATION

```
#starting with importing libraaries
import pandas as pd
import numpy as np
```

```
df=pd.read_csv('/content/ProjectDatasetEE.csv' , encoding='ISO-8859-1')
df.head(5)
```

	v1	v2	Unnamed: 2	Unnamed: 3	Unnamed: 4
0	ham	Go until jurong point, crazy.. Available only ...	NaN	NaN	NaN
1	spam	strictly private . gooday , with warm hear...	NaN	NaN	NaN
2	spam	all graphics software available , cheap oem ...	NaN	NaN	NaN
3	spam	important 42745 start your own adult enter...	NaN	NaN	NaN
4	spam	the government grants you $ 25 , 000 ! free...	NaN	NaN	NaN

```
df.shape
```

```
(5644, 5)
```

Data Cleaning

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5644 entries, 0 to 5643
Data columns (total 5 columns):
 #   Column      Non-Null Count  Dtype 
---  ------      --------------  ----- 
 0   v1          5644 non-null   object
 1   v2          5644 non-null   object
 2   Unnamed: 2  37 non-null     object
 3   Unnamed: 3  9 non-null      object
 4   Unnamed: 4  4 non-null      object
dtypes: object(5)
memory usage: 220.6+ KB
```

```
df.drop(columns=['Unnamed: 2','Unnamed: 3','Unnamed: 4'],inplace=True)
```

```
df.head()
```

	v1	v2
0	ham	Go until jurong point, crazy.. Available only ...
1	spam	strictly private . gooday , with warm hear...
2	spam	all graphics software available , cheap oem ...
3	spam	important 42745 start your own adult enter...
4	spam	the government grants you $ 25 , 000 ! free...

```
df.rename(columns={'v1' : 'target' , 'v2' : 'text'},inplace=True)
```

```
df.head()
```

	target	text
0	ham	Go until jurong point, crazy.. Available only ...
1	spam	strictly private . gooday , with warm hear...
2	spam	all graphics software available , cheap oem ...
3	spam	important 42745 start your own adult enter...
4	spam	the government grants you $ 25 , 000 ! free...

```
from sklearn.preprocessing import LabelEncoder
encoder = LabelEncoder()
```

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

```
df.head()
```

	target	text
0	0	Go until jurong point, crazy.. Available only ...
1	1	strictly private . gooday , with warm hear...
2	1	all graphics software available , cheap oem ...
3	1	important 42745 start your own adult enter...
4	1	the government grants you $ 25 , 000 ! free...

```
# checking is there any missing value or not?
df.isnull().sum()
```

```
target    0
text      0
dtype: int64
```

```
# checking is there any duplicate value or not?
df.duplicated().sum()
```

```
279
```

```
df = df.drop_duplicates(keep='first')
```

```
df.duplicated().sum()
```

```
0
```

```
df.shape
```

```
(5365, 2)
```

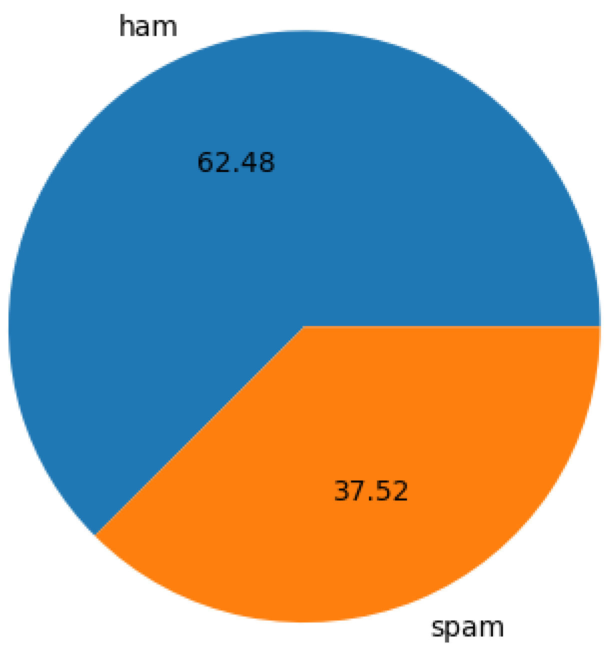
EDA - Exploratory data analysis

```
df['target'].value_counts()
```

```
0    3352
1    2013
Name: target, dtype: int64
```

```
#pie chart for HAM-SPAM portion
import matplotlib.pyplot as plt
plt.pie(df['target'].value_counts(), labels=['ham','spam'], autopct="%0.2f")
plt.show()

