q2-naive-bayes

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0.3 Naive Bayes Implementation

[1]:
```
from ucimlrepo import fetch_ucirepo
from tabulate import tabulate
import pandas as pd
import numpy as np
from sklearn import datasets
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, precision_score, recall_score,␣
↪f1_score
import matplotlib.pyplot as plt
import random
from collections import Counter
import seaborn as sns
```

0.4 Part A

[2]:
```
def roll_biased_die(k):
    probs = [1/(2**(i-1)) for i in range(2, k+1)]  # Probabilities for faces 2␣
↪to k
    probs = [1/(2**(k-1))] + probs  # Add probability for face 1 at the␣
↪beginning
    return random.choices(range(1, k+1), probs, k=1)[0]
```

[3]:
```
def simulate_rolls(k, num_rolls_per_simulation, num_simulations):
    results = []
    for _ in range(num_simulations):
        rolls = [roll_biased_die(k) for _ in range(num_rolls_per_simulation)]
        total = sum(rolls)
        results.append(total)
    return results
```

[4]:
```
def plot_histogram(results, num_simulations, num_rolls):
    sns.set(style="whitegrid")  # Use Seaborn's style
```

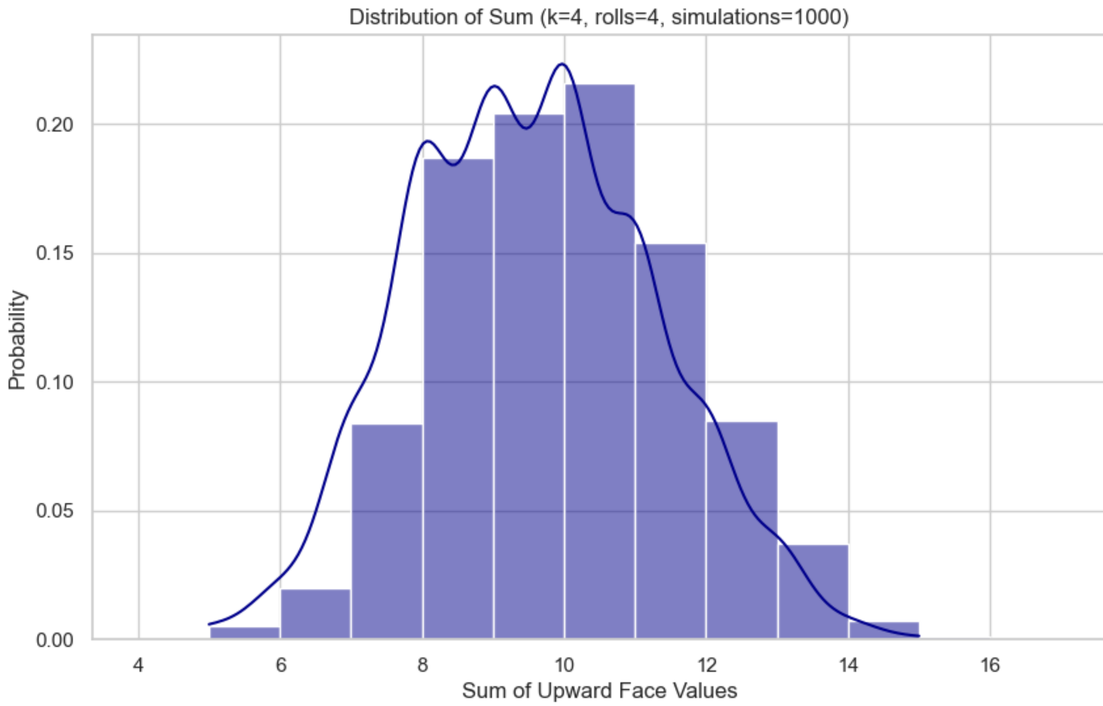
```
    plt.figure(figsize=(10, 6))  # Set the figure size

    sns.histplot(results, bins=range(num_rolls, num_rolls * k + 2), kde=True,␣
 ↪stat="probability", color='darkblue')
    plt.xlabel('Sum of Upward Face Values')
    plt.ylabel('Probability')
    plt.title(f'Distribution of Sum (k={k}, rolls={num_rolls},␣
 ↪simulations={num_simulations})')
    plt.show()
```

