Email_Spam_or_Ham_Classification

May 26, 2023

1 Problem Statements: Email Spam or Ham Classification

1.1 Description:

- **Spam or ham classification is the process of automatically identifying whether an email message is spam or ham. Spam is unsolicited commercial email, while ham is any other type of email. Spammers use a variety of techniques to try to trick people into opening their emails, such as using deceptive subject lines, including attachments, and using personal information. Spam can be a nuisance and can also be a security risk, as it can contain malware or phishing links.**

- **Spam or ham classification is a challenging problem, as spam messages are constantly evolving. However, with the right machine learning algorithm and a large enough training dataset, it is possible to achieve high accuracy in spam or ham classification.**

Here are some of the benefits of spam or ham classification:

- **Reduces the amount of spam that users receive**
- **Protects users from malware and phishing attacks**
- **Frees up users' time so they can focus on more important tasks**
- **Here are some of the challenges of spam or ham classification:**

2 1.0 Importing Libraries

[ ]:

```
import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
plt.style.use('dark_background')
import seaborn as sns
sns.set_style('whitegrid')

import nltk
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
from nltk.tokenize import RegexpTokenizer
from sklearn.metrics import accuracy_score, classification_report,␣
  ↪confusion_matrix
```

```
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import LinearSVC, SVC
from time import perf_counter
import warnings
warnings.filterwarnings(action='ignore')
```

3 2.0 Datasets Infromation

3.1 2.1 Reading Datasets

```
[ ]: from google.colab import drive
     drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

```
[ ]: df=pd.read_csv("/content/drive/MyDrive/Colab Notebooks/DS_PROJECT/
       ↪Email_Spam_or_Ham_Classification/spam_ham_dataset.csv")
     df.head()
```

```
[ ]:    Unnamed: 0 label                                               text  \
     0         605   ham  Subject: enron methanol ; meter # : 988291\r\n…
     1        2349   ham  Subject: hpl nom for january 9 , 2001\r\n( see…
     2        3624   ham  Subject: neon retreat\r\nho ho ho , we ' re ar…
     3        4685  spam  Subject: photoshop , windows , office . cheap …
     4        2030   ham  Subject: re : indian springs\r\nthis deal is t…

        label_num
     0          0
     1          0
     2          0
     3          1
     4          0
```

3.2 2.2 Datasets Summary:

- Here are the information features of the dataset:
- **Label:** This is the target variable, which indicates whether the email is spam (1) or ham (0). Subject: This is the subject line of the email.
- **Body:** This is the body of the email.

- **WordCount:** This is the number of words in the email.
- **UniqueWords:** This is the number of unique words in the email.
- **StopWords:** This is the number of stop words in the email.
- **Punctuation:** This is the number of punctuation marks in the email.
- **Capitalization:** This is the number of capitalized words in the email.
- **SpamWords:** This is the number of spam words in the email.
- **HamWords:** This is the number of ham words in the email.

4 3.0 Data Exploration

```
[ ]: df.drop('Unnamed: 0',axis=1,inplace=True)
     df.columns=['Label','Text','Label_Number']
     df.head()
```

```
[ ]:   Label                                               Text  Label_Number
     0   ham  Subject: enron methanol ; meter # : 988291\r\n…             0
     1   ham  Subject: hpl nom for january 9 , 2001\r\n( see…             0
     2   ham  Subject: neon retreat\r\nho ho ho , we ' re ar…             0
     3  spam  Subject: photoshop , windows , office . cheap …             1
     4   ham  Subject: re : indian springs\r\nthis deal is t…             0
```

```
[ ]: df.shape
```

```
[ ]: (5171, 3)
```

```
[ ]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5171 entries, 0 to 5170
Data columns (total 3 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   Label         5171 non-null   object
 1   Text          5171 non-null   object
 2   Label_Number  5171 non-null   int64
dtypes: int64(1), object(2)
memory usage: 121.3+ KB
```