#Ham-62.48%, Spam-37.52%
```



```
pip install nltk
```

```
Requirement already satisfied: nltk in /usr/local/lib/python3.10/dist-packages (3.8.1)
Requirement already satisfied: click in /usr/local/lib/python3.10/dist-packages (from nltk) (8.1.7)
Requirement already satisfied: joblib in /usr/local/lib/python3.10/dist-packages (from nltk) (1.3.2)
Requirement already satisfied: regex>=2021.8.3 in /usr/local/lib/python3.10/dist-packages (from nltk) (2023.6.3)
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages (from nltk) (4.66.1)
```

```
import nltk
```

```
nltk.download('punkt')
```

```
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
True
```

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

```
df.head()
```

	target	text	num_characters
0	0	Go until jurong point, crazy.. Available only ...	111
1	1	strictly private . gooday , with warm hear...	4913
2	1	all graphics software available , cheap oem ...	969
3	1	important 42745 start your own adult enter...	1059
4	1	the government grants you $ 25 , 000 ! free...	17631

```
df['num_words'] = df['text'].apply(lambda x:len(nltk.word_tokenize(x)))
```

```
df.head()
```

	target	text	num_characters	num_words
0	0	Go until jurong point, crazy.. Available only ...	111	24
1	1	strictly private . gooday , with warm hear...	4913	1008
2	1	all graphics software available , cheap oem ...	969	202
3	1	important 42745 start your own adult enter...	1059	193
4	1	the government grants you $ 25 , 000 ! free...	17631	3402

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

```
df.head()
```

	target	text	num_characters	num_words	num_sent
0	0	Go until jurong point, crazy.. Available only	111	24	2

```
df[['num_characters','num_words','num_sent']].describe()
```

	num_characters	num_words	num_sent
count	5365.000000	5365.000000	5365.000000
mean	395.042125	81.913141	6.161603
std	1266.198054	252.304523	15.922438
min	2.000000	1.000000	1.000000
25%	45.000000	11.000000	1.000000
50%	100.000000	23.000000	2.000000
75%	200.000000	44.000000	5.000000
max	28425.000000	6129.000000	438.000000

```
#for ham
df[df['target'] == 0][['num_characters','num_words','num_sent']].describe()
```

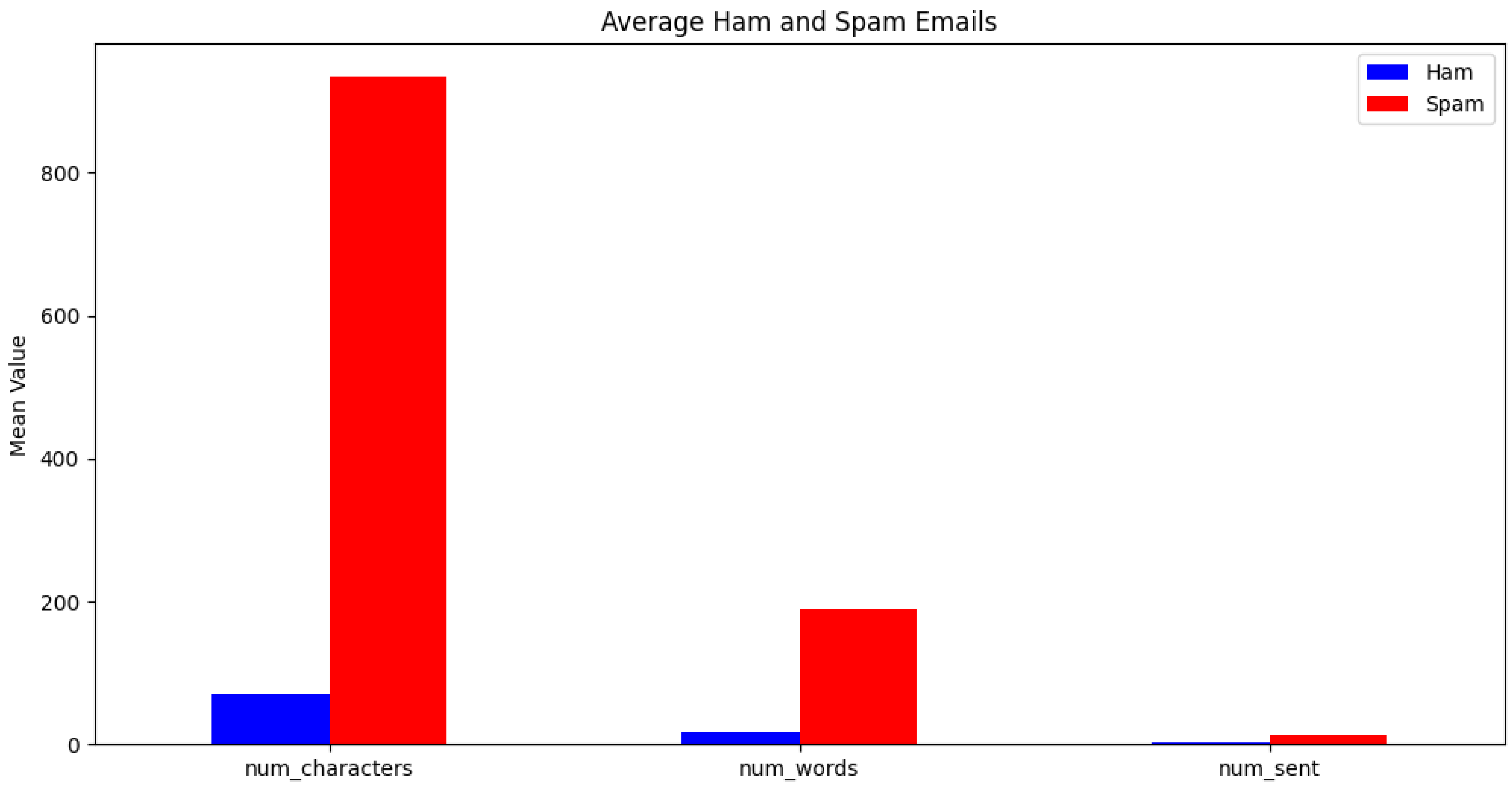
	num_characters	num_words	num_sent
count	3352.000000	3352.000000	3352.000000
mean	71.325477	17.332936	1.833532
std	53.315914	12.962131	1.408410
min	2.000000	1.000000	1.000000
25%	34.000000	9.000000	1.000000
50%	54.000000	13.000000	1.000000
75%	93.000000	22.000000	2.000000
max	611.000000	220.000000	38.000000