[5]:
```
def calculate_theoretical_expected_value(k, num_rolls):
    return sum([i * (1 / (2 ** (i - 1))) for i in range(2, k + 1)]) * num_rolls

## function to find the five_number summary
def five_number_summary(data):
    return np.percentile(data, [0, 25, 50, 75, 100])

def top_level_function(k,num_rolls_a, num_simulations_a):
    results_a = simulate_rolls(k, num_rolls_a, num_simulations_a)
    plot_histogram(results_a, num_simulations_a, num_rolls_a)
    expected_value_theoretical_a = calculate_theoretical_expected_value(k,␣
 ↪num_rolls_a)
    expected_value_actual_a = np.mean(results_a)
    summary_a = five_number_summary(results_a)
    print(f"Theoretical Expected Value: {expected_value_theoretical_a}")
    print(f"Actual Expected Value (Simulation): {expected_value_actual_a}")
    print(f"Five-Number Summary: {summary_a}")
```

0.4.1 Function calls

1. K=4 , number of rolls = 4, number of simulations = 1000;

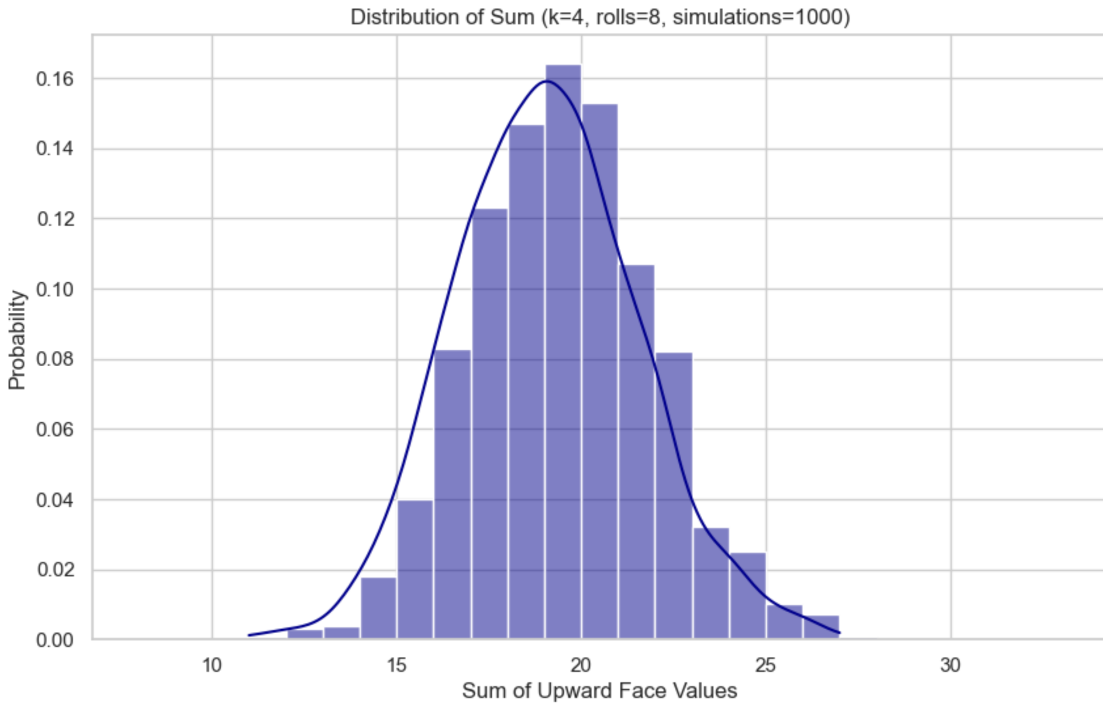
[6]:
```
k = 4
num_rolls_a = 4
num_simulations_a = 1000
top_level_function(k,num_rolls_a, num_simulations_a)
```




```
Theoretical Expected Value: 9.0
Actual Expected Value (Simulation): 9.533
Five-Number Summary: [ 5.   8.   9.5 11.  15. ]
```

