Data Science Bharat Internship

SMS Classification

- Prajwal Singh R

Importing Required Libraries

In [4]:

```
import pandas as pd
import numpy as np
import string

import matplotlib.pyplot as plt
from matplotlib.gridspec import GridSpec
import seaborn as sns

import re
from bs4 import BeautifulSoup
from wordcloud import WordCloud
from collections import Counter

import nltk
from nltk.tokenize import word_tokenize
from nltk.stem import SnowballStemmer
from nltk.corpus import stopwords

import time
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.ensemble import AdaBoostClassifier, GradientBoostingClassifier, RandomForest
Classifier, ExtraTreesClassifier
from sklearn.svm import SVC
from xgboost import XGBClassifier
from sklearn.metrics import classification_report, balanced_accuracy_score, accuracy_scor
e, precision_score, recall_score, f1_score, confusion_matrix
from sklearn.model_selection import cross_val_score
from sklearn.utils.multiclass import unique_labels

import chardet

import warnings
warnings.filterwarnings("ignore")
```

In [9]:

```
# Importing Data

# Detect the encoding of the file
with open(r'G:\My Drive\My Learning\Bharat intern\sms_spam_dataset.csv', 'rb') as f:
    result = chardet.detect(f.read())

# Read the file using the detected encoding
df = pd.read_csv(r'G:\My Drive\My Learning\Bharat intern\sms_spam_dataset.csv"', encoding
=result['encoding'])
df
```

Out[9]:

	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

EDA

In [10]:

```
df.shape
```

Out[10]:

```
(5572, 5)
```

In [11]:

```
df.isnull().sum()
```

Out[11]:

```
v1               0
v2               0
Unnamed: 2    5522
Unnamed: 3    5560
Unnamed: 4    5566
dtype: int64
```

In [12]:

```
# Drop irrelevant columns

df = df.drop(['Unnamed: 2', 'Unnamed: 3', 'Unnamed: 4'], axis=1)
```

In [13]:

```
df.head(2)
```

Out[13]:

	v1	v2
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...

In [14]:

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

Out[14]:

```
403
```

In [15]:

```
# Drop Duplicates

df.drop_duplicates(inplace = True)
```

In [16]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 5169 entries, 0 to 5571
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   v1      5169 non-null   object
 1   v2      5169 non-null   object
dtypes: object(2)
memory usage: 121.1+ KB
```

In [17]:

```
# Rename Columns

df = df.rename(columns={'v1': 'label', 'v2': 'message'})
df.head(2)
```

Out[17]:

	label	message
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...

In [18]:

```
# Create columns of message_length

df['message_length'] = df['message'].apply(len)
df.head()
```

Out[18]:

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

In [19]:

```
df.describe(include='object')
```

Out[19]:

	label	message
count	5169	5169
unique	2	5169
top	ham	Go until jurong point, crazy.. Available only ...

	label	message
freq	4516	1

In [ ]:

```
# Statistical Summary

df.groupby('label').describe().T
```

In [21]:

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

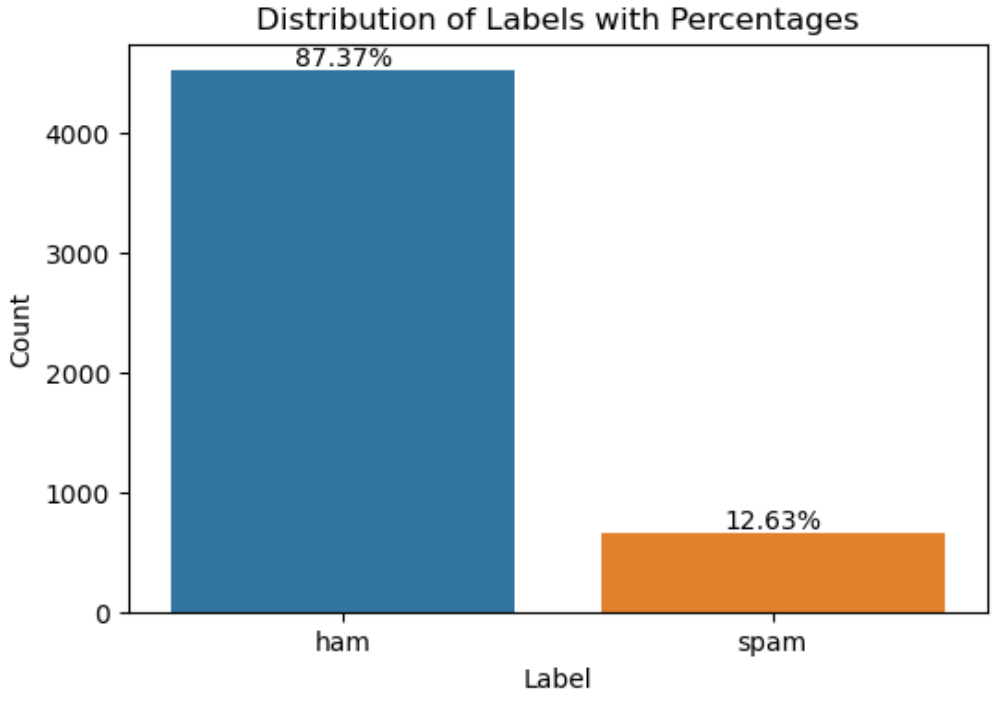
Out[21]:

```
ham     4516
spam     653
Name: label, dtype: int64
```

Data Visulaization

In [22]:

```
# Plot the value counts of 'label' with percentage inside bars
plt.figure(figsize=(6, 4))  # Adjust the figure size if needed
ax = sns.countplot(data=df, x='label')

# Calculate percentage and annotate bars with percentages
total = float(len(df['label']))
for p in ax.patches:
    height = p.get_height()
    ax.annotate(f'{(height/total)*100:.2f}%', (p.get_x() + p.get_width() / 2., height),
                ha='center', va='bottom', fontsize=10, color='black')

# Add labels and title
plt.xlabel('Label')
plt.ylabel('Count')
plt.title('Distribution of Labels with Percentages')

# Show the plot
plt.show()
```

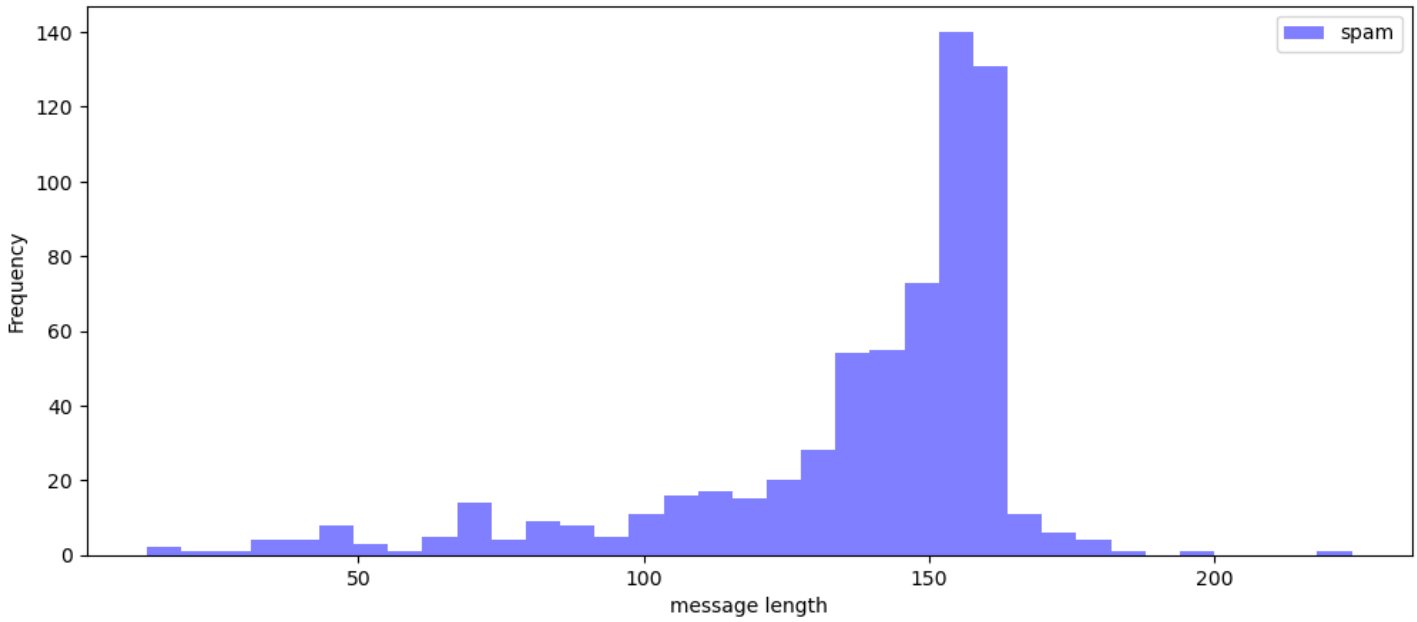


Dataset contains 87.37% of 'Ham' messages and 12.63% of 'Spam' Messages.

Ploting Distribution of Spam & Ham (Message Length)