```
#for spam
df[df['target'] == 1][['num_characters','num_words','num_sent']].describe()
```

	num_characters	num_words	num_sent
count	2013.000000	2013.000000	2013.000000
mean	934.087432	189.450571	13.368604
std	1950.450621	388.475507	24.277927
min	11.000000	2.000000	1.000000
25%	157.000000	32.000000	3.000000
50%	407.000000	80.000000	7.000000
75%	918.000000	202.000000	13.000000
max	28425.000000	6129.000000	438.000000

```
#bar chart with comparision of characteristic
import matplotlib.pyplot as plt
import seaborn as sns
num_features = ['num_characters', 'num_words', 'num_sent']
df_grouped = df[num_features + ['target']]
grouped_data = df_grouped.groupby('target').mean()
fig, ax = plt.subplots(figsize=(12, 6))

grouped_data.T.plot(kind='bar', ax=ax, color=['blue', 'red'])
plt.title('Average Ham and Spam Emails')
plt.ylabel('Mean Value')
plt.xticks(rotation=0)
plt.legend(['Ham', 'Spam'])
plt.show()
```



Data preprocessing

```
from nltk.corpus import stopwords
nltk.download('stopwords')
stop_word = stopwords.words('english')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

```
print(stop_word)
```

```
['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've", "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', 'she'
```

```
import string
string.punctuation
```

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

```
from nltk.stem.porter import PorterStemmer
from nltk.stem import SnowballStemmer
ps = PorterStemmer()
snow = SnowballStemmer("english") #i m using portstemmer instead of snowballstemmer because both are same just tested
ps.stem('walking') #example
#snow.stem('walking') #example
```

```
'walk'
```

```
#creating function to pre-process the text
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('Hola My Name i#s NIJ And ?? @mail Dancing Coding () what you are doing me')
```

```
'hola name nij mail danc code'
```

```
#now applying 'transform_text' function to our 'text' column

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