1. K=4 , number of rolls = 8, number of simulations = 1000;

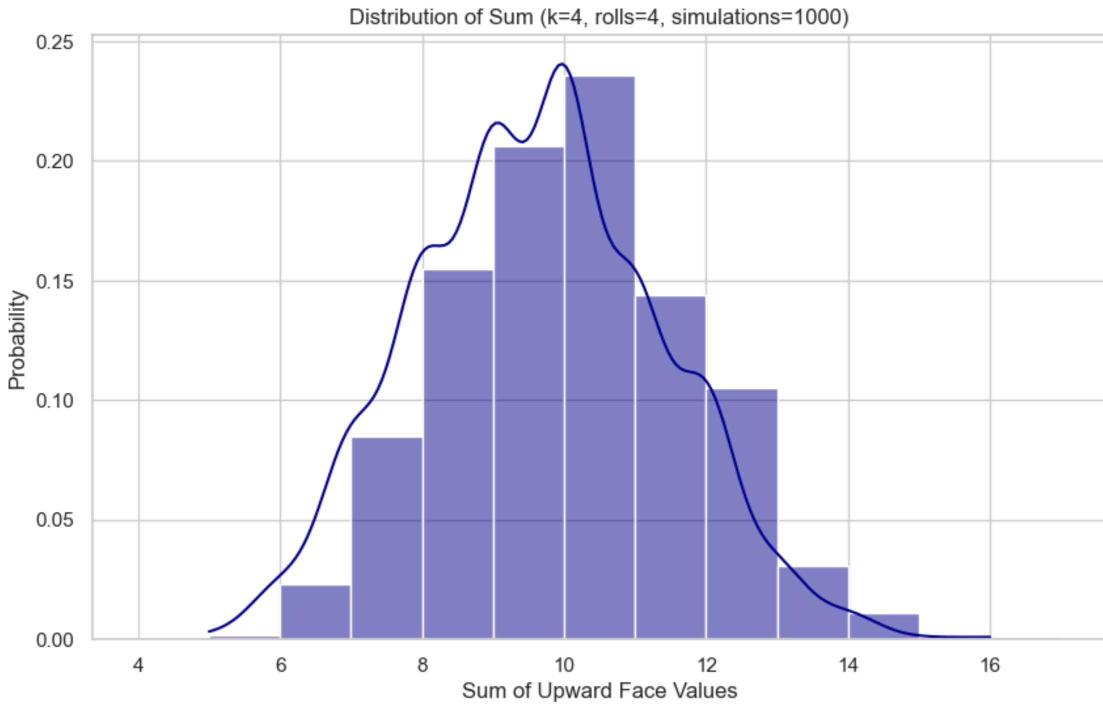
[7]:
```
k = 4
num_rolls_a = 8
num_simulations_a = 1000
top_level_function(k,num_rolls_a, num_simulations_a)
```




```
Theoretical Expected Value: 18.0
Actual Expected Value (Simulation): 19.038
Five-Number Summary: [11. 17. 19. 21. 27.]
```

1. K=16 , number of rolls = 4, number of simulations = 1000;k = 16

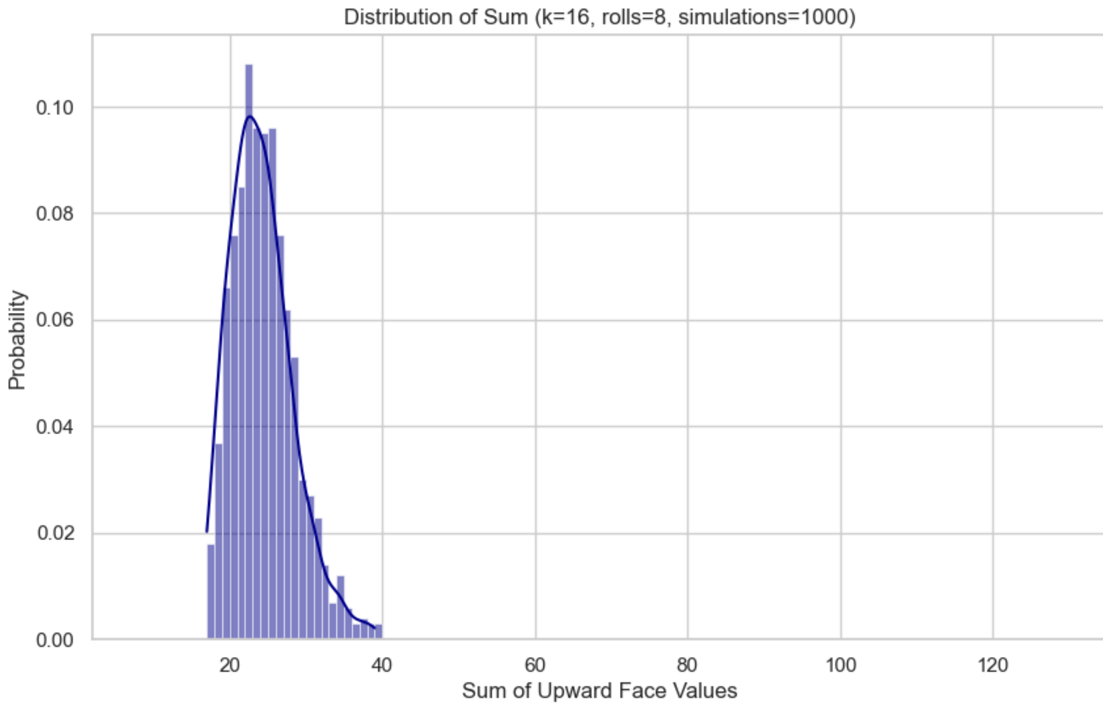
[8]:
```
num_rolls_a = 4
num_simulations_a = 1000
top_level_function(k,num_rolls_a, num_simulations_a)
```




```
Theoretical Expected Value: 9.0
Actual Expected Value (Simulation): 9.629
Five-Number Summary: [ 5.  8. 10. 11. 16.]
```