```
[ ]: df.isnull().sum()
```

```
[ ]: Label           0
     Text            0
     Label_Number    0
     dtype: int64
```

- **Let's Check how many many email is spam and how many Ham.**

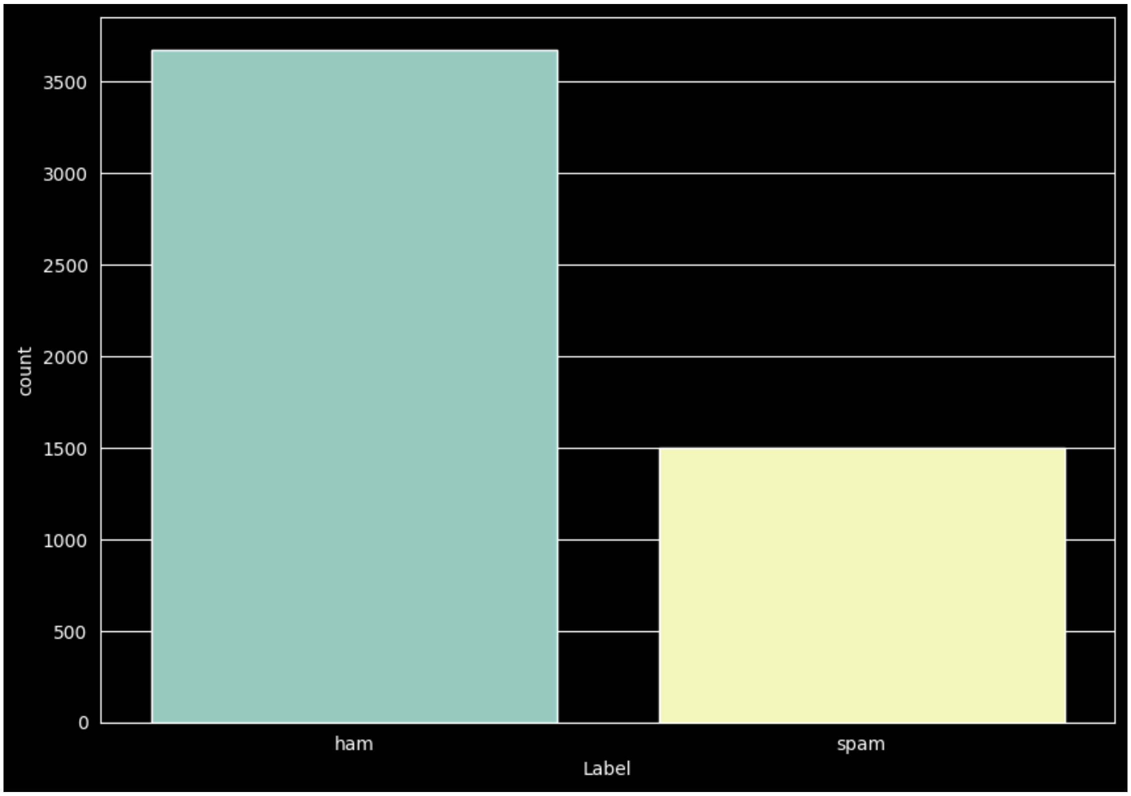
```
[ ]: df['Label_Number'].value_counts()
```

```
[ ]: 0    3672
     1    1499
     Name: Label_Number, dtype: int64
```

- 3672 is Ham and 1499 is spam

```
[ ]: plt.style.use('dark_background')
     plt.figure(figsize=(10,7))
     sns.countplot(data=df,x="Label")
```

```
[ ]: <Axes: xlabel='Label', ylabel='count'>
```



- **Count The word in each row dataframe**

```
[ ]: import nltk
     nltk.download('punkt')
```

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

[ ]:

```
True
```

[ ]:

```
def count_words(text):
    words = word_tokenize(text)#word_tokenize() function to split the string␣
 ↪into a list of words. It then returns the length of this list.
    return len(words)

#This line of code uses the apply() function to apply the count_words()␣
 ↪function to each row in the df DataFrame.
df['count'] = df['Text'].apply(count_words)
df['count']
```

[ ]:

```
0        68
1        24
2       551
3        49
4        71
       …
5166    156
5167    306
5168     79
5169    112
5170    200
Name: count, Length: 5171, dtype: int64
```

[ ]:

```
df.groupby("Label_Number")['count'].mean()
```

[ ]:

```
Label_Number
0    226.239107
1    236.387592
Name: count, dtype: float64
```

[ ]:

```
%%time
#magic function to time the execution of the following code.
def clean_str(string, reg = RegexpTokenizer(r'[a-z]+')):  #unction to split the␣
 ↪string into a list of words.
    # Clean a string with RegexpTokenizer
    string = string.lower()
    tokens = reg.tokenize(string)
    return " ".join(tokens)

print('Before cleaning:')
df.head()
```

```
Before cleaning:
CPU times: user 1.22 ms, sys: 8 µs, total: 1.22 ms
Wall time: 1.2 ms
```

```
[ ]:   Label                                             Text  Label_Number  \
     0   ham  Subject: enron methanol ; meter # : 988291\r\n…             0
     1   ham  Subject: hpl nom for january 9 , 2001\r\n( see…             0
     2   ham  Subject: neon retreat\r\nho ho ho , we ' re ar…             0
     3  spam  Subject: photoshop , windows , office . cheap …             1
     4   ham  Subject: re : indian springs\r\nthis deal is t…             0

        count
     0     68
     1     24
     2    551
     3     49
     4     71
```

```
[ ]: print('After cleaning:')
     df['Text'] = df['Text'].apply(lambda string: clean_str(string))
     df.head()
```

```
After cleaning:
```

```
[ ]:   Label                                             Text  Label_Number  \
     0   ham  subject enron methanol meter this is a follow …             0
     1   ham  subject hpl nom for january see attached file …             0
     2   ham  subject neon retreat ho ho ho we re around to …             0
     3  spam  subject photoshop windows office cheap main tr…             1
     4   ham  subject re indian springs this deal is to book…             0

        count
     0     68
     1     24
     2    551
     3     49
     4     71
```

- **Removing Subject From Each Mail**

```
[ ]: df["Text"] = [' '.join([item for item in x.split()
                       if item not in 'subject'])
                       for x in df["Text"]]
     df.head()
```

```
[ ]:   Label                                             Text  Label_Number  \
     0   ham  enron methanol meter this is a follow up to th…             0
     1   ham  hpl nom for january see attached file hplnol x…             0
     2   ham  neon retreat ho ho ho we re around to that mos…             0
     3  spam  photoshop windows office cheap main trending a…             1
     4   ham  re indian springs this deal is to book the tec…             0
```

```
   count
0     68
1     24
2    551
3     49
4     71
```

[ ]:

```python
# Import the PorterStemmer class from the nltk.stem module.
# The PorterStemmer class is used to stem words. Stemming is the process of␣
 ↪reducing a word to its root form.
from nltk.stem import PorterStemmer

# Create a PorterStemmer object.
# The PorterStemmer object is used to stem words.
stemmer = PorterStemmer()

# Define the `stemming()` function.
# The `stemming()` function takes a string as input and returns a stemmed␣
 ↪version of the string.
# The function first splits the string into a list of words.
# It then uses the `stemmer.stem()` method to stem each word in the list.
# Finally, it returns the list of stemmed words as a single string.
def stemming(text):
  """
  Stems the given text.

  Args:
    text: The text to stem.