```
df.head()
```

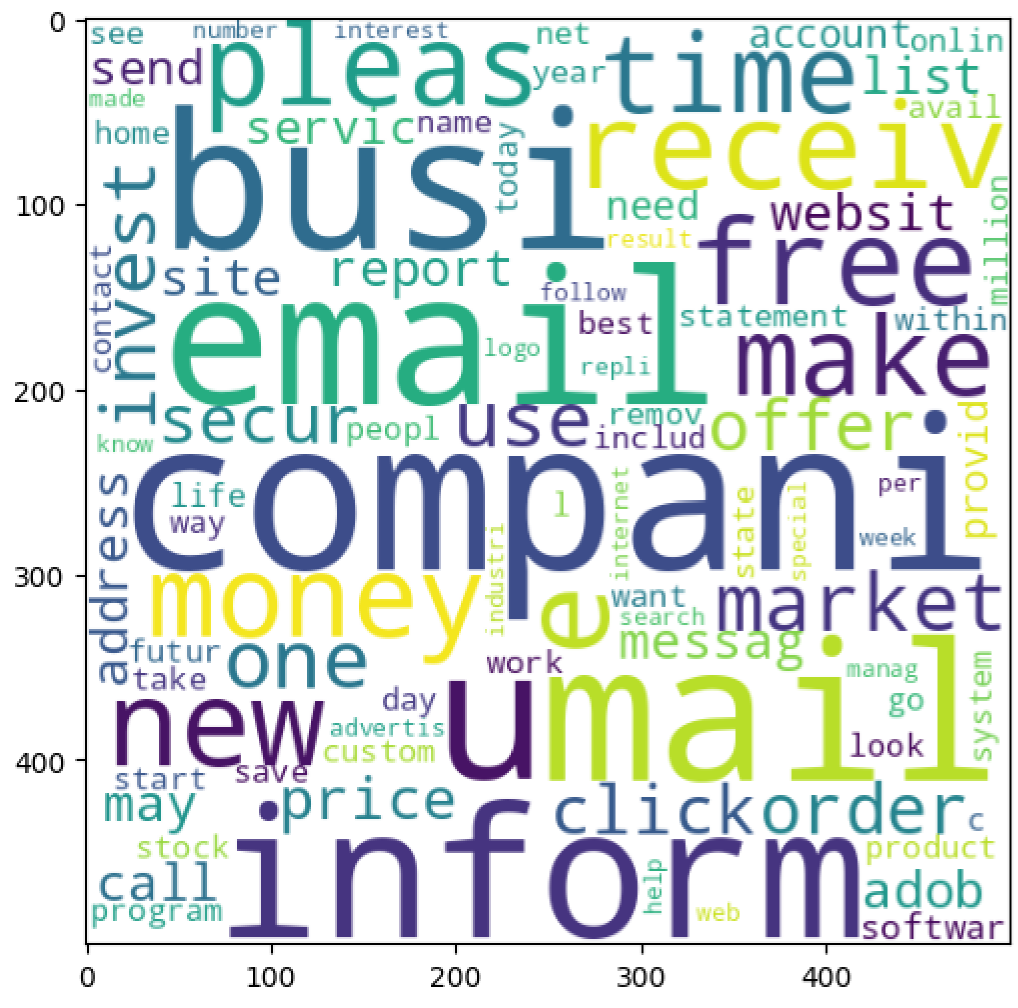
	target	text	num_characters	num_words	num_sent	transformed_text
0	0	Go until jurong point, crazy.. Available only ...	111	24	2	go jurong point crazi avail bugi n great world...
1	1	strictly private . gooday , with warm hear...	4913	1008	43	strictli privat gooday warm heart friend send ...
2	1	all graphics software available , cheap oem ...	969	202	18	graphic softwar avail cheap oem version good m...
3	1	important 42745 start your own adult enter...	1059	193	7	import 42745 start adult entertain busi entert...
4	1	the government grants you $ 25 , 000 ! free...	17631	3402	179	govern grant 25 000 free person busi grant qua...

```
#wordcloud for spam
from wordcloud import WordCloud
wc = WordCloud(width=500,height=500,min_font_size=10,background_color='white',collocations=False)
```

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

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

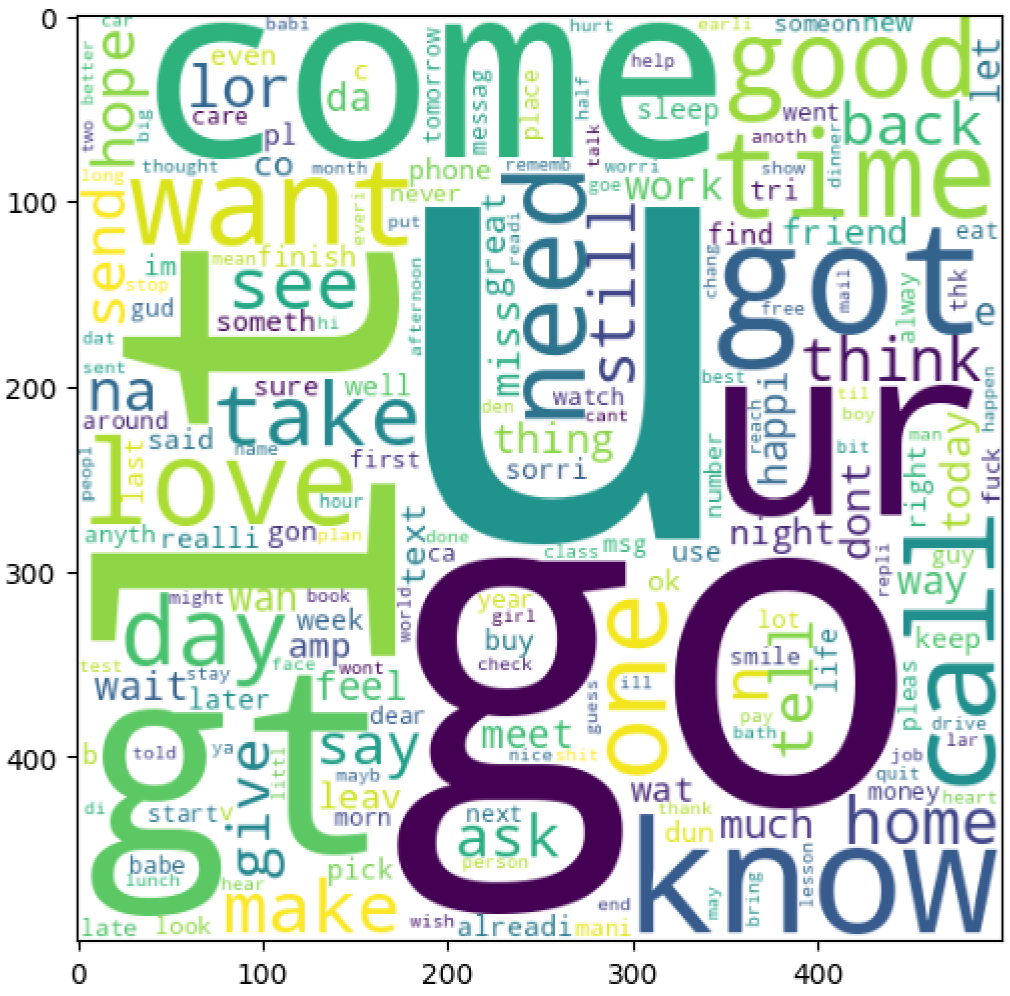
```
<matplotlib.image.AxesImage at 0x7b69ba836380>
```