1. K=16 , number of rolls = 8, number of simulations = 1000;

[9]:
```
k = 16
num_rolls_a = 8
num_simulations_a = 1000
top_level_function(k,num_rolls_a, num_simulations_a)
```




```
Theoretical Expected Value: 23.99560546875
Actual Expected Value (Simulation): 24.106
Five-Number Summary: [17. 21. 24. 26. 39.]
```

[ ]:

0.5 Part B

[10]:
```python
spambase = fetch_ucirepo(id=94)
```

[11]:
```python
X = spambase.data.features
y = spambase.data.targets
```

[12]:
```python
X.head()
```

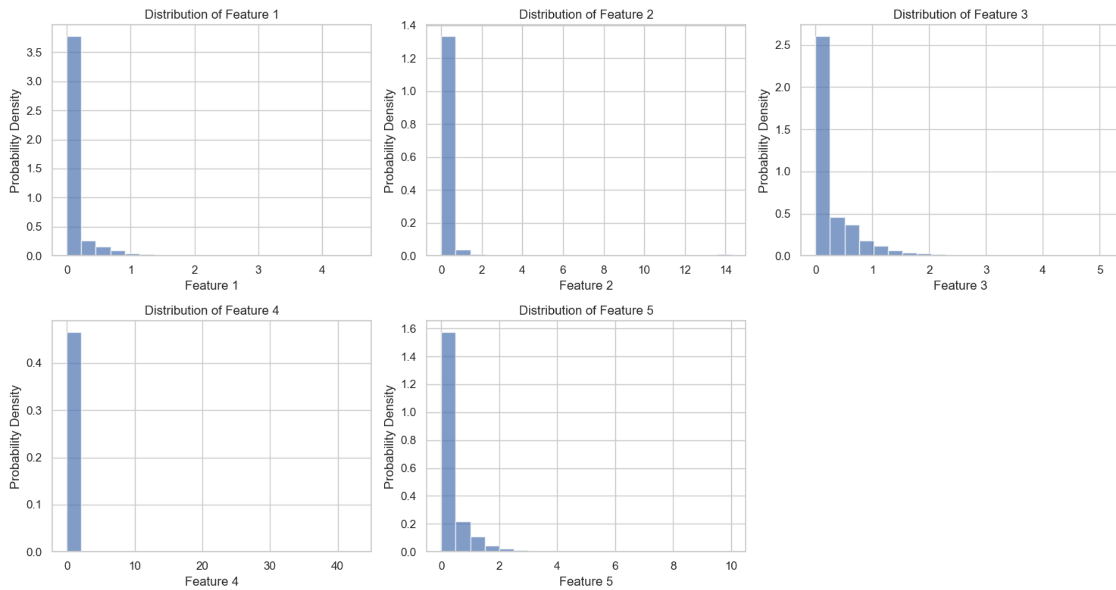
[12]:
```
   word_freq_make  word_freq_address  word_freq_all  word_freq_3d  \
0            0.00               0.64           0.64           0.0
1            0.21               0.28           0.50           0.0
2            0.06               0.00           0.71           0.0
3            0.00               0.00           0.00           0.0
4            0.00               0.00           0.00           0.0

   word_freq_our  word_freq_over  word_freq_remove  word_freq_internet  \
0           0.32            0.00              0.00                0.00
```

```
1           0.14            0.28              0.21                0.07
2           1.23            0.19              0.19                0.12
3           0.63            0.00              0.31                0.63
4           0.63            0.00              0.31                0.63

   word_freq_order  word_freq_mail  …  word_freq_conference  char_freq_;  \
0             0.00            0.00  …                   0.0         0.00
1             0.00            0.94  …                   0.0         0.00
2             0.64            0.25  …                   0.0         0.01
3             0.31            0.63  …                   0.0         0.00
4             0.31            0.63  …                   0.0         0.00

   char_freq_(  char_freq_[  char_freq_!  char_freq_$  char_freq_#  \
0        0.000          0.0        0.778        0.000        0.000
1        0.132          0.0        0.372        0.180        0.048
2        0.143          0.0        0.276        0.184        0.010
3        0.137          0.0        0.137        0.000        0.000
4        0.135          0.0        0.135        0.000        0.000

   capital_run_length_average  capital_run_length_longest  \
0                       3.756                          61
1                       5.114                         101
2                       9.821                         485
3                       3.537                          40
4                       3.537                          40

   capital_run_length_total
0                       278
1                      1028
2                      2259
3                       191
4                       191

[5 rows x 57 columns]
```