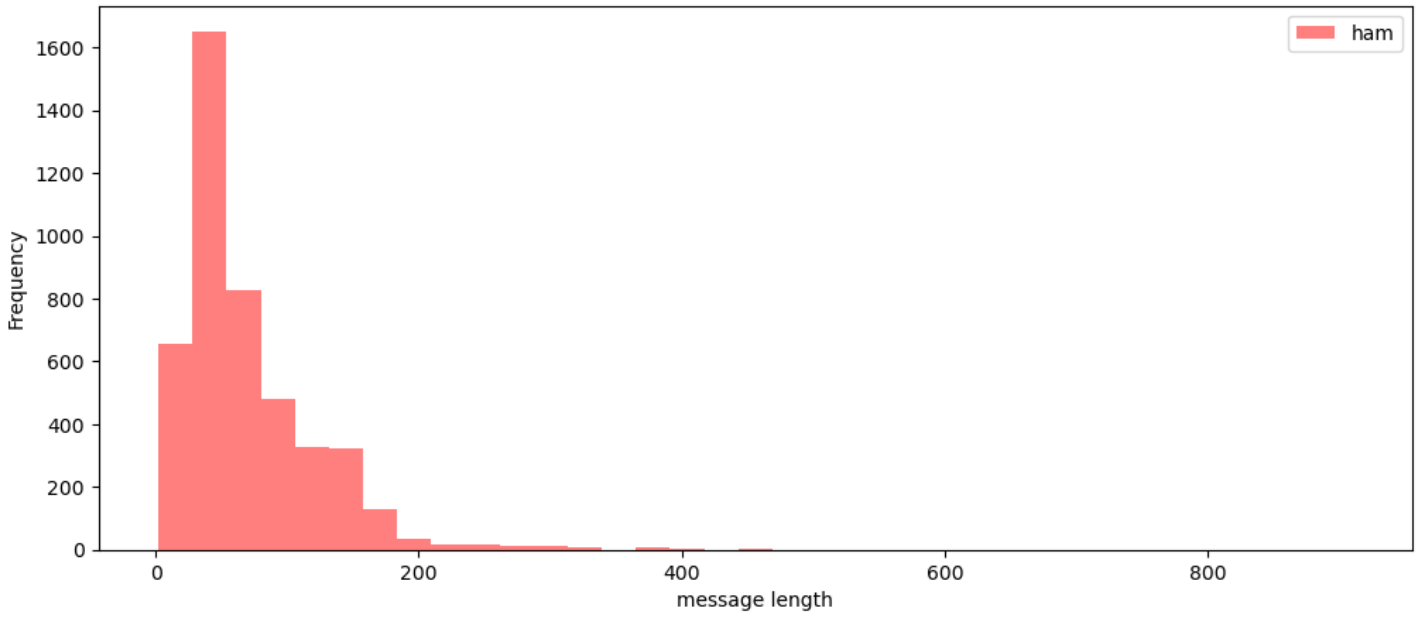
In [23]:

```
plt.figure(figsize=(12,5))
df[df['label']=='spam']['message_length'].plot(bins=35,kind='hist',color='blue',label='spam',alpha=0.5)
plt.legend()
plt.xlabel('message length')
plt.show()
```



In [24]:

```
plt.figure(figsize=(12,5))
df[df['label']=='ham']['message_length'].plot(bins=35,kind='hist',color='red',label='ham',alpha=0.5)
plt.legend()
plt.xlabel('message length')
plt.show()
```



The message length of spam is negatively skewed, while ham is positively skewed. This indicates that spam messages are typically longer than ham messages.

Convert Labels into numerical and save the copy of data

In [25]:

```
# Convert Labels into numerical

df.label.replace("ham",0,inplace = True)
df.label.replace("spam",1,inplace = True)

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

Out[25]:

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

In [26]:

```
#Save dataste copy

df_copy = df.copy()
```

Data Cleaning / Text Pre-Processing / Data Preparation

In [42]:

```
custom_stopwords = [
    "i", "me", "my", "myself", "we", "our", "ours", "ourselves",
    "you", "your", "yours", "yourself", "yourselves", "he", "him", "his",
    "himself", "she", "her", "hers", "herself", "it", "its", "itself",
    "they", "them", "their", "theirs", "themselves", "what", "which", "who",
    "whom", "this", "that", "these", "those", "am", "is", "are", "was", "were",
    "be", "been", "being", "have", "has", "had", "having", "do", "does", "did",
    "doing", "a", "an", "the", "and", "but", "if", "or", "because", "as", "until",
    "while", "of", "at", "by", "for", "with", "about", "against", "between", "into",
    "through", "during", "before", "after", "above", "below", "to", "from", "up",
    "down", "in", "out", "on", "off", "over", "under", "again", "further", "then",
    "once", "here", "there", "when", "where", "why", "how", "all", "any", "both",
    "each", "few", "more", "most", "other", "some", "such", "no", "nor", "not",
    "only", "own", "same", "so", "than", "too", "very", "s", "t", "can", "will", "just",
    "don", "should", "now"
]
```

In [43]:

```
def remove_stopwords_and_punctuation(text):
    punctuation = string.punctuation
    text = ' '.join([word for word in text.split() if word.lower() not in custom_stopwor
ds and word not in punctuation])
    return text
```

In [44]:

```
import pandas as pd
import re
import string
from bs4 import BeautifulSoup

# Custom list of stopwords
custom_stopwords = [
    # ... (add your custom stopwords here)
]

# Define a function to remove stopwords and punctuation
def remove_stopwords_and_punctuation(text):
    punctuation = string.punctuation
    text = ' '.join([word for word in text.split() if word.lower() not in custom_stopwor
ds and word not in punctuation])
    return text

# ... (the rest of your code remains the same) ...
```

```
# Apply the master function on a DataFrame column
df['clean_message'] = df['message'].apply(preprocess_text)

# Print the first two rows of the DataFrame
print(df.head(2))
```

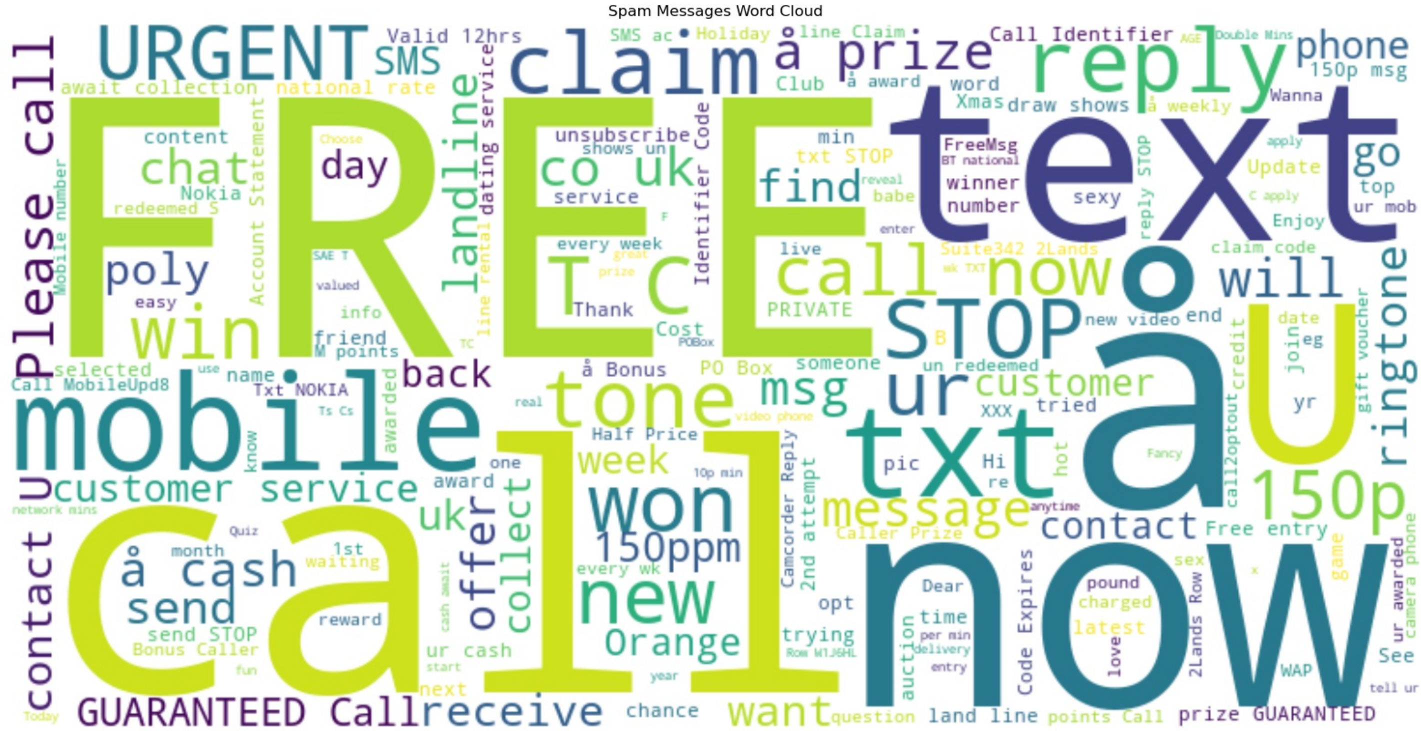
```
   label                                            message  message_length  \
0      0  Go until jurong point, crazy.. Available only ...             111
1      0                      Ok lar... Joking wif u oni...              29

                                       clean_message
0  Go until jurong point, crazy.. Available only ...
1                      Ok lar... Joking wif u oni...
```

Word Cloud of 'Ham' & 'Spam' Messages

In [36]:

```
# Separate the messages based on categories
ham_messages = df[df['label'] == 0]['message']
spam_messages = df[df['label'] == 1]['message']

# Combine ham messages into a single string
ham_text = " ".join(ham_messages)

# Combine spam messages into a single string
spam_text = " ".join(spam_messages)

# Create word cloud for ham messages
ham_wordcloud = WordCloud(width=800, height=400, background_color='white').generate(ham_t
ext)

# Create word cloud for spam messages
spam_wordcloud = WordCloud(width=800, height=400, background_color='white').generate(spam
_text)

# Plot the ham word cloud
plt.figure(figsize=(20, 20))
plt.imshow(ham_wordcloud, interpolation='bilinear')
plt.title('Ham Messages Word Cloud')
plt.axis('off')
plt.show()

print('-'*127)

# Plot the spam word cloud
plt.figure(figsize=(20, 20))
plt.imshow(spam_wordcloud, interpolation='bilinear')
plt.title('Spam Messages Word Cloud')
plt.axis('off')
plt.show()
```


```
--------------------------------------------------------------------------------------------------------------------------------
```



In [50]:

```python
# Add a new column 'clean_message_length'
df['clean_message_length'] = df['clean_message'].apply(len)

# Display the updated DataFrame
df
```

Out[50]:

	label	message	message_length	clean_message	clean_message_length
0	0	Go until jurong point, crazy.. Available only ...	111	Go until jurong point, crazy.. Available only ...	111
1	0	Ok lar... Joking wif u oni...	29	Ok lar... Joking wif u oni...	29
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	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	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	Nah I don't think he goes to usf, he lives aro...	61
...	...	...	...	...	...
5567	1	This is the 2nd time we have tried 2 contact u...	161	This is the 2nd time we have tried 2 contact u...	161
5568	0	Will Ì_ b going to esplanade fr home?	37	Will Ì_ b going to esplanade fr home?	37
5569	0	Pity, * was in mood for that. So...any other s...	57	Pity, was in mood for that. So...any other sug...	55
5570	0	The guy did some bitching but I acted like i'd...	125	The guy did some bitching but I acted like i'd...	125
5571	0	Rofl. Its true to its name	26	Rofl. Its true to its name	26

	label	message	message_length	clean_message	clean_message_length

5169 rows × 5 columns

In [51]:

```
# Creating independent & dependent variable

X = df['clean_message']
y = df['label']
```

Text Vectorization Using TF-IDF

In [52]:

```
# Convert text into vectors using TF-IDF

tf = TfidfVectorizer()

tfTrainReviews = tf.fit_transform(X)

tfTrainReviews
```

Out[52]:

```
<5169x8651 sparse matrix of type '<class 'numpy.float64'>'
 with 67427 stored elements in Compressed Sparse Row format>
```

In [53]:

```
tfTrainReviews.toarray()
```

Out[53]:

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

In [54]:

```
# Get the feature names (words)
feature_names = tf.get_feature_names_out()

# Convert the TF-IDF matrix to a DataFrame for better visualization
tfidf_df = pd.DataFrame(tfTrainReviews.toarray(), columns=feature_names)

# Display the TF-IDF features
tfidf_df.head()
```

Out[54]:

	00	000	000pes	008704050406	0089	0121	01223585236	01223585334	0125698789	02	...	û_	û_thanks	ûªm	ûªt	ûªve
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0

5 rows × 8651 columns

Train Test Split

In [55]:

```
X_train, X_test, y_train, y_test = train_test_split(tfTrainReviews, y, test_size = 0.20,
random_state = 42)
```

In [56]:

```
print("X_train shape: {}\nX_test shape: {}\nY_train shape: {}\nY_test shape: {}".format(
X_train.shape,X_test.shape,y_train.shape,y_test.shape))
```

```
X_train shape: (4135, 8651)
X_test shape: (1034, 8651)
Y_train shape: (4135,)
Y_test shape: (1034,)
```

Model Building

In [57]:

```
# Set random state and n_jobs
random_state = 42
n_jobs = -1

# Initialize a list of classifiers with specified parameters
classifiers = [
    LogisticRegression(random_state=random_state, n_jobs=n_jobs),
    DecisionTreeClassifier(random_state=random_state),
    KNeighborsClassifier(n_jobs=n_jobs),
    MultinomialNB(),
    AdaBoostClassifier(random_state=random_state),
    GradientBoostingClassifier(random_state=random_state),
    RandomForestClassifier(random_state=random_state, n_jobs=n_jobs),
    XGBClassifier(random_state=random_state, n_jobs=n_jobs),
    SVC(random_state=random_state)
]

results = []

# Loop through each classifier
for classifier in classifiers:
    start_time = time.time()

    # Train the classifier
    classifier.fit(X_train, y_train)

    # Predict on the training set
    y_train_pred = classifier.predict(X_train)

    # Predict on the test set
    y_test_pred = classifier.predict(X_test)

    # Calculate performance metrics for training set
    train_accuracy = np.mean(y_train_pred == y_train)
    train_report = classification_report(y_train, y_train_pred, output_dict=True)
    train_precision = train_report['weighted avg']['precision']
    train_recall = train_report['weighted avg']['recall']
    train_f1 = train_report['weighted avg']['f1-score']
    train_balanced_acc = balanced_accuracy_score(y_train, y_train_pred)

    # Calculate performance metrics for test set
    test_accuracy = np.mean(y_test_pred == y_test)
    test_report = classification_report(y_test, y_test_pred, output_dict=True)
    test_precision = test_report['weighted avg']['precision']
    test_recall = test_report['weighted avg']['recall']
    test_f1 = test_report['weighted avg']['f1-score']
    test_balanced_acc = balanced_accuracy_score(y_test, y_test_pred)

    # Calculate the time taken for training
```

```
    build_time = time.time() - start_time

    # Append results to the list
    results.append([classifier.__class__.__name__, train_accuracy, train_precision, trai
n_recall, train_f1, train_balanced_acc,
                    test_accuracy, test_precision, test_recall, test_f1, test_balanced_a
cc, build_time])

# Create a DataFrame from the results
columns = ["Algorithm",
           "Train Accuracy", "Train Precision", "Train Recall", "Train F1-score", "Train
Balanced Accuracy",
           "Test Accuracy", "Test Precision", "Test Recall", "Test F1-score", "Test Bala
nced Accuracy",
           "Building Time (s)"]

results_df = pd.DataFrame(results, columns=columns)

# Print the results
print("Model Performance on Training and Test Sets")
results_df
```

```
Model Performance on Training and Test Sets
```

Out[57]:

	Algorithm	Train Accuracy	Train Precision	Train Recall	Train F1-score	Train Balanced Accuracy	Test Accuracy	Test Precision	Test Recall	Test F1-score	Ba Ac
0	LogisticRegression	0.968319	0.969213	0.968319	0.966329	0.872756	0.953578	0.954359	0.953578	0.950183	0.
1	DecisionTreeClassifier	1.000000	1.000000	1.000000	1.000000	1.000000	0.965184	0.964831	0.965184	0.964979	0.
2	KNeighborsClassifier	0.918501	0.925429	0.918501	0.900085	0.668307	0.899420	0.909954	0.899420	0.874080	0.
3	MultinomialNB	0.959855	0.961612	0.959855	0.956384	0.836614	0.954545	0.956828	0.954545	0.950735	0.
4	AdaBoostClassifier	0.979686	0.979524	0.979686	0.979171	0.929172	0.965184	0.964468	0.965184	0.964206	0.
5	GradientBoostingClassifier	0.981137	0.981231	0.981137	0.980566	0.928307	0.969052	0.968997	0.969052	0.967862	0.
6	RandomForestClassifier	1.000000	1.000000	1.000000	1.000000	1.000000	0.974855	0.975299	0.974855	0.973888	0.
7	XGBClassifier	0.996614	0.996619	0.996614	0.996597	0.987067	0.977756	0.977615	0.977756	0.977243	0.
8	SVC	0.997098	0.997108	0.997098	0.997083	0.988189	0.978723	0.979237	0.978723	0.977980	0.

Build Random Forest Classifier

In [58]:

```
# Initialize Random Forest Classifier
random_forest_classifier = RandomForestClassifier(random_state=42, n_jobs=-1)

# Train the classifier
random_forest_classifier.fit(X_train, y_train)
```

Out[58]:

```
RandomForestClassifier(n_jobs=-1, random_state=42)
```

In [59]:

```
# Predict on the train set
y_train_pred = random_forest_classifier.predict(X_train)

# Predict on the test set
y_test_pred = random_forest_classifier.predict(X_test)

# Calculate performance metrics for training set
train_report = classification_report(y_train, y_train_pred, output_dict=True)
```

```
train_accuracy = train_report['accuracy']
train_precision = train_report['weighted avg']['precision']
train_recall = train_report['weighted avg']['recall']
train_f1 = train_report['weighted avg']['f1-score']
train_balanced_acc = balanced_accuracy_score(y_train, y_train_pred)

# Calculate performance metrics for test set
test_report = classification_report(y_test, y_test_pred, output_dict=True)
test_accuracy = test_report['accuracy']
test_precision = test_report['weighted avg']['precision']
test_recall = test_report['weighted avg']['recall']
test_f1 = test_report['weighted avg']['f1-score']
test_balanced_acc = balanced_accuracy_score(y_test, y_test_pred)

# Create a DataFrame to store results
results_df = pd.DataFrame({
    'Metric': ['Accuracy', 'Precision', 'Recall', 'F1-score', 'Balanced Accuracy'],
    'Train': [train_accuracy, train_precision, train_recall, train_f1, train_balanced_ac
c],
    'Test': [test_accuracy, test_precision, test_recall, test_f1, test_balanced_acc]
})

# Print the results DataFrame
results_df
```

Out[59]:

	Metric	Train	Test
0	**Accuracy**	**1.0**	**0.974855**
1	**Precision**	**1.0**	**0.975299**
2	**Recall**	**1.0**	**0.974855**
3	**F1-score**	**1.0**	**0.973888**
4	**Balanced Accuracy**	**1.0**	**0.913231**

Model evaluation

In [60]:

```
# Generate classification report for training data
train_report = classification_report(y_train, y_train_pred)
print("Classification Report for Training Data:\n", train_report)

print('-'*127)

# Generate classification report for test data
test_report = classification_report(y_test, y_test_pred)
print("Classification Report for Test Data:\n", test_report)
```

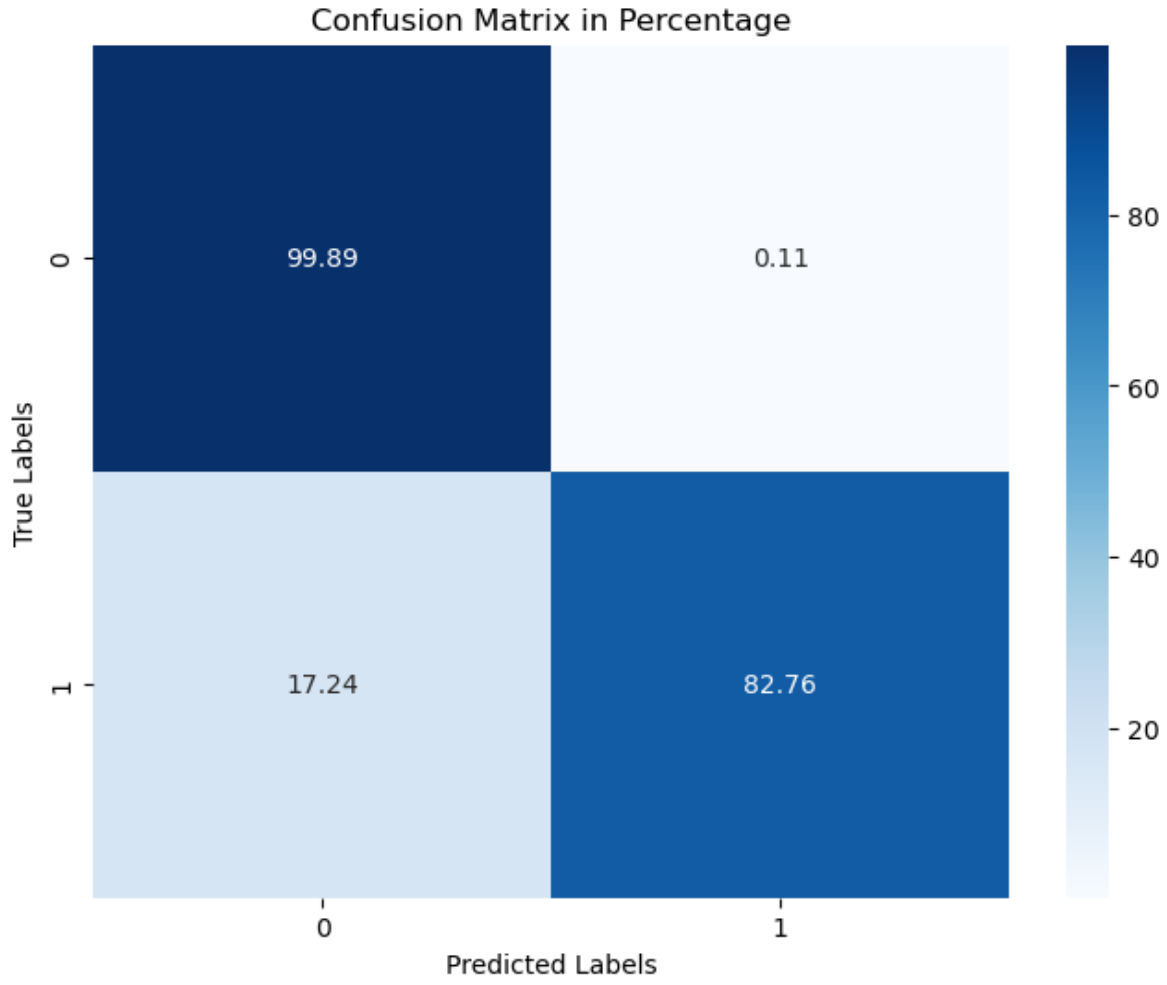
```
Classification Report for Training Data:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      3627
           1       1.00      1.00      1.00       508

    accuracy                           1.00      4135
   macro avg       1.00      1.00      1.00      4135
weighted avg       1.00      1.00      1.00      4135

---------------------------------------------------------------------------------------
---------------------------------------
Classification Report for Test Data:
              precision    recall  f1-score   support

           0       0.97      1.00      0.99       889
           1       0.99      0.83      0.90       145

    accuracy                           0.97      1034
```

accuracy			0.97	1034
macro avg	0.98	0.91	0.94	1034
weighted avg	0.98	0.97	0.97	1034

Confusion Matrix

In [61]:

```
# Generate confusion matrix
cm = confusion_matrix(y_test, y_test_pred)

# Calculate percentages
cm_percent = (cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]) * 100

# Get class labels
class_labels = unique_labels(y_test, y_test_pred)

# Create a heatmap of the confusion matrix
plt.figure(figsize=(8, 6))
sns.heatmap(cm_percent, annot=True, fmt=".2f", cmap="Blues", xticklabels=class_labels, y
ticklabels=class_labels)
plt.xlabel('Predicted Labels')
plt.ylabel('True Labels')
plt.title('Confusion Matrix in Percentage')
plt.show()
```



Cross Validation

In [62]:

```
#cross validation of Recall

from sklearn.model_selection import cross_val_score
```

```
scores = cross_val_score(random_forest_classifier, X_train, y_train, cv=5, scoring='accu
racy',n_jobs=-1)

print("Cross-Validation Scores (Accuracy):", scores)
print()
print("Mean Accuracy Score:", scores.mean())
```

```
Cross-Validation Scores (Accuracy): [0.9758162  0.96856106 0.97339782 0.96493349 0.968561
06]

Mean Accuracy Score: 0.970253929866989
```

In [63]:

```
#cross validation of Recall

scores = cross_val_score(random_forest_classifier, X_train, y_train, cv=5, scoring='accu
racy',n_jobs=-1)

print("Cross-Validation Scores (Accuracy):", scores)
print()
print("Mean Accuracy Score:", scores.mean())
```

```
Cross-Validation Scores (Accuracy): [0.9758162  0.96856106 0.97339782 0.96493349 0.968561
06]

Mean Accuracy Score: 0.970253929866989
```

Save Model to System

In [64]:

```
import joblib

model = random_forest_classifier

joblib.dump(model, 'Ham_Vs_Spam_Classifier.pkl')
```

Out[64]:

```
['Ham_Vs_Spam_Classifier.pkl']
```