```
#wordcloud for ham
ham_wc = wc.generate(df[df['target'] == 0]['transformed_text'].str.cat(sep=""))
```

```
plt.figure(figsize=(15,6))
plt.imshow(ham_wc)
```

```
<matplotlib.image.AxesImage at 0x7b69ba7bd780>
```



```
spam_corpus = []
df[df['target'] == 1]['transformed_text'].tolist()
for msg in df[df['target'] == 1]['transformed_text'].tolist():
  for word in msg.split():
    spam_corpus.append(word)
```

```
len(spam_corpus)
```

```
183067
```

```
#for spam
from collections import Counter
Counter(spam_corpus).most_common(30)
```

```
[('compani', 1068),
 ('com', 1000),
 ('1', 980),
 ('mail', 917),
 ('busi', 898),
 ('email', 867),
 ('inform', 827),
 ('free', 797),
 ('get', 767),
 ('2', 765),
 ('receiv', 758),
 ('e', 702),
 ('5', 695),
 ('pleas', 668),
 ('money', 666),
 ('3', 624),
 ('http', 621),
 ('make', 614),
 ('time', 611),
 ('one', 602),
 ('market', 601),
 ('new', 567),
 ('offer', 560),
 ('000', 560),
 ('use', 558),
 ('order', 558),
 ('click', 557),
 ('us', 544),
 ('invest', 540),
 ('secur', 521)]
```

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

```
len(ham_corpus)
```

```
26538
```

```
from collections import Counter
Counter(ham_corpus).most_common(30)
```

```
[('u', 675),
 ('go', 311),
 ('get', 250),
 ('gt', 220),
 ('lt', 216),
 ('come', 208),
 ('2', 202),
 ('know', 188),
 ('like', 182),
 ('call', 178),
 ('got', 171),
 ('time', 166),
 ('ok', 163),
 ('love', 159),
 ('want', 156),
 ('ur', 156),
 ('good', 147),
 ('day', 137),
 ('need', 128),
 ('one', 125),
 ('home', 118),
 ('think', 115),
 ('see', 112),
 ('4', 111),
 ('take', 108),
 ('lor', 103),
 ('back', 99),
 ('still', 99),
 ('dont', 97),
 ('today', 96)]
```

Vectorizing

```
#installing sklearn library
!pip install sklearn
```

```
Collecting sklearn
  Using cached sklearn-0.0.post12.tar.gz (2.6 kB)
  error: subprocess-exited-with-error

  × python setup.py egg_info did not run successfully.
  │ exit code: 1
  ╰─> See above for output.

  note: This error originates from a subprocess, and is likely not a problem with pip.
  Preparing metadata (setup.py) ... error
error: metadata-generation-failed

× Encountered error while generating package metadata.
╰─> See above for output.

note: This is an issue with the package mentioned above, not pip.
hint: See above for details.
```

```
import sklearn
from sklearn.feature_extraction.text import CountVectorizer,TfidfVectorizer #i will use Tfidf instead of Countvectorizer for more accuracy and improvement
Tfidf = TfidfVectorizer()
```