[13]:
```python
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.3, random_state=42)
X_val, X_test, y_val, y_test = train_test_split(X_test, y_test,
test_size=0.5, random_state=42)
```

[14]:
```python
# selected_columns = ['word_freq_hp', 'word_freq_make', 'word_freq_internet',
 'word_freq_mail', 'word_freq_all']
X_ = X.to_numpy()
selected_columns = [X_[:, 0], X_[:, 1], X_[:, 2], X_[:, 3], X_[:, 4]]

plt.figure(figsize=(15, 8))
```

```python
for i, column_data in enumerate(selected_columns):
    plt.subplot(2, 3, i + 1)
    plt.hist(column_data, bins=20, density=True, alpha=0.7)
    plt.title(f'Distribution of Feature {i+1}')
    plt.xlabel(f'Feature {i+1}')
    plt.ylabel('Probability Density')

plt.tight_layout()
plt.show()
```



[15]:
```python
class Naive_bayes :

    def __init__(self) :
        self.no_of_features = 0
        self.mean_list = [[],[]]
        self.var_list = [[],[]]
        self.p = [[],[]]
        self.y_pred = []
        self.no_of_parameters = 0

    def fit(self,X_train,y_train) :
        self.no_of_features = X_train.shape[1]
        sum1 = np.sum(y_train,axis=0)
        self.p[1] = sum1/y_train.shape[0]
        self.p[0] = 1-self.p[1]
        for i in range(self.no_of_features) :
```

```
            self.mean_list[1].append(np.mean(X_train.
↪loc[(y_train['Class']==1),X_train.columns[i]]))
            self.mean_list[0].append(np.mean(X_train.
↪loc[(y_train['Class']==0),X_train.columns[i]]))
            self.var_list[1].append(np.var(X_train.
↪loc[(y_train['Class']==1),X_train.columns[i]]))
            self.var_list[0].append(np.var(X_train.
↪loc[(y_train['Class']==0),X_train.columns[i]]))


        self.mean_list[1] = np.array(self.mean_list[1])
        self.mean_list[0] = np.array(self.mean_list[0])
        self.var_list[1] = np.array(self.var_list[1])
        self.var_list[0] = np.array(self.var_list[0])

        self.no_of_parameters = 2*self.no_of_features + 2

    def predict(self,X_test) :
        for i in range(X_test.shape[0]) :
            p1 = np.prod((1/np.sqrt(2*np.pi*self.var_list[1]))*np.exp(-((X_test.
↪iloc[i,:]-self.mean_list[1])**2)/(2*self.var_list[1])))
            p0 = np.prod((1/np.sqrt(2*np.pi*self.var_list[0]))*np.exp(-((X_test.
↪iloc[i,:]-self.mean_list[0])**2)/(2*self.var_list[0])))

            if (p1*self.p[1] > p0*self.p[0]).all():
                self.y_pred.append(1)
            else :
                self.y_pred.append(0)
        # return np array
        return self.y_pred
```