  Returns:
    The stemmed text.
  """

  # Stem each word in the list.
  # Join the stemmed words together with spaces.

  # Return the stemmed text.
  return ''.join([stemmer.stem(word) for word in text])

# Apply the `stemming()` function to each row in the `df['Text']` column.
# The `apply()` function takes a function as input and applies it to each row␣
 ↪in the DataFrame.
# In this case, the `stemming()` function is applied to each row in the␣
 ↪`df['Text']` column.
# The result is a new column in the DataFrame called `df['StemmedText']`.
# This column contains the stemmed version of the text in each email.
df['Text'] = df['Text'].apply(stemming)
```

```
# Print the first five rows of the `df` DataFrame.
# This is done to show the data after the text has been stemmed.
df.head()
```

```
[ ]:   Label                                               Text  Label_Number  \
    0    ham  enron methanol meter this is a follow up to th…             0
    1    ham  hpl nom for january see attached file hplnol x…             0
    2    ham  neon retreat ho ho ho we re around to that mos…             0
    3   spam  photoshop windows office cheap main trending a…             1
    4    ham  re indian springs this deal is to book the tec…             0

       count
    0     68
    1     24
    2    551
    3     49
    4     71
```

5 4.0 Feature Extraction

- **Spliting Into dependent and independent varaiable**

```
[ ]: X=df.loc[:,'Text'] # independent
     y=df.loc[:,'Label_Number']

     X.shape ,y.shape
```

```
[ ]: ((5171,), (5171,))
```

- **The code below provided will create a CountVectorizer object, fit it to the Text column of the df DataFrame, and then transform the Text column into a sparse matrix of token counts. The y variable will contain the labels for the text data.**

```
[ ]: # Import the CountVectorizer class from the scikit-learn library.
     from sklearn.feature_extraction.text import CountVectorizer

     # Create a CountVectorizer object.
     cv = CountVectorizer()

     # Fit the CountVectorizer object to the Text column of the df DataFrame.
     # This will transform the column into a sparse matrix of token counts.
     X = cv.fit_transform(df.Text)

     # Assign the Label column of the df DataFrame to the y variable.
     y = df.Label
```

6 5.0 Model Training

[ ]:

```
# Split the data into a training set and a test set.
# The training set will contain 80% of the data and the test set will contain 20% of the data.
# The `random_state` argument is used to ensure that the data is split randomly each time the code is run.
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)

# Create a dictionary of models, where the keys are the names of the models and the values are the models themselves.
# The models are created using the `RandomForestClassifier()`, `GradientBoostingClassifier()`, `MultinomialNB()`, `LogisticRegression()`, `KNeighborsClassifier()`, `DecisionTreeClassifier()`, `LinearSVC()`, and `SVC()` classes from the scikit-learn library.
models = {
    "Random Forest": {"model":RandomForestClassifier(), "perf":0},
    "Gradient Boosting": {"model":GradientBoostingClassifier(), "perf":0},
    "MultinomialNB": {"model":MultinomialNB(), "perf":0},
    "Logistic Regr.": {"model":LogisticRegression(), "perf":0},
    "KNN": {"model":KNeighborsClassifier(), "perf":0},
    "Decision Tree": {"model":DecisionTreeClassifier(), "perf":0},
    "SVM (Linear)": {"model":LinearSVC(), "perf":0},
    "SVM (RBF)": {"model":SVC(), "perf":0}
}

# For each model in the dictionary, train the model on the training set and measure the time it takes to train the model.
# Print the name of the model and the time it took to train the model.
for name, model in models.items():
    # Start a timer.
    start = perf_counter()

    # Fit the model on the training set.
    model['model'].fit(X_train, y_train)

    # Calculate the time it took to train the model.
    duration = perf_counter() - start

    # Round the time to two decimal places.
    duration = round(duration,2)

    # Store the time it took to train the model in the `perf` key of the model dictionary.
    model["perf"] = duration
    # Print the name of the model and the time it took to train the model.
    print(f"{name:20} trained in {duration} sec")
```

```
Random Forest        trained in 7.12 sec
Gradient Boosting    trained in 22.68 sec
MultinomialNB        trained in 0.02 sec
Logistic Regr.       trained in 1.45 sec
KNN                  trained in 0.01 sec
Decision Tree        trained in 0.81 sec
SVM (Linear)         trained in 0.2 sec
SVM (RBF)            trained in 5.12 sec
```

6.1 5.2 Model Accuracy

[ ]:

```
# Create an empty list called `models_accuracy`.
models_accuracy = []

# Iterate over the dictionary of models.
for name, model in models.items():

    # Calculate the accuracy of the model on the test set.
    accuracy = model["model"].score(X_test, y_test)

    # Append a tuple to the `models_accuracy` list.
    # The tuple contains the name of the model, the accuracy of the model on␣
  ↪the test set, and the time it took to train the model.
    models_accuracy.append([name, accuracy, model["perf"]])

# Create an empty list called `models_accuracy1`.
models_accuracy1 = []

# Iterate over the dictionary of models.
for name, model in models.items():

    # Calculate the accuracy of the model on the training set.
    accuracy = model["model"].score(X_train, y_train)

    # Append a tuple to the `models_accuracy1` list.
    # The tuple contains the name of the model, the accuracy of the model on␣
  ↪the training set, and the time it took to train the model.
    models_accuracy1.append([name, accuracy, model["perf"]])
```

[ ]:

```
# Create a Pandas DataFrame from the `models_accuracy` list.
df_accuracy = pd.DataFrame(models_accuracy)

# Set the column names of the DataFrame.
df_accuracy.columns = ['Model', 'Test Accuracy', 'Training time (sec)']
```

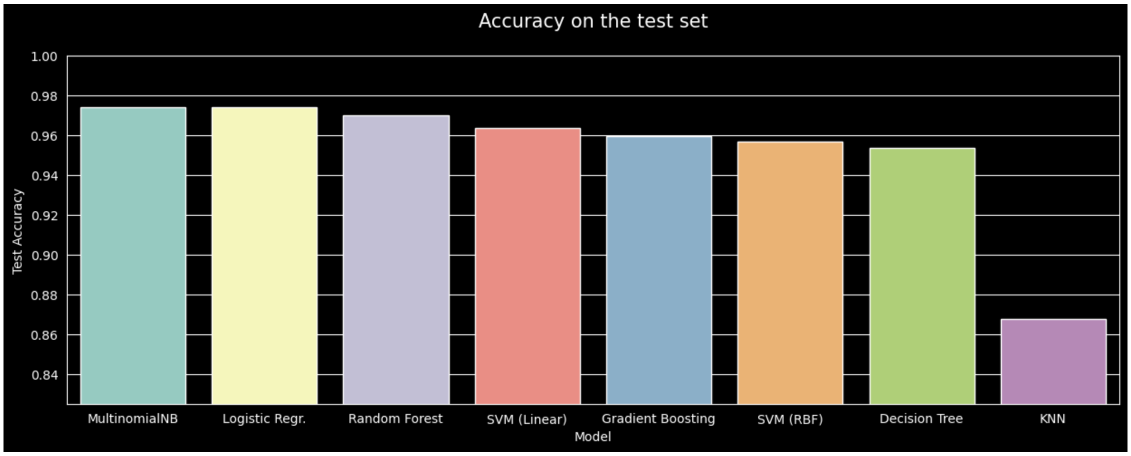
```
# Sort the DataFrame by the `Test Accuracy` column in descending order.
df_accuracy.sort_values(by = 'Test Accuracy', ascending = False, inplace=True)

# Reset the index of the DataFrame.
df_accuracy.reset_index(drop = True, inplace=True)

# Print the DataFrame.
df_accuracy
```

[ ]:

```
               Model  Test Accuracy  Training time (sec)
0      MultinomialNB       0.973913                 0.02
1     Logistic Regr.       0.973913                 1.45
2      Random Forest       0.970048                 7.12
3       SVM (Linear)       0.963285                 0.20
4  Gradient Boosting       0.959420                22.68
5          SVM (RBF)       0.956522                 5.12
6      Decision Tree       0.953623                 0.81
7                KNN       0.867633                 0.01
```

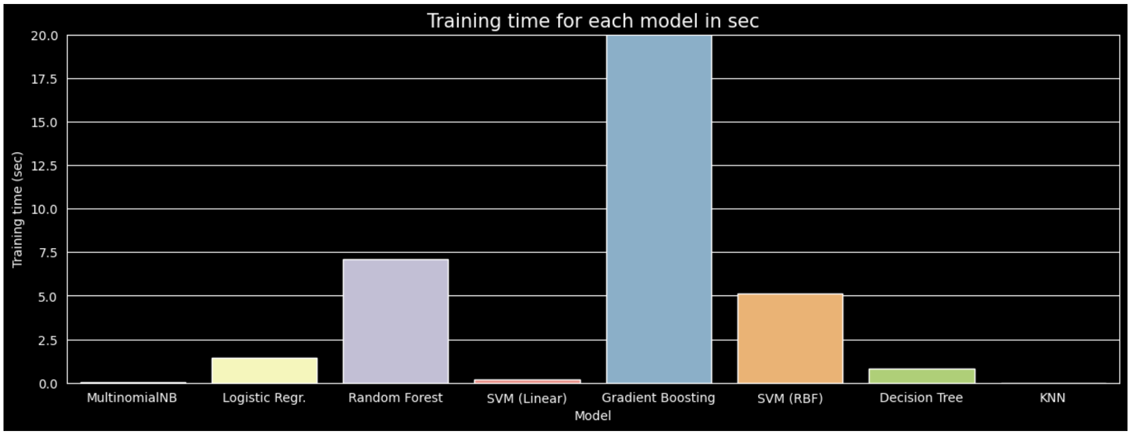
[ ]:

```
plt.figure(figsize = (15,5))
sns.barplot(x = 'Model', y ='Test Accuracy', data = df_accuracy)
plt.title('Accuracy on the test set\n', fontsize = 15)
plt.ylim(0.825,1)
plt.show()
```



[ ]:

```
plt.figure(figsize = (15,5))
sns.barplot(x = 'Model', y = 'Training time (sec)', data = df_accuracy)
plt.title('Training time for each model in sec', fontsize = 15)
plt.ylim(0,20)
plt.show()
```



- **MutinomialNB gives the best results in terms of both the training tone and the Test Accuracy**

[ ]:

```python
# Import the MultinomialNB class from the sklearn.naive_bayes library.
from sklearn.naive_bayes import MultinomialNB

# Import the GridSearchCV class from the sklearn.model_selection library.
from sklearn.model_selection import GridSearchCV

# Create a dictionary of hyperparameters to search over.
parameters = {"alpha": [0.2, 1, 2, 5, 10], "fit_prior": [True, False]}

# Create a GridSearchCV object.
grid = GridSearchCV(MultinomialNB(), param_grid=parameters)

# Fit the GridSearchCV object to the training data.
grid.fit(X_train, y_train)

# Create a DataFrame of the GridSearchCV results.
df_results = pd.DataFrame(grid.cv_results_)

# Select the `params` and `mean_test_score` columns from the DataFrame.
df_results = df_results[['params', 'mean_test_score']]

# Sort the DataFrame by the `mean_test_score` column in descending order.
df_results.sort_values(by='mean_test_score', ascending=False, inplace=True)

# Print the DataFrame.
print(df_results)
```

```
                               params  mean_test_score
0   {'alpha': 0.2, 'fit_prior': True}         0.981625
1  {'alpha': 0.2, 'fit_prior': False}         0.981384
```

```
3    {'alpha': 1, 'fit_prior': False}         0.980899
2     {'alpha': 1, 'fit_prior': True}         0.978240
5    {'alpha': 2, 'fit_prior': False}         0.972197
4     {'alpha': 2, 'fit_prior': True}         0.967845
7    {'alpha': 5, 'fit_prior': False}         0.937141
6     {'alpha': 5, 'fit_prior': True}         0.931096
9   {'alpha': 10, 'fit_prior': False}         0.890478
8    {'alpha': 10, 'fit_prior': True}         0.881290
```

[ ]:
```
grid.best_params_
```

[ ]:
```
{'alpha': 0.2, 'fit_prior': True}
```

[ ]:
```
# Import the MultinomialNB class from the sklearn.naive_bayes library.
from sklearn.naive_bayes import MultinomialNB

# Get the best hyperparameters from the GridSearchCV object.
alpha, fit_prior = grid.best_params_['alpha'], grid.best_params_['fit_prior']

# Create a MultinomialNB model with the best hyperparameters.
model = MultinomialNB(alpha=alpha)

# Fit the model to the training data.
model.fit(X_train, y_train)

# Predict the labels of the test data.
y_pred = model.predict(X_test)

# Import the classification_report and accuracy_score functions from the␣
 ↪sklearn.metrics library.
from sklearn.metrics import classification_report, accuracy_score

# Print the classification report.
print(classification_report(y_test, y_pred))

# Print the accuracy score.
print(f'## Accuracy: {round(accuracy_score(y_test, y_pred), 3) * 100}%\n')
```

```
              precision    recall  f1-score   support

         ham       0.98      0.98      0.98       732
        spam       0.96      0.96      0.96       303

    accuracy                           0.97      1035
   macro avg       0.97      0.97      0.97      1035
weighted avg       0.97      0.97      0.97      1035

## Accuracy: 97.5%
```

[ ]:

```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

         ham       0.98      0.98      0.98       732
        spam       0.96      0.96      0.96       303

    accuracy                           0.97      1035
   macro avg       0.97      0.97      0.97      1035
weighted avg       0.97      0.97      0.97      1035
```

[ ]:

```
def display_result(df, number=2):
    """
    Displays the results of the spam classifier on a given number of emails.

    Args:
        df: The DataFrame containing the emails.
        number: The number of emails to display.

    Returns:
        None.
    """

    # Iterate over the first `number` emails in the DataFrame.
    for i in range(number):

        # Get the email text and label.
        msg = df['Text'].iloc[i]
        label = df["Label"].iloc[i]

        # Convert the email text to a vector.
        msg_vec = cv.transform([msg])

        # Predict the label of the email.
        pred_label = model.predict(msg_vec)

        # Print the real and predicted labels.
        print(f"**Real: {label}, Predicted: {pred_label[0]}**")

        # Print the email text.
        print(f"**E-Mail:** {msg}")

        # Print a separator between emails.
        print("_______________________________________________________________")
```

```python
# Get the spam and ham emails.
df_spam = df[df['Label'] == 'spam']
df_ham = df[df['Label'] == 'ham']

# Display the results for the spam emails.
display_result(df_spam)

# Display the results for the ham emails.
display_result(df_ham)
```

```
**Real: spam, Predicted: spam**
**E-Mail:** photoshop windows office cheap main trending abasements darer
prudently fortuitous undergone lighthearted charm orinoco taster railroad
affluent pornographic cuvier irvin parkhouse blameworthy chlorophyll robed
diagrammatic fogarty clears bayda inconveniencing managing represented smartness
hashish academies shareholders unload badness danielson pure caffein spaniard
chargeable levin

---------------------------------------------------------------
**Real: spam, Predicted: spam**
**E-Mail:** looking for medication we re the best source it is difficult to make
our material condition better by the best law but it is easy enough to ruin it
by bad laws excuse me you just found the best and simpliest site for medication
on the net no perscription easy delivery private secure and easy better see
rightly on a pound a week than squint on a million we ve got anything that you
will ever want erection treatment pills anti depressant pills weight loss and
more http splicings bombahakcx com knowledge and human power are synonymous only
high quality stuff for low rates moneyback guarantee there is no god nature
sufficeth unto herself in no wise hath she need of an author

---------------------------------------------------------------
**Real: ham, Predicted: ham**
**E-Mail:** enron methanol meter this is a follow up to the note i gave you on
monday preliminary flow data provided by daren please override pop daily volume
presently zero to reflect daily activity you can obtain from gas control this
change is needed asap for economics purposes

---------------------------------------------------------------
**Real: ham, Predicted: ham**
**E-Mail:** hpl nom for january see attached file hplnol xls hplnol xls

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

7 Thank You