```
x = Tfidf.fit_transform(df['transformed_text']).toarray()
```

```
x
```

```
array([[0.        , 0.        , 0.        , ..., 0.        , 0.        ,
        0.        ],
       [0.        , 0.0956254 , 0.        , ..., 0.        , 0.        ,
        0.        ],
       [0.        , 0.        , 0.        , ..., 0.        , 0.        ,
        0.        ],
       ...,
       [0.        , 0.        , 0.26396532, ..., 0.        , 0.        ,
        0.        ],
       [0.        , 0.        , 0.        , ..., 0.        , 0.        ,
        0.        ],
       [0.00647193, 0.00573124, 0.        , ..., 0.        , 0.        ,
        0.        ]])
```

```
y = df['target'].values
```

```
y
```

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

Train-Test Splitting

```
from sklearn.model_selection import train_test_split
```

```
from imblearn.over_sampling import SMOTE

# Applying SMOTE
smote = SMOTE()
x_resampled, y_resampled = smote.fit_resample(x, y)
```

```
x_train,x_test,y_train,y_test = train_test_split(x_resampled,y_resampled,test_size=0.2,random_state=2)
```

Model Building

```
#installing important libraries for model building
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import accuracy_score,confusion_matrix,precision_score,f1_score
```

```
from sklearn.naive_bayes import MultinomialNB
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.model_selection import GridSearchCV
```

```
#assigning model initially
mnb = MultinomialNB()
dtc = DecisionTreeClassifier()
rfc = RandomForestClassifier()
svc = SVC()
```

Finding the best hyperparameters

```
#for decision tree
from sklearn.model_selection import GridSearchCV

# Define the hyperparameters and their possible values
param_grid_dtc = {
    'criterion': ['gini', 'entropy'],
    'max_depth': [None, 5, 10, 20],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}

# Create a GridSearchCV object
grid_search_dtc = GridSearchCV(dtc, param_grid_dtc, cv=5, scoring='f1')

# Fit the model to the data
grid_search_dtc.fit(x_train, y_train)

# Print the best hyperparameters
print("Best Hyperparameters for Decision Tree Classifier:", grid_search_dtc.best_params_)

# Get the best model
best_dtc_model = grid_search_dtc.best_estimator_
```

```
Best Hyperparameters for Decision Tree Classifier: {'criterion': 'gini', 'max_depth': None, 'min_samples_leaf': 1, 'min_samples_split': 10}
```

```
#for support vector machine
param_grid_svc = {
    'C': [0.1, 1, 10],
    'kernel': ['linear', 'poly', 'rbf', 'sigmoid'],
    'degree': [2, 3, 4],
    'gamma': ['scale', 'auto', 0.1, 1],
}

# Create an SVC classifier
svc = SVC()

# Create a GridSearchCV object
grid_search_svc = GridSearchCV(svc, param_grid_svc, cv=5, scoring='f1')

# Fit the model to the data
grid_search_svc.fit(x_train, y_train)

# Print the best hyperparameters
print("Best Hyperparameters for Support Vector Machine (SVC):", grid_search_svc.best_params_)

# Get the best model
best_svc_model = grid_search_svc.best_estimator_
```

```
Best Hyperparameters for Support Vector Machine (SVC): {'C': 1, 'kernel': 'rbf', 'degree': 2, 'gamma': 'scale'}
```

```
#Finding the best suitable Hyperparameters for MNB Model

from sklearn.model_selection import GridSearchCV

# Defining the hyperparameters and their possible values
param_grid_mnb = {'alpha': [0.1, 0.5, 1.0, 2.0, 5.0]}

# Creating a GridSearchCV object
grid_search = GridSearchCV(mnb, param_grid_mnb, cv=5, scoring='f1')

# Fit the model to the data
grid_search.fit(x_train, y_train)

# Print the best hyperparameters
print("Best Hyperparameters:", grid_search.best_params_)

# Get the best model
best_model = grid_search.best_estimator_
```

```
Best Hyperparameters: {'alpha': 0.1}
```

```
#for random forest
from sklearn.model_selection import GridSearchCV

param_grid_rfc = {
    'n_estimators': [50, 100, 150],
    'max_depth': [None, 10, 20]
}

# Creating a GridSearchCV object
grid_search_rf = GridSearchCV(rfc, param_grid_rfc, cv=5, scoring='f1', n_jobs=-1)

# Fitting the model to the data
grid_search_rf.fit(x_train, y_train)

print("Best Hyperparameters:", grid_search_rf.best_params_)

#best model of RF
best_rf_model = grid_search_rf.best_estimator_
```

```
Best Hyperparameters: {'max_depth': None, 'n_estimators': 100}
```

```
#assigning models with the hyperparameters
mnb_new = MultinomialNB(alpha=5.0)
dtc_new = DecisionTreeClassifier(criterion='gini', max_depth=None, min_samples_leaf=1, min_samples_split= 10)
rfc_new = RandomForestClassifier(n_estimators=100, max_depth= None, max_features='sqrt')
svm_new = SVC(kernel='rbf', C=1, degree=2, gamma='scale')
```

```
clfs = {'NB' : mnb_new, 'DT' : dtc_new, 'RF' : rfc_new, 'SVM' : svm_new}
```

```
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)
  f1 = f1_score(y_test,y_pred)
  return accuracy, precision, f1
```

```
train_classifier(svm_new,x_train,y_train,x_test,y_test)
```

```
(0.9731543624161074, 0.9835575485799701, 0.9733727810650888)
```

```
accuracy_scores = []
precision_scores = []
f1_scores = []

for name,clf in clfs.items():
  current_accuracy,current_precision,current_f1 = train_classifier(clf,x_train,y_train,x_test,y_test)

  print("for ",name)
  print("Accuracy - ",current_accuracy)
  print("pricision - ",current_precision)
  print("f1 - ",current_f1)

  accuracy_scores.append(current_accuracy)
  precision_scores.append(current_precision)
  f1_scores.append(current_f1)
```

```
for  NB
Accuracy -  0.9090231170768084
pricision -  0.8582375478927203
f1 -  0.9167803547066848
for  DT
Accuracy -  0.9485458612975392
pricision -  0.9475218658892128
f1 -  0.9495982468955441
for  RF
Accuracy -  0.9783743475018642
pricision -  1.0
f1 -  0.9783096484667165
for  SVM
Accuracy -  0.9776286353467561
pricision -  0.9939485627836612
f1 -  0.9776785714285715
```

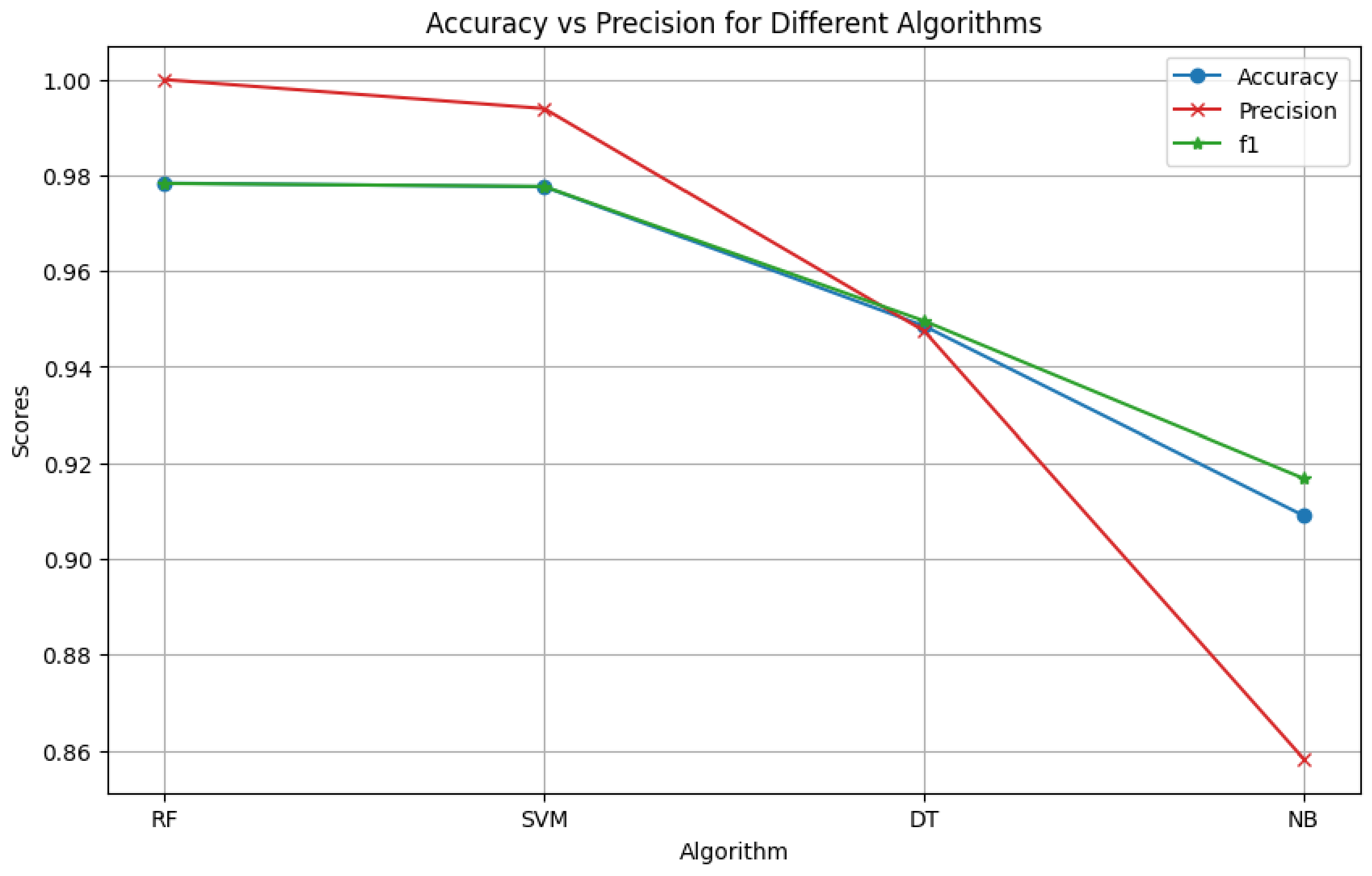
```
performance_df = pd.DataFrame({'Algorithm':clfs.keys(),'Accuracy':accuracy_scores,'Precision':precision_scores,'f1':f1_scores}).sort_values(['Precision','Accuracy','f1'],ascending=False)
```

```
performance_df
```

	Algorithm	Accuracy	Precision	f1
2	RF	0.978374	1.000000	0.978310
3	SVM	0.977629	0.993949	0.977679
1	DT	0.948546	0.947522	0.949598
0	NB	0.909023	0.858238	0.916780

Comparision of Performance Metrics for each model

```
import pandas as pd
import matplotlib.pyplot as plt
plt.figure(figsize=(10, 6))
# Plotting the scores with lines connecting them
plt.plot(performance_df['Algorithm'], performance_df['Accuracy'], color='tab:blue', label='Accuracy', marker='o')
plt.plot(performance_df['Algorithm'], performance_df['Precision'], color='tab:red', label='Precision', marker='x')
plt.plot(performance_df['Algorithm'], performance_df['f1'], color='tab:green', label='f1', marker='*')
plt.xlabel('Algorithm')
plt.ylabel('Scores')
plt.title('Accuracy vs Precision for Different Algorithms')
plt.legend()
plt.grid(True)
plt.show()
```



Cross-validation on MNB

```
from sklearn.model_selection import cross_val_score, KFold

# number of folds (k)
k = 5
kf = KFold(n_splits=k, shuffle=True, random_state=42)

# Performing cross-validation
cross_val_results = cross_val_score(mnb_new, x_train, y_train, cv=kf, scoring='f1')

# Printing the results
print("Cross-Validation Results:")
print("Mean F1 Score:", cross_val_results.mean())
print("Standard Deviation:", cross_val_results.std())
```

```
     Cross-Validation Results:
     Mean F1 Score: 0.9144443333666411
     Standard Deviation: 0.01816482027593451
```

Cross-validation on Random Forest

```
# number of folds (k)
k = 5
kf = KFold(n_splits=k, shuffle=True, random_state=42)

# Performing cross-validation
cross_val_results = cross_val_score(rfc_new, x_train, y_train, cv=kf, scoring='f1')

# Printing the results
print("Cross-Validation Results:")
print("Mean F1 Score:", cross_val_results.mean())
print("Standard Deviation:", cross_val_results.std())
```

```
     Cross-Validation Results:
     Mean F1 Score: 0.9735219328576322
     Standard Deviation: 0.005508424196587164
```

Cross-validation on Support Vector Machine

```
# number of folds (k)
k = 5
kf = KFold(n_splits=k, shuffle=True, random_state=42)

# Performing cross-validation
cross_val_results = cross_val_score(svm_new, x_train, y_train, cv=kf, scoring='f1')

# Printing the results
print("Cross-Validation Results:")
print("Mean F1 Score:", cross_val_results.mean())
print("Standard Deviation:", cross_val_results.std())
```

```
     Cross-Validation Results:
     Mean F1 Score: 0.9730915667699858
     Standard Deviation: 0.007672098088400527
```

Cross-validation on Decision Tree

```
# number of folds (k)
k = 5
kf = KFold(n_splits=k, shuffle=True, random_state=42)

# Performing cross-validation
cross_val_results = cross_val_score(dtc_new, x_train, y_train, cv=kf, scoring='f1')

# Printing the results
print("Cross-Validation Results:")
print("Mean F1 Score:", cross_val_results.mean())
print("Standard Deviation:", cross_val_results.std())
```

```
     Cross-Validation Results:
     Mean F1 Score: 0.9487419861325529
     Standard Deviation: 0.004967184376277291
```

Deployment

```
#pipeline for RFC
from joblib import dump
dump(Tfidf, 'vectorizerrfc.joblib')
dump(rfc_new, 'modelrfc.joblib')
```

```
     ['modelrfc.joblib']
```