[16]:
```
# Initialize and fit the Naive Bayes classifier
nb_classifier = Naive_bayes()
nb_classifier.fit(X_train, y_train)

# Make predictions on the test data
y_pred = nb_classifier.predict(X_test)
print(y_pred[:20])
```

```
C:\Users\GKS\AppData\Local\Temp\ipykernel_16312\1708062161.py:32:
RuntimeWarning: divide by zero encountered in divide
  p1 = np.prod((1/np.sqrt(2*np.pi*self.var_list[1]))*np.exp(-((X_test.iloc[i,:]-
self.mean_list[1])**2)/(2*self.var_list[1])))
```

```
[0, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 0, 1, 0]
```

[17]:
```
def print_res(y_test, y_pred):
    y_test = np.ravel(y_test)
    y_pred = np.ravel(y_pred)
    f1 = f1_score(y_test, y_pred)
    acc = accuracy_score(y_test, y_pred)
    prec = precision_score(y_test, y_pred)
    recal = recall_score(y_test, y_pred)

    table = [["Metrics", "Value"],
             ["Accuracy", acc],
             ["Precision", prec],
             ["Recall", recal],
             ["F1-score", f1]]

    print(tabulate(table, headers="firstrow", tablefmt="fancy_grid"))
print("The Accuracy Scores without log transformations")
print_res(y_test,y_pred)
```

```
The Accuracy Scores without log transformations
```

Metrics	Value
Accuracy	0.817656
Precision	0.709424
Recall	0.947552
F1-score	0.811377

[18]:
```
X_train_new = np.log(X_train+1)
X_test_new = np.log(X_test+1)
X_train_new.head()
```

[18]:
```
      word_freq_make  word_freq_address  word_freq_all  word_freq_3d  \
958         0.000000           0.000000       0.000000           0.0
1533        0.000000           0.000000       0.000000           0.0
654         0.285179           0.000000       0.285179           0.0
1497        0.418710           0.837248       0.231112           0.0
3844        0.000000           0.000000       0.000000           0.0

      word_freq_our  word_freq_over  word_freq_remove  word_freq_internet  \
958        0.000000        0.000000          0.792993            0.000000
1533       0.000000        0.000000          0.000000            0.000000
654        0.000000        0.000000          0.506818            0.000000
1497       1.360977        0.231112          0.582216            0.231112
```

```
3844       0.000000        0.000000         0.000000           0.000000

      word_freq_order  word_freq_mail  …  word_freq_conference  char_freq_;  \
958               0.0        0.792993  …                    0.0          0.0
1533              0.0        0.000000  …                    0.0          0.0
654               0.0        0.000000  …                    0.0          0.0
1497              0.0        0.582216  …                    0.0          0.0
3844              0.0        0.000000  …                    0.0          0.0

      char_freq_(  char_freq_[  char_freq_!  char_freq_$  char_freq_#  \
958      0.000000          0.0     0.000000     0.000000     0.000000
1533     0.188966          0.0     0.348542     0.188966     0.000000
654      0.109751          0.0     0.340749     0.381172     0.298622
1497     0.129272          0.0     0.044973     0.000000     0.000000
3844     0.000000          0.0     0.000000     0.000000     0.000000

      capital_run_length_average  capital_run_length_longest  \
958                     0.984323                    2.772589
1533                    1.571113                    2.833213
654                     2.070905                    3.784190
1497                    1.369657                    4.110874
3844                    2.708050                    3.988984

      capital_run_length_total
958                   4.060443
1533                  4.127134
654                   6.242223
1497                  4.912655
3844                  4.043051

[5 rows x 57 columns]
```

[19]:

```
nb_classifier_new = Naive_bayes()
nb_classifier_new.fit(X_train_new, y_train)

# Make predictions on the test data
y_pred = nb_classifier_new.predict(X_test_new)
print(type(X_train_new), type(y_train), type(X_test_new))
```

```
C:\Users\GKS\AppData\Local\Temp\ipykernel_16312\1708062161.py:32:
RuntimeWarning: divide by zero encountered in divide
  p1 = np.prod((1/np.sqrt(2*np.pi*self.var_list[1]))*np.exp(-((X_test.iloc[i,:]-
self.mean_list[1])**2)/(2*self.var_list[1])))
```

```
<class 'pandas.core.frame.DataFrame'> <class 'pandas.core.frame.DataFrame'>
<class 'pandas.core.frame.DataFrame'>
```

[20]:
```
print("The Accuracy Scores with log transformations")
print_res(y_test,y_pred)
```

The Accuracy Scores with log transformations

Metrics	Value
Accuracy	0.845152
Precision	0.745205
Recall	0.951049
F1-score	0.835637

0.6 Part C

[21]:
```
from sklearn.naive_bayes import GaussianNB
```

[22]:
```
X = spambase.data.features
y = spambase.data.targets
```

[23]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.3, random_state=42)
X_val, X_test, y_val, y_test = train_test_split(X_test, y_test,
test_size=0.5, random_state=42)
```

[24]:
```
guassian_model = GaussianNB()
```

[25]:
```
guassian_model.fit(X_train , y_train)
predicted_test = guassian_model.predict(X_test)
predicted_test=np.ravel(predicted_test)
y_test=np.ravel(y_test)
print("The Accuracy Scores without log transformations")
print_res(y_test,predicted_test)
```

The Accuracy Scores without log transformations

Metrics	Value
Accuracy	0.827786
Precision	0.71916
Recall	0.958042

```
 F1-score    0.821589
```

```
C:\Users\GKS\anaconda3\lib\site-packages\sklearn\utils\validation.py:1143:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples, ), for example using
ravel().
  y = column_or_1d(y, warn=True)
```

[26]:

```python
all_columns = X.columns.tolist()
X_train_new = np.log(X_train+1)
X_test_new = np.log(X_test+1)
X_val_new = np.log(X_val+1)
X_train_new.head()
```

[26]:

```
      word_freq_make  word_freq_address  word_freq_all  word_freq_3d  \
958         0.000000           0.000000       0.000000           0.0
1533        0.000000           0.000000       0.000000           0.0
654         0.285179           0.000000       0.285179           0.0
1497        0.418710           0.837248       0.231112           0.0
3844        0.000000           0.000000       0.000000           0.0

      word_freq_our  word_freq_over  word_freq_remove  word_freq_internet  \
958        0.000000        0.000000          0.792993            0.000000
1533       0.000000        0.000000          0.000000            0.000000
654        0.000000        0.000000          0.506818            0.000000
1497       1.360977        0.231112          0.582216            0.231112
3844       0.000000        0.000000          0.000000            0.000000

      word_freq_order  word_freq_mail  …  word_freq_conference  char_freq_;  \
958               0.0        0.792993  …                   0.0          0.0
1533              0.0        0.000000  …                   0.0          0.0
654               0.0        0.000000  …                   0.0          0.0
1497              0.0        0.582216  …                   0.0          0.0
3844              0.0        0.000000  …                   0.0          0.0

      char_freq_(  char_freq_[  char_freq_!  char_freq_$  char_freq_#  \
958      0.000000          0.0     0.000000     0.000000     0.000000
1533     0.188966          0.0     0.348542     0.188966     0.000000
654      0.109751          0.0     0.340749     0.381172     0.298622
1497     0.129272          0.0     0.044973     0.000000     0.000000
3844     0.000000          0.0     0.000000     0.000000     0.000000

      capital_run_length_average  capital_run_length_longest  \
958                     0.984323                    2.772589
1533                    1.571113                    2.833213
654                     2.070905                    3.784190
1497                    1.369657                    4.110874
```

```
3844                    2.708050                    3.988984

      capital_run_length_total
958                     4.060443
1533                    4.127134
654                     6.242223
1497                    4.912655
3844                    4.043051

[5 rows x 57 columns]
```

[27]:

```
guassian_model_new = GaussianNB()
guassian_model_new.fit(X_train_new , y_train)
predicted_test = guassian_model_new.predict(X_test_new)
predicted_test=np.ravel(predicted_test)
print("The Accuracy Scores with log transformations")
print_res(y_test,predicted_test)
```

The Accuracy Scores with log transformations

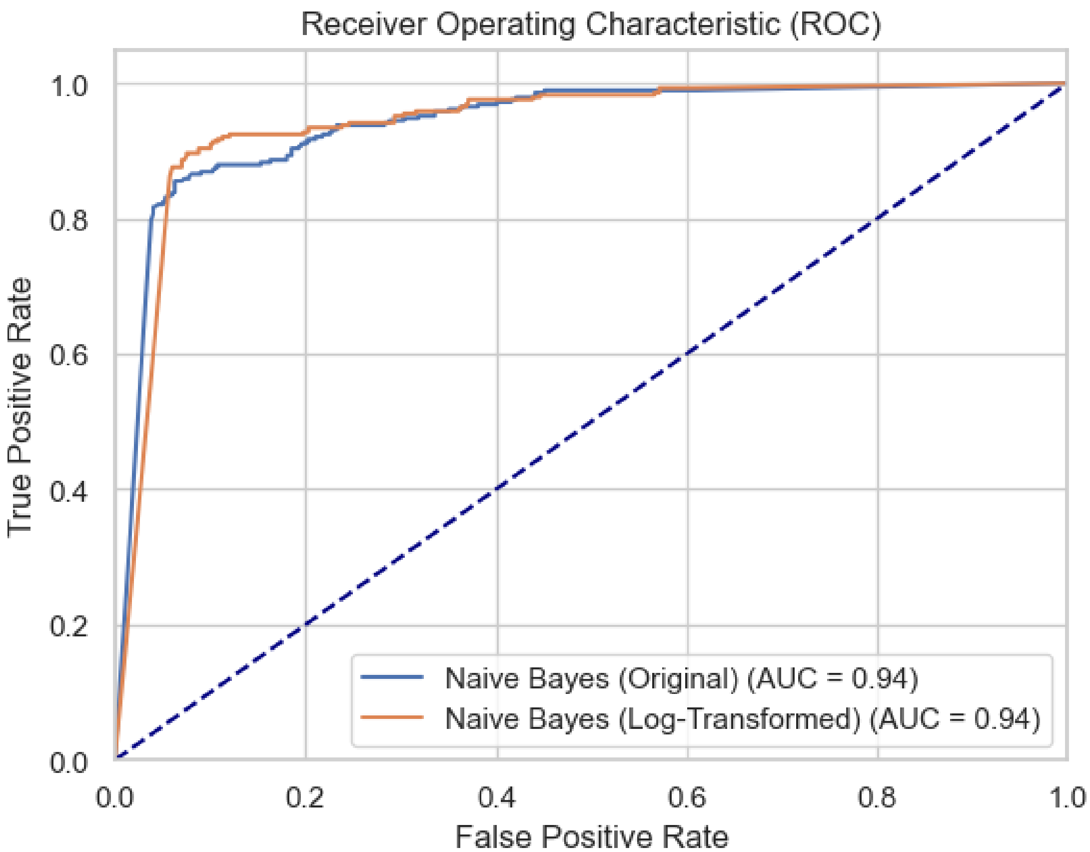
Metrics	Value
Accuracy	0.839363
Precision	0.737127
Recall	0.951049
F1-score	0.830534

```
C:\Users\GKS\anaconda3\lib\site-packages\sklearn\utils\validation.py:1143:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples, ), for example using
ravel().
  y = column_or_1d(y, warn=True)
```

[28]:

```
from sklearn.metrics import accuracy_score, roc_curve, auc
def plot_roc_curve(model, X, y, label, linestyle='-'):
    y_score = model.predict_proba(X)[:, 1]
    fpr, tpr, _ = roc_curve(y, y_score)
    roc_auc = auc(fpr, tpr)
    plt.plot(fpr, tpr, linestyle, label=f'{label} (AUC = {roc_auc:.2f})')

plt.figure()
plot_roc_curve(guassian_model, X_val, y_val, 'Naive Bayes (Original)')
plot_roc_curve(guassian_model_new, X_val_new, y_val, 'Naive Bayes␣
 ↪(Log-Transformed)')
```

```python
plt.plot([0, 1], [0, 1], color='navy', linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC)')
plt.legend(loc="lower right")
plt.show()
```



[ ]:

[ ]:

[ ]: