

**Sri Sivasubramaniya Nadar College of Engineering,  
Chennai**  
(An Autonomous Institution affiliated to Anna University)

Degree & Branch	B.E. Computer Science & Engineering	Semester	VI
Subject Code & Name	UCS2612 – Machine Learning Algorithms Laboratory		
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**Experiment 1: Working with Python packages-Numpy, Scipy,  
Scikit-Learn, Matplotlibs**

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## Aim of the Experiment

The aim of this experiment is to explore different real-world datasets and identify the appropriate type of machine learning task associated with each dataset. The experiment also focuses on understanding suitable feature selection techniques and selecting appropriate machine learning algorithms based on the nature of the problem, such as classification or regression.

### 0.1 Loan

```
[1]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler, MinMaxScaler, \
    ↳RobustScaler, LabelBinarizer
```

```
[2]: df = pd.read_csv("loan_dataset.csv")
df.head()
```

```
[2]:   loan_id  no_of_dependents  education  self_employed  \
    ↳income_annum  \
0         1                2    Graduate             No    9600000
1         2                0  Not Graduate             Yes    4100000
2         3                3    Graduate             No    9100000
```

```

    loan_status
0    Approved
1    Rejected
2    Rejected
3    Rejected
4    Rejected

```

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

```
[3]: (4269, 13)
```

```
[4]: df.columns
```

```
[4]: Index(['loan_id', 'no_of_dependents', 'education', 'self_employed',
          'income_annum', 'loan_amount', 'loan_term', 'cibil_score',
          'residential_assets_value', 'commercial_assets_value',
          'luxury_assets_value', 'bank_asset_value', 'loan_status'],
          dtype='object')
```

```
[5]: df.columns = [col.strip() for col in df.columns]
```

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

```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4269 entries, 0 to 4268
Data columns (total 13 columns):
#   Column                                Non-Null Count  Dtype
---  -
0   loan_id                              4269 non-null   int64
1   no_of_dependents                     4269 non-null   int64
2   education                            4269 non-null   object
3   self_employed                        4269 non-null   object
4   income_annum                         4269 non-null   int64
5   loan_amount                         4269 non-null   int64
6   loan_term                           4269 non-null   int64
7   cibil_score                          4269 non-null   int64
8   residential_assets_value             4269 non-null   int64
9   commercial_assets_value             4269 non-null   int64
10  luxury_assets_value                  4269 non-null   int64
11  bank_asset_value                     4269 non-null   int64
12  loan_status                          4269 non-null   object
dtypes: int64(10), object(3)
memory usage: 433.7+ KB

```

```
[7]: df.describe()
```

```
[7]:      loan_id  no_of_dependents  income_annum  loan_amount  \
      ↳loan_term \
count  4269.000000      4269.000000  4.269000e+03  4.269000e+03  4269.
      ↳000000
mean    2135.000000      2.498712  5.059124e+06  1.513345e+07  10.
      ↳900445
std     1232.498479      1.695910  2.806840e+06  9.043363e+06  5.
      ↳709187
min        1.000000      0.000000  2.000000e+05  3.000000e+05  2.
      ↳000000
25%     1068.000000      1.000000  2.700000e+06  7.700000e+06  6.
      ↳000000
50%     2135.000000      3.000000  5.100000e+06  1.450000e+07  10.
      ↳000000
75%     3202.000000      4.000000  7.500000e+06  2.150000e+07  16.
      ↳000000
max     4269.000000      5.000000  9.900000e+06  3.950000e+07  20.
      ↳000000
```

```
      cibil_score  residential_assets_value  commercial_assets_value  \
count  4269.000000      4.269000e+03      4.269000e+03
mean    599.936051      7.472617e+06      4.973155e+06
std     172.430401      6.503637e+06      4.388966e+06
min     300.000000     -1.000000e+05      0.000000e+00
25%     453.000000      2.200000e+06      1.300000e+06
50%     600.000000      5.600000e+06      3.700000e+06
75%     748.000000      1.130000e+07      7.600000e+06
max     900.000000      2.910000e+07      1.940000e+07
```

```
      luxury_assets_value  bank_asset_value
count      4.269000e+03      4.269000e+03
mean      1.512631e+07      4.976692e+06
std       9.103754e+06      3.250185e+06
min       3.000000e+05      0.000000e+00
25%       7.500000e+06      2.300000e+06
50%       1.460000e+07      4.600000e+06
75%       2.170000e+07      7.100000e+06
max       3.920000e+07      1.470000e+07
```

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

```
[8]: loan_id      0
     no_of_dependents  0
     education      0
```

```

self_employed          0
income_annum           0
loan_amount            0
loan_term              0
cibil_score            0
residential_assets_value 0
commercial_assets_value 0
luxury_assets_value     0
bank_asset_value        0
loan_status            0
dtype: int64

```

```
[9]: df.duplicated().sum()
```

```
[9]: np.int64(0)
```

```
[10]: X=df.drop(columns=['loan_amount'])
      y=df['loan_amount']
```

```
[11]: X=df.drop(columns=['loan_id'])
```

```
[12]: nums_cols=X.select_dtypes(include=['int64','float64']).columns.tolist()
      print("The number columns are: ",nums_cols)
      binary_cols=[col for col in X.columns if X[col].nunique()==2]
      print("The binary columns are: ",binary_cols)
      cat_cols=X.select_dtypes(include='object').columns.tolist()
      cat_cols=[col for col in cat_cols if col not in binary_cols]
      print("The categorical columns are: ",cat_cols)
```

```

The number columns are:  ['no_of_dependents', 'income_annum', 'loan_amount',
'loan_term', 'cibil_score', 'residential_assets_value',
'commercial_assets_value', 'luxury_assets_value', 'bank_asset_value']
The binary columns are:  ['education', 'self_employed', 'loan_status']
The categorical columns are:  []

```

```
[13]: df = df[df['residential_assets_value'] >= 0]
```

```
[14]: money_cols = [
      'income_annum',
      'loan_amount',
      'residential_assets_value',
      'commercial_assets_value',
      'luxury_assets_value',
      'bank_asset_value'
]
```

```
for col in money_cols:
    df[col] = np.log1p(df[col])
```

```
[15]: X = pd.get_dummies(X, columns=cat_cols, drop_first=True)
```

```
[16]: print(X)
```

	no_of_dependents	education	self_employed	income_annum \
0	2	Graduate	No	9600000
1	0	Not Graduate	Yes	4100000
2	3	Graduate	No	9100000
3	3	Graduate	No	8200000
4	5	Not Graduate	Yes	9800000
...	...	...	...	...
4264	5	Graduate	Yes	1000000
4265	0	Not Graduate	Yes	3300000
4266	2	Not Graduate	No	6500000
4267	1	Not Graduate	No	4100000
4268	1	Graduate	No	9200000

	loan_amount	loan_term	cibil_score	residential_assets_value \
0	29900000	12	778	2400000
1	12200000	8	417	2700000
2	29700000	20	506	7100000
3	30700000	8	467	18200000
4	24200000	20	382	12400000
...	...	...	...	...
4264	2300000	12	317	2800000
4265	11300000	20	559	4200000
4266	23900000	18	457	1200000
4267	12800000	8	780	8200000
4268	29700000	10	607	17800000

	commercial_assets_value	luxury_assets_value	bank_asset_value \
0	17600000	22700000	8000000
1	2200000	8800000	3300000
2	4500000	33300000	12800000
3	3300000	23300000	7900000
4	8200000	29400000	5000000
...	...	...	...
4264	500000	3300000	800000
4265	2900000	11000000	1900000
4266	12400000	18100000	7300000
4267	700000	14100000	5800000

4268	11800000	35700000	12000000
------	----------	----------	----------

	loan_status
0	Approved
1	Rejected
2	Rejected
3	Rejected
4	Rejected
...	...
4264	Rejected
4265	Approved
4266	Rejected
4267	Approved
4268	Approved

[4269 rows x 12 columns]

```
[17]: scaler = StandardScaler()
      X[nums_cols] = scaler.fit_transform(X[nums_cols])
```

```
[18]: X = pd.get_dummies(X, columns=cat_cols, drop_first=True)
```

```
[19]: print(X)
```

	no_of_dependents	education	self_employed	income_annum \
0	-0.294102	Graduate	No	1.617979
1	-1.473548	Not Graduate	Yes	-0.341750
2	0.295621	Graduate	No	1.439822
3	0.295621	Graduate	No	1.119139
4	1.475067	Not Graduate	Yes	1.689242
...	...	...	...	...
4264	1.475067	Graduate	Yes	-1.446324
4265	-1.473548	Not Graduate	Yes	-0.626801
4266	-0.294102	Not Graduate	No	0.513405
4267	-0.883825	Not Graduate	No	-0.341750
4268	-0.883825	Graduate	No	1.475453

	loan_amount	loan_term	cibil_score	residential_assets_value \
0	1.633052	0.192617	1.032792	-0.780058
1	-0.324414	-0.508091	-1.061051	-0.733924
2	1.610933	1.594031	-0.544840	-0.057300
3	1.721525	-0.508091	-0.771045	1.649637
4	1.002681	1.594031	-1.264055	0.757724
...	...	...	...	...
4264	-1.419268	0.192617	-1.641063	-0.718546

4265	-0.423946	1.594031	-0.237434	-0.503257
4266	0.969504	1.243677	-0.829046	-0.964591
4267	-0.258059	-0.508091	1.044393	0.111856
4268	1.610933	-0.157737	0.040972	1.588126

	commercial_assets_value	luxury_assets_value	bank_asset_value	\
0	2.877289	0.832028	0.930304	
1	-0.631921	-0.694993	-0.515936	
2	-0.107818	1.996520	2.407316	
3	-0.381263	0.897943	0.899533	
4	0.735304	1.568075	0.007172	
...	...	...	...	
4264	-1.019301	-1.299210	-1.285213	
4265	-0.472412	-0.453306	-0.946732	
4266	1.692361	0.326683	0.714907	
4267	-0.973727	-0.112748	0.253341	
4268	1.555638	2.260178	2.161148	

	loan_status
0	Approved
1	Rejected
2	Rejected
3	Rejected
4	Rejected
...	...
4264	Rejected
4265	Approved
4266	Rejected
4267	Approved
4268	Approved

[4269 rows x 12 columns]

```
[20]: plt.figure(figsize=(18, 12))

# 1 Income Distribution (Histogram)
plt.subplot(3, 3, 1)
plt.hist(df['income_annum'], bins=20)
plt.title("Income Distribution")
plt.xlabel("Annual Income")
plt.ylabel("Frequency")

# 2 Loan Amount Distribution (Histogram)
plt.subplot(3, 3, 2)
```

```

plt.hist(df['loan_amount'], bins=20)
plt.title("Loan Amount Distribution")
plt.xlabel("Loan Amount")
plt.ylabel("Frequency")

# 3 Income vs Loan Amount (Scatter Plot)
plt.subplot(3, 3, 3)
plt.scatter(df['income_annum'], df['loan_amount'])
plt.title("Income vs Loan Amount")
plt.xlabel("Annual Income")
plt.ylabel("Loan Amount")

# 4 Self Employed Distribution (Bar Chart)
plt.subplot(3, 3, 4)
df['self_employed'].value_counts().plot(kind='bar')
plt.title("Self Employed Distribution")
plt.xlabel("Self Employed")
plt.ylabel("Count")

# 5 Education Distribution (Bar Chart)
plt.subplot(3, 3, 5)
df['education'].value_counts().plot(kind='bar')
plt.title("Education Distribution")
plt.xlabel("Education")
plt.ylabel("Count")

# 6 Loan Status Distribution (Bar Chart)
plt.subplot(3, 3, 6)
df['loan_status'].value_counts().plot(kind='bar')
plt.title("Loan Status Distribution")
plt.xlabel("Loan Status")
plt.ylabel("Count")

# 7 CIBIL Score Distribution (Histogram)
plt.subplot(3, 3, 7)
plt.hist(df['cibil_score'], bins=20)
plt.title("CIBIL Score Distribution")
plt.xlabel("CIBIL Score")
plt.ylabel("Frequency")

# 8 CIBIL Score vs Loan Amount (Scatter Plot)
plt.subplot(3, 3, 8)
plt.scatter(df['cibil_score'], df['loan_amount'])
plt.title("CIBIL Score vs Loan Amount")

```



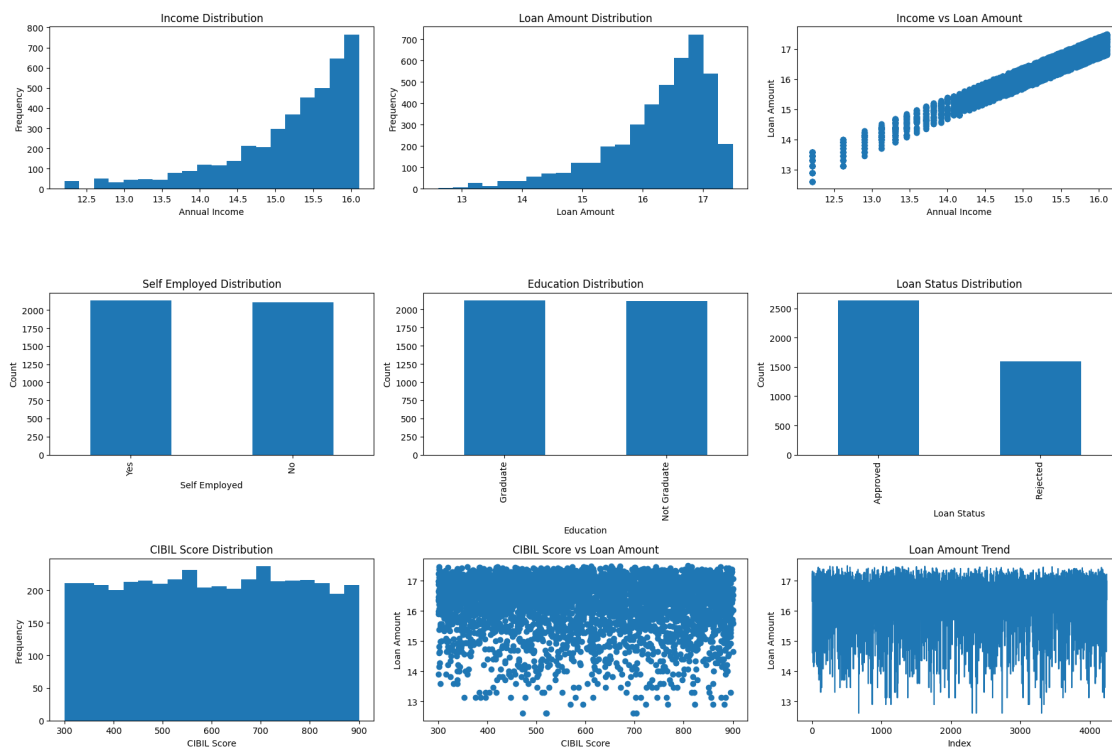
```

plt.xlabel("CIBIL Score")
plt.ylabel("Loan Amount")

# 9 Loan Amount Trend (Line Plot)
plt.subplot(3, 3, 9)
plt.plot(df['loan_amount'].values)
plt.title("Loan Amount Trend")
plt.xlabel("Index")
plt.ylabel("Loan Amount")

plt.tight_layout()
plt.show()

```



```

[21]: X = df.drop(columns=['loan_id', 'loan_amount'])
      y = df['loan_amount']

```

```

[22]: cat_cols = X.select_dtypes(include='object').columns.tolist()
      print("Categorical columns:", cat_cols)

```

Categorical columns: ['education', 'self\_employed', 'loan\_status']

```

[23]: X = pd.get_dummies(X, columns=cat_cols, drop_first=True)

```

```
[24]: from sklearn.feature_selection import SelectKBest, f_regression
```

```
selector = SelectKBest(score_func=f_regression, k=8)
X_selected = selector.fit_transform(X, y)

selected_features = X.columns[selector.get_support()]
print("Selected Features:", selected_features)
```

```
Selected Features: Index(['income_annum', 'loan_term', 'cibil_score',
                        'residential_assets_value',
                        'commercial_assets_value', 'luxury_assets_value', 'bank_asset_value',
                        'education_Not Graduate'],
                        dtype='object')
```

```
[25]: from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test = train_test_split(
    X_selected, y, test_size=0.2, random_state=42
)

print("Training set shape:", X_train.shape)
print("Testing set shape:", X_test.shape)
```

```
Training set shape: (3392, 8)
Testing set shape: (849, 8)
```

## 0.2 Hand Written

```
[26]: !ls -lh
```

```
total 47M
-rw-r--r-- 1 root root 3.7M Jan 27 17:55 diabetes_prediction_dataset.csv
-rw-r--r-- 1 root root 30M Jan 27 17:55 email_classification.csv
-rw-r--r-- 1 root root 14M Jan 27 17:55 Handwritten_dataset.zip
drwxr-xr-x 2 root root 124K Jan 27 17:59 Img
-rw-r--r-- 1 root root 5.0K Jan 27 17:55 Iris.csv
-rw-r--r-- 1 root root 376K Jan 27 17:55 loan_dataset.csv
drwxr-xr-x 1 root root 4.0K Jan 16 14:24 sample_data
```

```
[27]: !file Handwritten_dataset.zip
```

```
Handwritten_dataset.zip: Zip archive data, at least v4.5 to extract,
compression
method=deflate
```

```
[28]: !unzip -q Handwritten_dataset.zip
```

```
replace Img/img001-001.png? [y]es, [n]o, [A]ll, [N]one, [r]ename: A
```

```
[29]: !ls
```

```
diabetes_prediction_dataset.csv  Handwritten_dataset.zip  loan_dataset.csv
email_classification.csv        Img                      sample_data
english.csv                     Iris.csv
```

```
[30]: import pandas as pd
```

```
df = pd.read_csv("english.csv")
df.head()
```

```
[30]:
```

	image	label
0	Img/img001-001.png	0
1	Img/img001-002.png	0
2	Img/img001-003.png	0
3	Img/img001-004.png	0
4	Img/img001-005.png	0

```
[31]: import os
```

```
import cv2
```

```
import numpy as np
```

```
X = []
```

```
y = []
```

```
base_path = "Img"
```

```
missing = 0
```

```
for _, row in df.iterrows():
```

```
    img_path = os.path.join(base_path, row['image'].split('/')[-1])
```

```
    label = row['label']
```

```
    img = cv2.imread(img_path, cv2.IMREAD_GRAYSCALE)
```

```
    if img is None:
```

```
        missing += 1
```

```
        continue
```

```
    img = cv2.resize(img, (28, 28))
```

```
    img = img / 255.0
```

```

X.append(img.flatten())
y.append(label)

X = np.array(X)
y = np.array(y)

print("Loaded images:", X.shape[0])
print("Missing images:", missing)
print("Feature shape:", X.shape)
print("Labels shape:", y.shape)

```

```

Loaded images: 3410
Missing images: 0
Feature shape: (3410, 784)
Labels shape: (3410,)

```

[31]:

[32]: `print(X)`

```

[[1. 1. 1. ... 1. 1. 1.]
 [1. 1. 1. ... 1. 1. 1.]
 [1. 1. 1. ... 1. 1. 1.]
 ...
 [1. 1. 1. ... 1. 1. 1.]
 [1. 1. 1. ... 1. 1. 1.]
 [1. 1. 1. ... 1. 1. 1.]]

```

[33]: `print(X.shape)`  
`print(y.shape)`  
`print(np.unique(y))`

```

(3410, 784)
(3410,)
['0' '1' '2' '3' '4' '5' '6' '7' '8' '9' 'A' 'B' 'C' 'D' 'E' 'F' 'G' 'H'
 'I' 'J' 'K' 'L' 'M' 'N' 'O' 'P' 'Q' 'R' 'S' 'T' 'U' 'V' 'W' 'X' 'Y' 'Z'
 'a' 'b' 'c' 'd' 'e' 'f' 'g' 'h' 'i' 'j' 'k' 'l' 'm' 'n' 'o' 'p' 'q' 'r'
 's' 't' 'u' 'v' 'w' 'x' 'y' 'z']

```

[34]: `from sklearn.preprocessing import StandardScaler`

```

scaler = StandardScaler()
X_scaled= scaler.fit_transform(X)

```

[35]: `from sklearn.decomposition import PCA`

```
pca = PCA(n_components=100)
X_decomposed = pca.fit_transform(X_scaled)
```

```
[36]: from sklearn.preprocessing import LabelEncoder
```

```
le = LabelEncoder()
y_encoded = le.fit_transform(y)
print(y_encoded)
```

```
[ 0  0  0 ... 61 61 61]
```

```
[37]: import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
from sklearn.decomposition import PCA

fig, axes = plt.subplots(1, 3, figsize=(9, 3)) # total width 9, each ~3

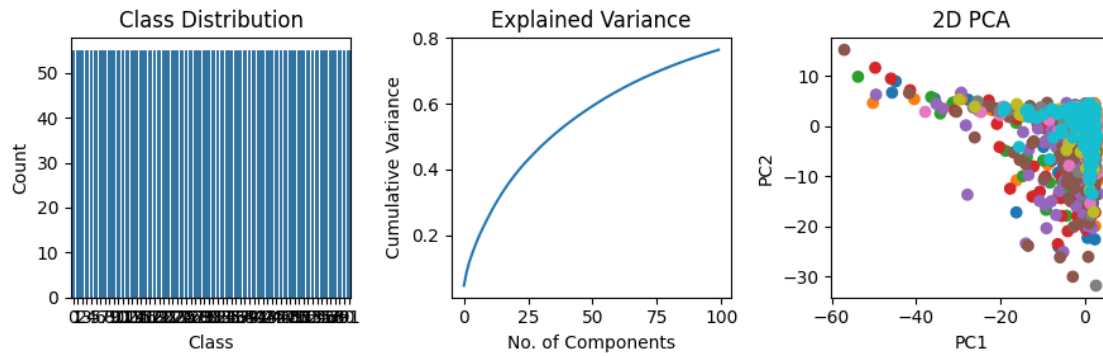
# 1 Class Distribution
sns.countplot(x=y_encoded, ax=axes[0])
axes[0].set_title("Class Distribution")
axes[0].set_xlabel("Class")
axes[0].set_ylabel("Count")

# 2 Cumulative Explained Variance
axes[1].plot(np.cumsum(pca.explained_variance_ratio_))
axes[1].set_title("Explained Variance")
axes[1].set_xlabel("No. of Components")
axes[1].set_ylabel("Cumulative Variance")

# 3 2D PCA Visualization
pca_2d = PCA(n_components=2)
X_2d = pca_2d.fit_transform(X_scaled)

scatter = axes[2].scatter(X_2d[:, 0], X_2d[:, 1],
                          c=y_encoded, cmap='tab10')
axes[2].set_title("2D PCA")
axes[2].set_xlabel("PC1")
axes[2].set_ylabel("PC2")

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



```
[38]: from sklearn.feature_selection import SelectKBest, f_classif

selector = SelectKBest(score_func=f_classif, k=50)
X_selected = selector.fit_transform(X_decomposed, y_encoded)

print("Selected feature shape:", X_selected.shape)
```

Selected feature shape: (3410, 50)

```
[39]: from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(
    X_selected, y_encoded, test_size=0.2, random_state=42,
    ↪stratify=y_encoded
)

print(X_train.shape, X_test.shape)
```

(2728, 50) (682, 50)

## 0.3 Email

```
[39]:
```

```
[40]: import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import LabelBinarizer
df = pd.read_csv("email_classification.csv")
```

```
[41]: df.head()
```

```
[41]:  Email No.  the  to  ect  and  for  of    a  you  hou  ...  connevey  \
→jay  \
0  Email 1    0  0    1  0    0  0    2  0  0  ...    0  0
1  Email 2    8 13   24  6    6  2 102  1 27  ...    0  0
2  Email 3    0  0    1  0    0  0    8  0  0  ...    0  0
3  Email 4    0  5   22  0    5  1   51  2 10  ...    0  0
4  Email 5    7  6   17  1    5  2   57  0  9  ...    0  0
```

```
      valued  lay  infrastructure  military  allowing  ff  dry  Prediction
0          0    0                0          0          0  0  0          0
1          0    0                0          0          0  1  0          0
2          0    0                0          0          0  0  0          0
3          0    0                0          0          0  0  0          0
4          0    0                0          0          0  1  0          0
```

[5 rows x 3002 columns]

```
[42]: df.describe()
```

```
[42]:          the          to          ect          and          for  \
count  5172.000000  5172.000000  5172.000000  5172.000000  5172.000000
mean      6.640565      6.188128      5.143852      3.075599      3.124710
std      11.745009      9.534576     14.101142      6.045970      4.680522
min       0.000000      0.000000      1.000000      0.000000      0.000000
25%       0.000000      1.000000      1.000000      0.000000      1.000000
50%       3.000000      3.000000      1.000000      1.000000      2.000000
75%       8.000000      7.000000      4.000000      3.000000      4.000000
max      210.000000     132.000000     344.000000     89.000000     47.000000

          of          a          you          hou          in  \
→...  \
count  5172.000000  5172.000000  5172.000000  5172.000000  5172.000000  \
→...
mean      2.627030      55.517401      2.466551      2.024362     10.600155  \
→...
std      6.229845      87.574172      4.314444      6.967878     19.281892  \
→...
min       0.000000      0.000000      0.000000      0.000000      0.000000  \
→...
25%       0.000000     12.000000      0.000000      0.000000      1.000000  \
→...
```

50%	1.000000	28.000000	1.000000	0.000000	5.000000	↳
↳...						
75%	2.000000	62.250000	3.000000	1.000000	12.000000	↳
↳...						
max	77.000000	1898.000000	70.000000	167.000000	223.000000	↳
↳...						

	connevey	jay	valued	lay	infrastructure	↳
↳ \						
count	5172.000000	5172.000000	5172.000000	5172.000000	5172.000000	
mean	0.005027	0.012568	0.010634	0.098028	0.004254	
std	0.105788	0.199682	0.116693	0.569532	0.096252	
min	0.000000	0.000000	0.000000	0.000000	0.000000	
25%	0.000000	0.000000	0.000000	0.000000	0.000000	
50%	0.000000	0.000000	0.000000	0.000000	0.000000	
75%	0.000000	0.000000	0.000000	0.000000	0.000000	
max	4.000000	7.000000	2.000000	12.000000	3.000000	

	military	allowing	ff	dry	Prediction	
count	5172.000000	5172.000000	5172.000000	5172.000000	5172.000000	
mean	0.006574	0.004060	0.914733	0.006961	0.290023	
std	0.138908	0.072145	2.780203	0.098086	0.453817	
min	0.000000	0.000000	0.000000	0.000000	0.000000	
25%	0.000000	0.000000	0.000000	0.000000	0.000000	
50%	0.000000	0.000000	0.000000	0.000000	0.000000	
75%	0.000000	0.000000	1.000000	0.000000	1.000000	
max	4.000000	3.000000	114.000000	4.000000	1.000000	

[8 rows x 3001 columns]

```
[43]: df.columns
```

```
[43]: Index(['Email No.', 'the', 'to', 'ect', 'and', 'for', 'of', 'a', 'you', 'hou',
↳
...
'connevey', 'jay', 'valued', 'lay', 'infrastructure', 'military',
'allowing', 'ff', 'dry', 'Prediction'],
dtype='object', length=3002)
```

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

```
[44]: (5172, 3002)
```

```
[45]: df.drop(columns=["Email No."], inplace=True)
```



```
[46]: X = df.drop(columns=["Prediction"])
      y = df["Prediction"]
```

```
[47]: # Numeric columns
num_cols = X.select_dtypes(include=["int64", "float64"]).columns.tolist()
print("The number columns are: ", num_cols)
# Binary columns (rare here, but included for completeness)
binary_cols = [col for col in X.columns if X[col].nunique() == 2]
print("The binary columns are: ", binary_cols)
# Categorical columns (usually none in BoW)
cat_cols = X.select_dtypes(include="object").columns.tolist()
cat_cols = [col for col in cat_cols if col not in binary_cols]
print("The categorical columns are: ", cat_cols)
```

```
The number columns are:  ['the', 'to', 'ect', 'and', 'for', 'of', 'a',
    ↳ 'you',
'hou', 'in', 'on', 'is', 'this', 'enron', 'i', 'be', 'that', 'will', 'have',
'with', 'your', 'at', 'we', 's', 'are', 'it', 'by', 'com', 'as', 'from',
    ↳ 'gas',
'or', 'not', 'me', 'deal', 'if', 'meter', 'hpl', 'please', 're', 'e', 'any',
'our', 'corp', 'can', 'd', 'all', 'has', 'was', 'know', 'need', 'an',
'forwarded', 'new', 't', 'may', 'up', 'j', 'mmbtu', 'should', 'do', 'am',
    ↳ 'get',
'out', 'see', 'no', 'there', 'price', 'daren', 'but', 'been', 'company',
    ↳ 'l',
'these', 'let', 'so', 'would', 'm', 'into', 'xls', 'farmer', 'attached',
    ↳ 'us',
'information', 'they', 'message', 'day', 'time', 'my', 'one', 'what',
    ↳ 'only',
'http', 'th', 'volume', 'mail', 'contract', 'which', 'month', 'more',
    ↳ 'robert',
'sitara', 'about', 'texas', 'nom', 'energy', 'pec', 'questions', 'www',
    ↳ 'deals',
'volumes', 'pm', 'ena', 'now', 'their', 'file', 'some', 'email', 'just',
    ↳ 'also',
'call', 'change', 'other', 'here', 'like', 'b', 'flow', 'net', 'following',
    ↳ 'p',
'production', 'when', 'over', 'back', 'want', 'original', 'them', 'below',
    ↳ 'o',
'ticket', 'c', 'he', 'could', 'make', 'inc', 'report', 'march', 'contact',
'were', 'days', 'list', 'nomination', 'system', 'who', 'april', 'number',
'sale', 'don', 'its', 'first', 'thanks', 'business', 'help', 'per',
    ↳ 'through',
```

'july', 'forward', 'font', 'free', 'daily', 'use', 'order', 'today', 'r',  
 ↳ 'had',  
 'fw', 'set', 'plant', 'statements', 'go', 'gary', 'oil', 'line', 'sales',  
 ↳ 'w',  
 'effective', 'well', 'tenaska', 'take', 'june', 'x', 'within', 'nbsp',  
 ↳ 'she',  
 'how', 'north', 'america', 'being', 'under', 'next', 'week', 'than',  
 ↳ 'january',  
 'last', 'two', 'service', 'purchase', 'name', 'less', 'height', 'off',  
 'agreement', 'k', 'work', 'tap', 'group', 'year', 'based', 'transport',  
 ↳ 'after',  
 'think', 'made', 'each', 'available', 'changes', 'due', 'f', 'h',  
 ↳ 'services',  
 'smith', 'send', 'management', 'stock', 'sent', 'll', 'co', 'office',  
 ↳ 'needs',  
 'cotten', 'did', 'actuals', 'u', 'money', 'before', 'looking', 'then',  
 ↳ 'pills',  
 'online', 'request', 'look', 'desk', 'ami', 'his', 'same', 'george',  
 ↳ 'chokshi',  
 'point', 'delivery', 'friday', 'does', 'size', 'august', 'product', 'pat',  
 'width', 'iv', 'noms', 'address', 'above', 'sure', 'give', 'october',  
 ↳ 'future',  
 'find', 'market', 'n', 'mary', 'vance', 'melissa', 'said', 'internet',  
 ↳ 'still',  
 'account', 'those', 'down', 'link', 'hsc', 'rate', 'people', 'pipeline',  
 ↳ 'best',  
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 'products', 'many', 'currently', 'spot', 'receive', 'good', 'such', 'going',  
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 ↳ 'fee',  
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 'check', 'trade', 'bob', 'created', 'steve', 'prior', 'copy', 'continue',  
 'numbers', 'via', 'world', 'demand', 'hanks', 'contracts', 'phone',  
 'transaction', 'customer', 'possible', 'pefs', 'meyers', 'months',  
 ↳ 'special',  
 'without', 'used', 'regarding', 'software', 'howard', 'support', 'buy',  
 ↳ 'young',  
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 'create', 'weissman', 'st', 'color', 'come', 'supply', 'brian', 'hplo',  
 ↳ 'own',  
 'correct', 'customers', 'web', 'allocation', 'soon', 'using', 'development',  
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 'add', 'deliveries', 'buyback', 'allocated', 'firm', 'james', 'marketing',  
 ↳ 'tx',  
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 'y', 'state', 'ees', 'rita', 'provided', 'employees', 'period', 'morning',  
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↪ 'game',  
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↪ 'hub',  
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 'land', 'occur', 'flowing', 'mar', 'terry', 'darren', 'cheap', 'weight',  
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 'fun', 'rest', 'instant', 'agent', 'communications', 'director', 'partners',  
 'investors', 'expedia', 'kevin', 'assist', 'safe', 'approval', 'allocate',  
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 'missing', 'jill', 'discussion', 'relief', 'respect', 'specific',  
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 ↳ 'room',  
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 ↳ 'prc',  
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 ↳ 'files',  
 'dan', 'billed', 'mccoy', 'rc', 'exactly', 'middle', 'select', 'bruce',  
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 'featured', 'cdnow', 'prize', 'reveffo', 'olsen', 'expects', 'estimate',  
 ↳ 'near',  
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 ↳ 'calling',  
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 ↳ 'enjoy',  
 'img', 'rnd', 'responsible', 'outstanding', 'member', 'panenergy',  
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 The binary columns are: ['hplo', 'moopid', 'hotlist', 'knle',  
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 'unless', 'choice', 'sdsnom', 'reviewed', 'atleast', 'hottlist', 'couldn',  
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 The categorical columns are: []

```
[48]: for col in X.columns:
      print(col,X[col].isnull().sum())
```

```
the 0
to 0
ect 0
and 0
for 0
of 0
a 0
you 0
hou 0
in 0
on 0
is 0
this 0
enron 0
i 0
be 0
that 0
will 0
have 0
with 0
your 0
at 0
we 0
s 0
are 0
it 0
by 0
com 0
as 0
from 0
gas 0
or 0
not 0
me 0
deal 0
if 0
meter 0
hpl 0
please 0
re 0
e 0
any 0
```

our 0  
corp 0  
can 0  
d 0  
all 0  
has 0  
was 0  
know 0  
need 0  
an 0  
forwarded 0  
new 0  
t 0  
may 0  
up 0  
j 0  
mmbtu 0  
should 0  
do 0  
am 0  
get 0  
out 0  
see 0  
no 0  
there 0  
price 0  
daren 0  
but 0  
been 0  
company 0  
l 0  
these 0  
let 0  
so 0  
would 0  
m 0  
into 0  
xls 0  
farmer 0  
attached 0  
us 0  
information 0  
they 0  
message 0  
day 0



time 0  
my 0  
one 0  
what 0  
only 0  
http 0  
th 0  
volume 0  
mail 0  
contract 0  
which 0  
month 0  
more 0  
robert 0  
sitara 0  
about 0  
texas 0  
nom 0  
energy 0  
pec 0  
questions 0  
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volumes 0  
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also 0  
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change 0  
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like 0  
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net 0  
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p 0  
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when 0

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want 0  
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them 0  
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make 0  
inc 0  
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today 0  
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fw 0  
set 0

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w 0  
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how 0  
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under 0  
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week 0  
than 0  
january 0  
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height 0  
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after 0  
think 0  
made 0

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changes 0  
due 0  
f 0  
h 0  
services 0  
smith 0  
send 0  
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stock 0  
sent 0  
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office 0  
needs 0  
cotten 0  
did 0  
actuals 0  
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looking 0  
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look 0  
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his 0  
same 0  
george 0  
chokshi 0  
point 0  
delivery 0  
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august 0  
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width 0  
iv 0  
noms 0

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future 0  
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market 0  
n 0  
mary 0  
vance 0  
melissa 0  
said 0  
internet 0  
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hsc 0  
rate 0  
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pipeline 0  
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very 0  
end 0  
home 0  
houston 0  
tu 0  
high 0  
her 0  
team 0  
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spot 0  
receive 0  
good 0  
such 0  
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process 0  
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monday 0  
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lloyd 0  
again 0  
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lisa 0  
ve 0  
september 0  
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resources 0  
because 0  
aol 0  
february 0  
where 0  
g 0  
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issue 0  
duke 0  
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way 0  
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computron 0  
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offer 0  
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right 0  
prices 0  
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utilities 0  
november 0  
clynes 0

jan 0  
securities 0  
meeting 0  
susan 0  
hplc 0  
julie 0  
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term 0  
id 0  
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fee 0  
hplno 0  
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txu 0  
data 0  
wellhead 0  
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taylor 0  
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unify 0  
michael 0  
provide 0  
note 0  
much 0  
access 0  
lannou 0  
every 0  
between 0  
keep 0  
tuesday 0  
review 0  
great 0  
tom 0  
put 0  
done 0  
long 0  
save 0  
section 0  
must 0

v 0  
part 0  
nd 0  
million 0  
check 0  
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jay 0
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military 0
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ff 0
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```
[49]: imp = SimpleImputer(missing_values=np.nan, strategy="mean")
      X = imp.fit_transform(X)
```

```
[50]: for col in num_cols: # example column
      df[col] = np.log1p(df[col])
```

```
[51]: for col in num_cols:
      mean = df[col].mean()
      median = df[col].median()
      mode = df[col].mode()
      std = df[col].std()
```

```
qk = df[col].quantile(0.75)
print(col,mean,median,mode,std,qk)
```

Streaming output truncated to the last 5000 lines.

```
fuels 0.020389538859418087 0.0 0 0.0
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getting 0.023759484157514003 0.0 0 0.0
Name: getting, dtype: float64 0.13449182562549095 0.0
advice 0.016515993832734704 0.0 0 0.0
Name: advice, dtype: float64 0.14762453371652678 0.0
why 0.025248619622488967 0.0 0 0.0
Name: why, dtype: float64 0.1444286545474938 0.0
increase 0.0331099979619155 0.0 0 0.0
Name: increase, dtype: float64 0.1695099860217808 0.0
path 0.0356489168671682 0.0 0 0.0
Name: path, dtype: float64 0.2143116778881631 0.0
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Name: issues, dtype: float64 0.14631722265122094 0.0
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Name: xp, dtype: float64 0.44785490004479434 0.0
plan 0.1011703736503624 0.0 0 0.0
Name: plan, dtype: float64 0.31761806425759803 0.0
current 0.0660305162176522 0.0 0 0.0
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 stocks 0.01645160886897867 0.0 0 0.0  
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might 0.022126078952105208 0.0 0 0.0  
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 operations 0.019652239137123134 0.0 0 0.0  
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 logistics 0.019309710760883666 0.0 0 0.0  
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 fax 0.04238167918030235 0.0 0 0.0  
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 cost 0.03390450550316946 0.0 0 0.0  
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 party 0.049599237436988394 0.0 0 0.0  
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 zero 0.023523914928906254 0.0 0 0.0  
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 pops 0.01775602418741175 0.0 0 0.0  
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 flowed 0.017986003885081536 0.0 0 0.0  
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 dollars 0.021071251944025184 0.0 0 0.0  
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 gco 0.0158860503648286 0.0 0 0.0  
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 katy 0.019173289705091228 0.0 0 0.0  
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 including 0.021812712378429095 0.0 0 0.0  
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 follow 0.11518043040059013 0.0 0 0.0  
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 yahoo 0.010773994403279296 0.0 0 0.0  
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 already 0.021744174555469124 0.0 0 0.0  
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 error 0.025096675195059693 0.0 0 0.0

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 page 0.03210136041792719 0.0 0 0.0  
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 stop 0.035018917738958294 0.0 0 0.0  
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 cotton 0.01820667306018065 0.0 0 0.0  
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 y 2.0187082946726607 2.0794415416798357 0 0.693147  
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 ees 0.04673868039096017 0.0 0 0.0  
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 entex 0.01487908906507683 0.0 0 0.0  
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 person 0.043071157019583944 0.0 0 0.0  
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 around 0.021344518905492084 0.0 0 0.0  
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 storage 0.014757330137620877 0.0 0 0.0  
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 mobil 0.027872294805655926 0.0 0 0.0  
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 shows 0.015526071334624057 0.0 0 0.0  
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 clem 0.01908112897361696 0.0 0 0.0  
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 papayoti 0.011040403236956686 0.0 0 0.0  
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 central 0.016032823783720562 0.0 0 0.0  
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 cds 0.003987943714884524 0.0 0 0.0  
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 br 0.3173056990556395 0.0 0 0.0  
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 apr 0.06444954601247992 0.0 0 0.0  
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 sullivan 0.005883722271177579 0.0 0 0.0  
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 basin 0.0036477434940335885 0.0 0 0.0

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 revenue 0.010491629888782453 0.0 0 0.0  
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 authority 0.0030143396286329057 0.0 0 0.0  
 Name: authority, dtype: float64 0.050380289443113485 0.0  
 flw 0.001761977576559848 0.0 0 0.0  
 Name: flw, dtype: float64 0.05014776742570746 0.0  
 straight 0.004334160063656422 0.0 0 0.0  
 Name: straight, dtype: float64 0.057711159495336284 0.0  
 worldnet 0.0009812787732470663 0.0 0 0.0  
 Name: worldnet, dtype: float64 0.04486984709735883 0.0  
 beemer 0.0034187990373100896 0.0 0 0.0  
 Name: beemer, dtype: float64 0.053622390824589576 0.0  
 ooo 0.006509132979189245 0.0 0 0.0  
 Name: ooo, dtype: float64 0.08837415943824183 0.0  
 defs 0.0025010361316136877 0.0 0 0.0  
 Name: defs, dtype: float64 0.05043069309938896 0.0

thorough 0.0041545944697135165 0.0 0 0.0  
 Name: thorough, dtype: float64 0.05350736727664012 0.0  
 officers 0.0026703069625019127 0.0 0 0.0  
 Name: officers, dtype: float64 0.04769549399420987 0.0  
 flight 0.00420014088721405 0.0 0 0.0  
 Name: flight, dtype: float64 0.06622190842593788 0.0  
 prefer 0.008645546918562577 0.0 0 0.0  
 Name: prefer, dtype: float64 0.08137397276635305 0.0  
 awesome 0.0032164602346169153 0.0 0 0.0  
 Name: awesome, dtype: float64 0.04711224762821178 0.0  
 macintosh 0.0013629649731739823 0.0 0 0.0  
 Name: macintosh, dtype: float64 0.046596311271584805 0.0  
 feet 0.0029006917815907326 0.0 0 0.0  
 Name: feet, dtype: float64 0.05252412542187626 0.0  
 constitutes 0.003082441058174544 0.0 0 0.0  
 Name: constitutes, dtype: float64 0.04612477896415239 0.0  
 formosa 0.0014492540494749143 0.0 0 0.0  
 Name: formosa, dtype: float64 0.049712243962777215 0.0  
 porn 0.0046021984165411645 0.0 0 0.0  
 Name: porn, dtype: float64 0.06082626156433913 0.0  
 armstrong 0.003072364491829027 0.0 0 0.0  
 Name: armstrong, dtype: float64 0.05051029353769447 0.0  
 driscoll 0.0021342302567324265 0.0 0 0.0  
 Name: driscoll, dtype: float64 0.05071452869457007 0.0  
 watches 0.003072364491829027 0.0 0 0.0  
 Name: watches, dtype: float64 0.05406423650514487 0.0  
 newsieter 0.0026146839786558604 0.0 0 0.0  
 Name: newsieter, dtype: float64 0.050085541176162485 0.0  
 twenty 0.0031279874756750792 0.0 0 0.0  
 Name: twenty, dtype: float64 0.05003362368007411 0.0  
 tommy 0.00313828223872976 0.0 0 0.0  
 Name: tommy, dtype: float64 0.05945089943696642 0.0  
 fields 0.003105214266924811 0.0 0 0.0  
 Name: fields, dtype: float64 0.05001255685380379 0.0  
 method 0.004700965938537683 0.0 0 0.0  
 Name: method, dtype: float64 0.061486650926920294 0.0  
 setup 0.0033732526198095546 0.0 0 0.0  
 Name: setup, dtype: float64 0.049995190065155105 0.0  
 allocating 0.0036185177639440303 0.0 0 0.0  
 Name: allocating, dtype: float64 0.049955522492451464 0.0  
 initially 0.0028927988978861203 0.0 0 0.0  
 Name: initially, dtype: float64 0.04564314776688668 0.0  
 missed 0.003082441058174544 0.0 0 0.0  
 Name: missed, dtype: float64 0.046124778964151465 0.0  
 clarification 0.003105214266924812 0.0 0 0.0

Name: clarification, dtype: float64 0.05183706975577499 0.0  
 especially 0.003428875603655606 0.0 0 0.0  
 Name: especially, dtype: float64 0.04951322344466954 0.0  
 dorcheus 0.0021084121220409104 0.0 0 0.0  
 Name: dorcheus, dtype: float64 0.048573908550121565 0.0  
 del 0.15983944784412016 0.0 0 0.0  
 Name: del, dtype: float64 0.39352305046984615 0.0  
 millions 0.004043348502021413 0.0 0 0.0  
 Name: millions, dtype: float64 0.05607975648143604 0.0  
 insurance 0.003171132013825545 0.0 0 0.0  
 Name: insurance, dtype: float64 0.05308664720663566 0.0  
 pooling 0.002255770987479212 0.0 0 0.0  
 Name: pooling, dtype: float64 0.048588531427052176 0.0  
 trial 0.017568185058945446 0.0 0 0.0  
 Name: trial, dtype: float64 0.14914836774661275 0.0  
 tennessee 0.0034744220211561415 0.0 0 0.0  
 Name: tennessee, dtype: float64 0.0548928224265345 0.0  
 ellis 0.004182215636227147 0.0 0 0.0  
 Name: ellis, dtype: float64 0.0674822082327483 0.0  
 direction 0.004523802223944846 0.0 0 0.0  
 Name: direction, dtype: float64 0.05966619975426842 0.0  
 bold 0.003360774174113969 0.0 0 0.0  
 Name: bold, dtype: float64 0.05781555113343074 0.0  
 catch 0.0038309331329827207 0.0 0 0.0  
 Name: catch, dtype: float64 0.05222431241639772 0.0  
 performing 0.002781552930194016 0.0 0 0.0  
 Name: performing, dtype: float64 0.046680733935636175 0.0  
 accepted 0.002837175914040069 0.0 0 0.0  
 Name: accepted, dtype: float64 0.046164889515025 0.0  
 matters 0.0032164602346169153 0.0 0 0.0  
 Name: matters, dtype: float64 0.04711224762821205 0.0  
 batch 0.004128994531731164 0.0 0 0.0  
 Name: batch, dtype: float64 0.06937543078215115 0.0  
 continuing 0.0041545944697135165 0.0 0 0.0  
 Name: continuing, dtype: float64 0.053507367276639635 0.0  
 winning 0.0034698364591651677 0.0 0 0.0  
 Name: winning, dtype: float64 0.060661488453912886 0.0  
 symbol 0.005729974811926188 0.0 0 0.0  
 Name: symbol, dtype: float64 0.06759976290285666 0.0  
 offsystem 0.0024554897141131527 0.0 0 0.0  
 Name: offsystem, dtype: float64 0.04655458538745569 0.0  
 decisions 0.002758779721443749 0.0 0 0.0  
 Name: decisions, dtype: float64 0.04462220888247576 0.0  
 produced 0.0035856679888482453 0.0 0 0.0  
 Name: produced, dtype: float64 0.05226325502534489 0.0

ended 0.04171965803234607 0.0 0 0.0  
 Name: ended, dtype: float64 0.192414097994909 0.0  
 greatest 0.002758779721443749 0.0 0 0.0  
 Name: greatest, dtype: float64 0.04462220888247798 0.0  
 degree 0.00503492203832316 0.0 0 0.0  
 Name: degree, dtype: float64 0.06955580606034842 0.0  
 solmonson 0.004066121710771679 0.0 0 0.0  
 Name: solmonson, dtype: float64 0.05609816401277893 0.0  
 imbalances 0.0035504163344023914 0.0 0 0.0  
 Name: imbalances, dtype: float64 0.05560693791681225 0.0  
 fall 0.010474085288614338 0.0 0 0.0  
 Name: fall, dtype: float64 0.09410791579959417 0.0  
 fear 0.004010498726925628 0.0 0 0.0  
 Name: fear, dtype: float64 0.05814516834573098 0.0  
 hate 0.010486563734309926 0.0 0 0.0  
 Name: hate, dtype: float64 0.08874714640516411 0.0  
 fight 0.0032063836682713984 0.0 0 0.0  
 Name: fight, dtype: float64 0.055768948566991064 0.0  
 reallocated 0.003105214266924811 0.0 0 0.0  
 Name: reallocated, dtype: float64 0.04811891400732794 0.0  
 debt 0.004010498726925628 0.0 0 0.0  
 Name: debt, dtype: float64 0.05814516834572917 0.0  
 reform 0.0034288756036556065 0.0 0 0.0  
 Name: reform, dtype: float64 0.04951322344466695 0.0  
 australia 0.0035504163344023923 0.0 0 0.0  
 Name: australia, dtype: float64 0.06179104491326762 0.0  
 plain 0.02303900544357456 0.0 0 0.0  
 Name: plain, dtype: float64 0.14128587507881424 0.0  
 prompt 0.005998013164810931 0.0 0 0.0  
 Name: prompt, dtype: float64 0.06618729355558108 0.0  
 remains 0.0027587797214437488 0.0 0 0.0  
 Name: remains, dtype: float64 0.04462220888247615 0.0  
 ifhsc 0.00334040284471377 0.0 0 0.0  
 Name: ifhsc, dtype: float64 0.05230101826040116 0.0  
 enhancements 0.002249024008389766 0.0 0 0.0  
 Name: enhancements, dtype: float64 0.055329342957279426 0.0  
 connevey 0.0027362247094026458 0.0 0 0.0  
 Name: connevey, dtype: float64 0.05443809033081992 0.0  
 jay 0.006306151129904892 0.0 0 0.0  
 Name: jay, dtype: float64 0.08544374314245708 0.0  
 valued 0.006926070833562015 0.0 0 0.0  
 Name: valued, dtype: float64 0.07377590767468337 0.0  
 lay 0.04988327773717531 0.0 0 0.0  
 Name: lay, dtype: float64 0.23091992457281557 0.0  
 infrastructure 0.0023567221921166346 0.0 0 0.0



```

Name: infrastructure, dtype: float64 0.049575836290276766 0.0
military 0.0032981637489268734 0.0 0 0.0
Name: military, dtype: float64 0.06234939194638986 0.0
allowing 0.002680383528847429 0.0 0 0.0
Name: allowing, dtype: float64 0.045132025111615785 0.0
ff 0.3893108045186561 0.0 0 0.0
Name: ff, dtype: float64 0.6033060217089345 0.6931471805599453
dry 0.004544173553345044 0.0 0 0.0
Name: dry, dtype: float64 0.05916983623716239 0.0

```

```

[52]: scaler = StandardScaler()
      X_scaled = scaler.fit_transform(X)

```

```

[53]: import numpy as np
      from sklearn.preprocessing import LabelBinarizer

      mask = ~np.isnan(y)
      y = y[mask]

      lb = LabelBinarizer(neg_label=0, pos_label=1)
      y_bin = lb.fit_transform(y)

```

```

[54]: print(X_scaled,y_bin)

```

```

[[-0.56544926 -0.64908256 -0.2938948 ... -0.0562853 -0.32904848
  -0.07097072]
 [ 0.11575699  0.71450797  1.33733653 ... -0.0562853  0.03067224
  -0.07097072]
 [-0.56544926 -0.64908256 -0.2938948 ... -0.0562853 -0.32904848
  -0.07097072]
 ...
 [-0.56544926 -0.64908256 -0.2938948 ... -0.0562853 -0.32904848
  -0.07097072]
 [-0.3951477  0.0851585 -0.2938948 ... -0.0562853  0.03067224
  -0.07097072]
 [ 1.30786793  1.86831533 -0.0102024 ... -0.0562853 -0.32904848
  -0.07097072]] [[0]
 [0]
 ...
 [1]
 [1]
 [0]]

```

```
[55]: counts = df['Prediction'].value_counts()
percent = df['Prediction'].value_counts(normalize=True) * 100

print(counts)
print(percent)
```

```
Prediction
0    3672
1    1500
Name: count, dtype: int64
Prediction
0    70.99768
1    29.00232
Name: proportion, dtype: float64
```

```
[56]: fig, axes = plt.subplots(2, 2, figsize=(10, 8))

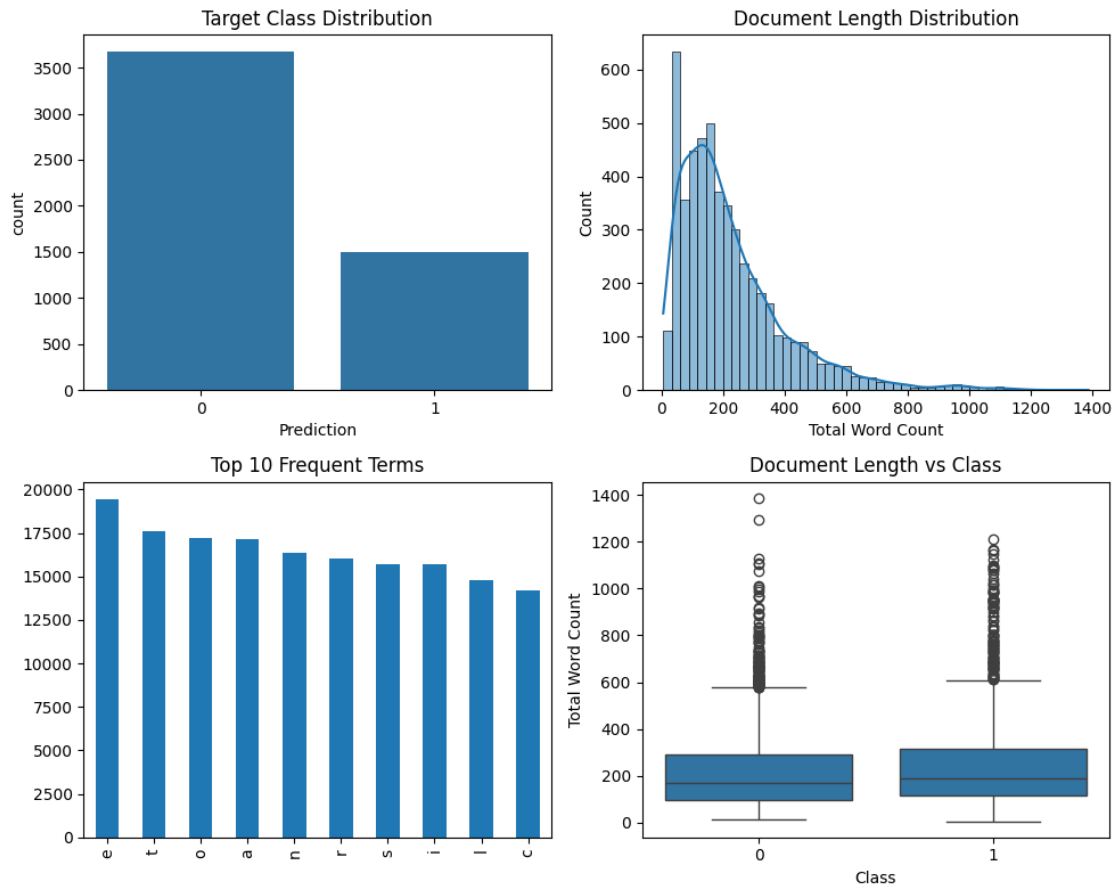
# 1 Target Class Distribution
sns.countplot(x=df['Prediction'], ax=axes[0, 0])
axes[0, 0].set_title("Target Class Distribution")

# 2 Document Length Distribution
doc_length = df.drop(columns=['Prediction']).sum(axis=1)
sns.histplot(doc_length, bins=50, kde=True, ax=axes[0, 1])
axes[0, 1].set_title("Document Length Distribution")
axes[0, 1].set_xlabel("Total Word Count")

# 3 Top Frequent Terms
word_freq = df.drop(columns=['Prediction']).sum().
    ↪sort_values(ascending=False)
word_freq.head(10).plot(kind='bar', ax=axes[1, 0])
axes[1, 0].set_title("Top 10 Frequent Terms")

# 4 Document Length vs Class
sns.boxplot(x=df['Prediction'], y=doc_length, ax=axes[1, 1])
axes[1, 1].set_title("Document Length vs Class")
axes[1, 1].set_xlabel("Class")
axes[1, 1].set_ylabel("Total Word Count")

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



```
[57]: from sklearn.feature_selection import SelectKBest, f_classif
```

```
selector = SelectKBest(score_func=f_classif, k=500)
X_selected = selector.fit_transform(X_scaled, y_bin.ravel())

print("Selected features shape:", X_selected.shape)
```

Selected features shape: (5172, 500)

```
[58]: from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test = train_test_split(
    X_selected, y_bin, test_size=0.2, random_state=42, stratify=y_bin
)

print(X_train.shape, X_test.shape)
```

(4137, 500) (1035, 500)

## 0.4 Diabetes

```
[59]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler, MinMaxScaler, \
    RobustScaler, LabelBinarizer
```

```
[60]: df=pd.read_csv("diabetes_prediction_dataset.csv")
```

```
[61]: df.head()
```

```
[61]:   gender  age  hypertension  heart_disease  smoking_history  bmi \
0  Female  80.0             0             1         never      25.19
1  Female  54.0             0             0         No Info      27.32
2   Male  28.0             0             0         never      27.32
3  Female  36.0             0             0         current      23.45
4   Male  76.0             1             1         current      20.14
```

```
   HbA1c_level  blood_glucose_level  diabetes
0           6.6                 140          0
1           6.6                 80          0
2           5.7                 158          0
3           5.0                 155          0
4           4.8                 155          0
```

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100000 entries, 0 to 99999
Data columns (total 9 columns):
#   Column                Non-Null Count  Dtype
---  -
0   gender                100000 non-null  object
1   age                  100000 non-null  float64
2   hypertension          100000 non-null  int64
3   heart_disease         100000 non-null  int64
4   smoking_history       100000 non-null  object
5   bmi                   100000 non-null  float64
6   HbA1c_level           100000 non-null  float64
7   blood_glucose_level   100000 non-null  int64
8   diabetes              100000 non-null  int64
dtypes: float64(3), int64(4), object(2)
memory usage: 6.9+ MB
```

```
[63]: df.describe()
```

```
[63]:
```

	age	hypertension	heart_disease	bmi \
count	100000.000000	100000.000000	100000.000000	100000.000000
mean	41.885856	0.07485	0.039420	27.320767
std	22.516840	0.26315	0.194593	6.636783
min	0.080000	0.00000	0.000000	10.010000
25%	24.000000	0.00000	0.000000	23.630000
50%	43.000000	0.00000	0.000000	27.320000
75%	60.000000	0.00000	0.000000	29.580000
max	80.000000	1.00000	1.000000	95.690000

	HbA1c_level	blood_glucose_level	diabetes
count	100000.000000	100000.000000	100000.000000
mean	5.527507	138.058060	0.085000
std	1.070672	40.708136	0.278883
min	3.500000	80.000000	0.000000
25%	4.800000	100.000000	0.000000
50%	5.800000	140.000000	0.000000
75%	6.200000	159.000000	0.000000
max	9.000000	300.000000	1.000000

```
[64]: df.columns
```

```
[64]: Index(['gender', 'age', 'hypertension', 'heart_disease', 'smoking_history',  
        'bmi', 'HbA1c_level', 'blood_glucose_level', 'diabetes'],  
        dtype='object')
```

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

```
[65]: (100000, 9)
```

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

```
[66]: gender          0  
age              0  
hypertension     0  
heart_disease    0  
smoking_history  0  
bmi              0  
HbA1c_level      0  
blood_glucose_level  0  
diabetes         0  
dtype: int64
```

```
[67]: X=df.drop(columns=['diabetes'])
      y=df['diabetes']
```

```
[68]: nums_cols=X.select_dtypes(include=['int64','float64']).columns.tolist()
      print("The number columns are: ",nums_cols)
      binary_cols=[col for col in X.columns if X[col].nunique()==2]
      print("The binary columns are: ",binary_cols)
      cat_cols=X.select_dtypes(include='object').columns.tolist()
      cat_cols=[col for col in cat_cols if col not in binary_cols]
      print("The categorical columns are: ",cat_cols)
```

The number columns are: ['age', 'hypertension', 'heart\_disease', 'bmi', 'HbA1c\_level', 'blood\_glucose\_level']

The binary columns are: ['hypertension', 'heart\_disease']

The categorical columns are: ['gender', 'smoking\_history']

```
[69]: df[nums_cols].skew()
```

```
[69]: age                -0.051979
      hypertension        3.231296
      heart_disease       4.733872
      bmi                 1.043836
      HbA1c_level         -0.066854
      blood_glucose_level  0.821655
      dtype: float64
```

```
[70]: df['bmi'] = np.log1p(df['bmi'])
```

```
[71]: for col in nums_cols:
      mean = df[col].mean()
      median = df[col].median()
      mode = df[col].mode()
      std = df[col].std()
      qk = df[col].quantile(0.75)
      print(col,mean,median,mode,std,qk)
```

age 41.885856 43.0 0 80.0  
Name: age, dtype: float64 22.51683987161513 60.0  
hypertension 0.07485 0.0 0 0  
Name: hypertension, dtype: int64 0.2631504702291422 0.0  
heart\_disease 0.03942 0.0 0 0  
Name: heart\_disease, dtype: int64 0.19459301699790674 0.0  
bmi 3.317219955426433 3.343568268825519 0 3.343568  
Name: bmi, dtype: float64 0.2300400805602167 3.420346200500916  
HbA1c\_level 5.527507 5.8 0 6.6  
Name: HbA1c\_level, dtype: float64 1.0706720918832282 6.2

```
blood_glucose_level 138.05806 140.0 0    130
Name: blood_glucose_level, dtype: int64 40.70813604870113 159.0
```

```
[72]: scaler = StandardScaler()
      X[nums_cols] = scaler.fit_transform(X[nums_cols])
```

```
[73]: X = pd.get_dummies(X, columns=cat_cols, drop_first=True)
```

```
[74]: print(X)
```

```

      age  hypertension  heart_disease    bmi  HbA1c_level \
0    1.692704    -0.284439     4.936379 -0.321056     1.001706
1    0.538006    -0.284439    -0.202578 -0.000116     1.001706
2   -0.616691    -0.284439    -0.202578 -0.000116     0.161108
3   -0.261399    -0.284439    -0.202578 -0.583232    -0.492690
4    1.515058     3.515687     4.936379 -1.081970    -0.679490
...      ...      ...      ...      ...      ...
99995  1.692704    -0.284439    -0.202578 -0.000116     0.628107
99996 -1.771388    -0.284439    -0.202578 -1.499343     0.908306
99997  1.070944    -0.284439    -0.202578  0.076729     0.161108
99998 -0.794336    -0.284439    -0.202578  1.220361    -1.426688
99999  0.671241    -0.284439    -0.202578 -0.736922     1.001706
```

```

      blood_glucose_level  gender_Male  gender_Other \
0              0.047704         False         False
1             -1.426210         False         False
2              0.489878          True         False
3              0.416183         False         False
4              0.416183          True         False
...              ...              ...              ...
99995          -1.180558         False         False
99996          -0.934905         False         False
99997              0.416183          True         False
99998          -0.934905         False         False
99999          -1.180558         False         False
```

```

      smoking_history_current  smoking_history_ever  smoking_history_former \
0              False              False              False
1              False              False              False
2              False              False              False
3               True              False              False
4               True              False              False
...              ...              ...              ...
99995          False              False              False
```

99996	False	False	False
99997	False	False	True
99998	False	False	False
99999	True	False	False

	smoking_history_never	smoking_history_not	current
0	True		False
1	False		False
2	True		False
3	False		False
4	False		False
...	...		...
99995	False		False
99996	False		False
99997	False		False
99998	True		False
99999	False		False

[100000 rows x 13 columns]

```
[75]: X = X.astype(int)
```

```
[76]: # Set figure size and layout (2 rows, 3 columns)
fig, axes = plt.subplots(2, 4, figsize=(18, 12)) # Adjust rows/cols as
→needed
fig.suptitle("Exploratory Data Analysis", fontsize=20)

# Flatten axes array for easy indexing
axes = axes.flatten()

# Target variable distribution
sns.countplot(x='diabetes', data=df, ax=axes[0])
axes[0].set_title("Target Variable Distribution")

# Age distribution (histogram + KDE)
sns.histplot(df['age'], bins=30, kde=True, ax=axes[1])
axes[1].set_title("Age Distribution")

# BMI vs Diabetes (boxplot)
sns.boxplot(x='diabetes', y='bmi', data=df, ax=axes[2])
axes[2].set_title("BMI vs Diabetes")

# Average BMI by Gender (barplot)
sns.barplot(x='gender', y='bmi', data=df, ax=axes[3])
```



```

axes[3].set_title("Average BMI by Gender")

# BMI vs Blood Glucose (scatter)
sns.scatterplot(x='bmi', y='blood_glucose_level', hue='diabetes',
    ↳data=df, ax=axes[4])
axes[4].set_title("BMI vs Blood Glucose")

# HbA1c Trend by Age (lineplot)
sns.lineplot(x='age', y='HbA1c_level', data=df, ax=axes[5])
axes[5].set_title("HbA1c Trend by Age")

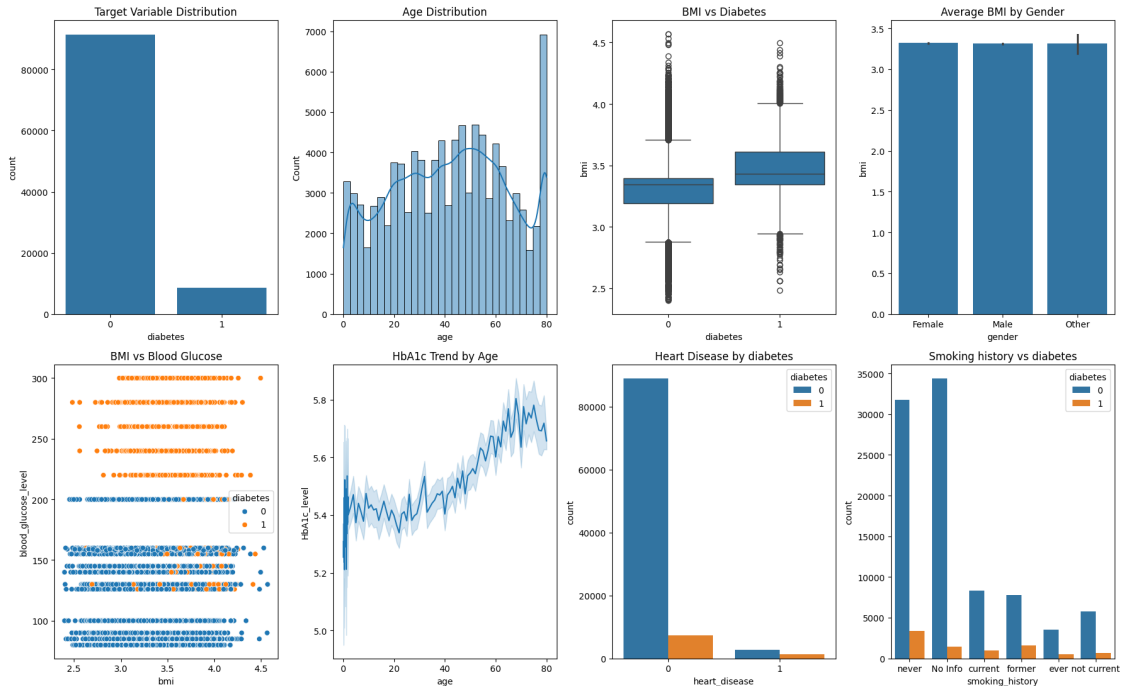
sns.countplot(x='heart_disease', hue='diabetes', data=df, ax=axes[6])
axes[6].set_title("Heart Disease by diabetes")

sns.countplot(x='smoking_history', hue='diabetes', data=df, ax=axes[7])
axes[7].set_title("Smoking history vs diabetes")

# Adjust layout so titles don't overlap
plt.tight_layout(rect=[0, 0, 1, 0.96]) # leave space for supitle
plt.show()

```

Exploratory Data Analysis



```
[77]: from sklearn.feature_selection import SelectKBest, f_classif
```

```
X_new = SelectKBest(score_func=f_classif, k=8)
X_selected = X_new.fit_transform(X, y)

selected_features = X.columns[X_new.get_support()]
print("Selected Features:", selected_features)
```

```
Selected Features: Index(['age', 'hypertension', 'heart_disease', 'bmi',
                          'HbA1c_level',
                          'blood_glucose_level', 'gender_Male', 'smoking_history_former'],
                          dtype='object')
```

```
[78]: from sklearn.model_selection import train_test_split
```

```
# Train + Test
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=42, stratify=y
)

# Train + Validation
X_train, X_val, y_train, y_val = train_test_split(
    X_train, y_train, test_size=0.2, random_state=42, stratify=y_train
)

print("Training set:", X_train.shape)
print("Validation set:", X_val.shape)
print("Testing set:", X_test.shape)
```

```
Training set: (64000, 13)
Validation set: (16000, 13)
Testing set: (20000, 13)
```

## 0.5 Iris

```
[79]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler, MinMaxScaler, \
    RobustScaler, LabelBinarizer
```

```
[80]: df = pd.read_csv("Iris.csv")
df.head()
```

```
[80]:   Id  SepalLengthCm  SepalWidthCm  PetalLengthCm  PetalWidthCm  ┘
      ↪Species
0    1             5.1             3.5             1.4             0.2 ┘
      ↪Iris-setosa
1    2             4.9             3.0             1.4             0.2 ┘
      ↪Iris-setosa
2    3             4.7             3.2             1.3             0.2 ┘
      ↪Iris-setosa
3    4             4.6             3.1             1.5             0.2 ┘
      ↪Iris-setosa
4    5             5.0             3.6             1.4             0.2 ┘
      ↪Iris-setosa
```

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

```
[81]: (150, 6)
```

```
[82]: df.columns
```

```
[82]: Index(['Id', 'SepalLengthCm', 'SepalWidthCm', 'PetalLengthCm', ┘
      ↪'PetalWidthCm',
          'Species'],
          dtype='object')
```

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 150 entries, 0 to 149
Data columns (total 6 columns):
#   Column          Non-Null Count  Dtype
---  -
0   Id              150 non-null   int64
1   SepalLengthCm   150 non-null   float64
2   SepalWidthCm    150 non-null   float64
3   PetalLengthCm   150 non-null   float64
4   PetalWidthCm    150 non-null   float64
5   Species         150 non-null   object
dtypes: float64(4), int64(1), object(1)
memory usage: 7.2+ KB
```

```
[84]: df.describe()
```

```
[84]:
```

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm
count	150.000000	150.000000	150.000000	150.000000	150.000000
mean	75.500000	5.843333	3.054000	3.758667	1.198667
std	43.445368	0.828066	0.433594	1.764420	0.763161
min	1.000000	4.300000	2.000000	1.000000	0.100000
25%	38.250000	5.100000	2.800000	1.600000	0.300000
50%	75.500000	5.800000	3.000000	4.350000	1.300000
75%	112.750000	6.400000	3.300000	5.100000	1.800000
max	150.000000	7.900000	4.400000	6.900000	2.500000

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

```
[85]: Id          0
      SepalLengthCm  0
      SepalWidthCm  0
      PetalLengthCm  0
      PetalWidthCm  0
      Species       0
      dtype: int64
```

```
[86]: df.duplicated().sum()
```

```
[86]: np.int64(0)
```

```
[87]: df['Species'].value_counts()
```

```
[87]: Species
      Iris-setosa      50
      Iris-versicolor  50
      Iris-virginica   50
      Name: count, dtype: int64
```

```
[88]: X=df.drop(columns=['Species'])
      y=df['Species']
```

```
[89]: nums_cols=X.select_dtypes(include=['int64','float64']).columns.tolist()
print("The number columns are: ",nums_cols)
binary_cols=[col for col in X.columns if X[col].nunique()==2]
print("The binary columns are: ",binary_cols)
cat_cols=X.select_dtypes(include='object').columns.tolist()
cat_cols=[col for col in cat_cols if col not in binary_cols]
print("The categorical columns are: ",cat_cols)
```

```
The number columns are:  ['Id', 'SepalLengthCm', 'SepalWidthCm',
 'PetalLengthCm', 'PetalWidthCm']
```

```
The binary columns are:  []
```

```
The categorical columns are:  []
```

```
[90]: scaler = StandardScaler()
X[nums_cols] = scaler.fit_transform(X[nums_cols])
```

```
[91]: print(X)
```

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm
0	-1.720542	-0.900681	1.032057	-1.341272	-1.312977
1	-1.697448	-1.143017	-0.124958	-1.341272	-1.312977
2	-1.674353	-1.385353	0.337848	-1.398138	-1.312977
3	-1.651258	-1.506521	0.106445	-1.284407	-1.312977
4	-1.628164	-1.021849	1.263460	-1.341272	-1.312977
..	...	...	...	...	...
145	1.628164	1.038005	-0.124958	0.819624	1.447956
146	1.651258	0.553333	-1.281972	0.705893	0.922064
147	1.674353	0.795669	-0.124958	0.819624	1.053537
148	1.697448	0.432165	0.800654	0.933356	1.447956
149	1.720542	0.068662	-0.124958	0.762759	0.790591

```
[150 rows x 5 columns]
```

```
[92]: plt.figure(figsize=(12, 8))

# Sepal Length
plt.subplot(2, 3, 1)
plt.hist(df['SepalLengthCm'], bins=20)
plt.title("Sepal Length")
plt.xlabel("cm")
plt.ylabel("Frequency")

# Sepal Width
plt.subplot(2, 3, 2)
plt.hist(df['SepalWidthCm'], bins=20)
```

```

plt.title("Sepal Width")
plt.xlabel("cm")

# Petal Length
plt.subplot(2, 3, 3)
plt.hist(df['PetalLengthCm'], bins=20)
plt.title("Petal Length")
plt.xlabel("cm")

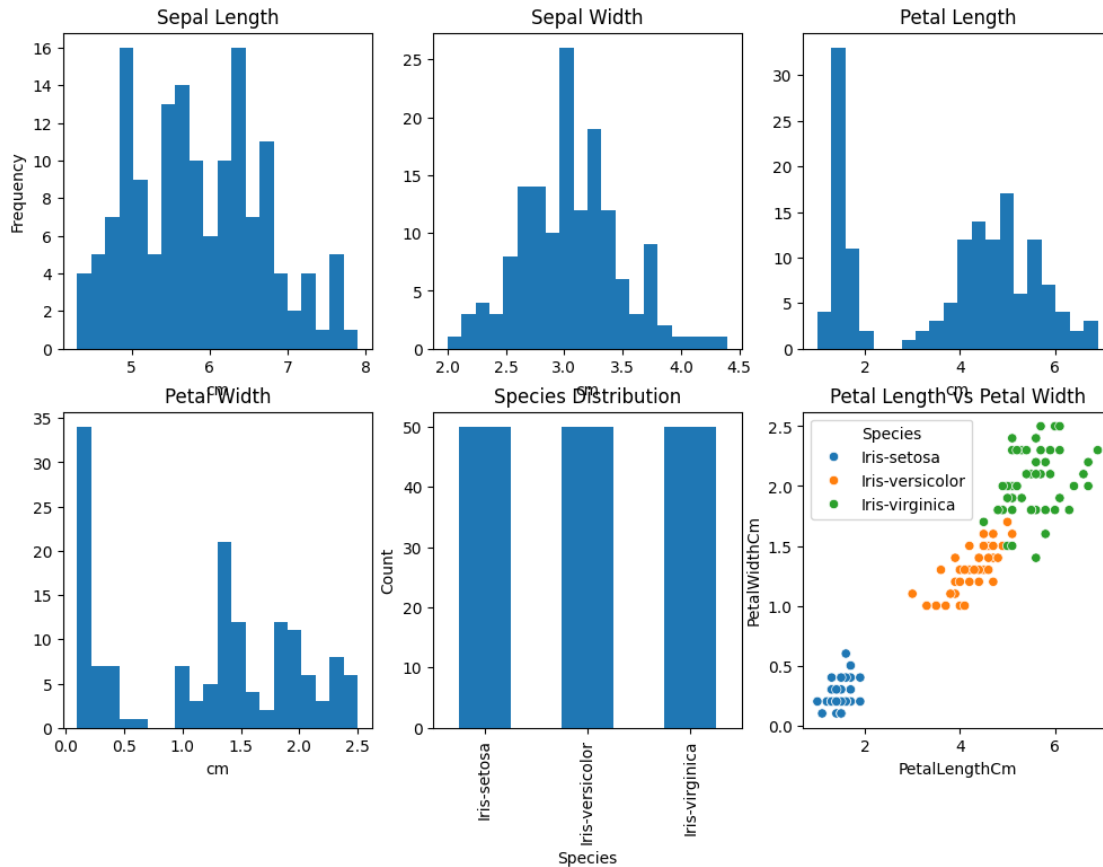
# Petal Width
plt.subplot(2, 3, 4)
plt.hist(df['PetalWidthCm'], bins=20)
plt.title("Petal Width")
plt.xlabel("cm")

# Species Count
plt.subplot(2, 3, 5)
df['Species'].value_counts().plot(kind='bar')
plt.title("Species Distribution")
plt.xlabel("Species")
plt.ylabel("Count")

plt.subplot(2,3,6)
sns.scatterplot(x='PetalLengthCm',
                y='PetalWidthCm',
                hue='Species',
                data=df)
plt.title("Petal Length vs Petal Width")
plt.show()

plt.tight_layout()
plt.show()

```



<Figure size 640x480 with 0 Axes>

```
[93]: from sklearn.feature_selection import SelectKBest, f_classif
```

```
selector = SelectKBest(score_func=f_classif, k=3)
X_selected = selector.fit_transform(X, y)

selected_features = X.columns[selector.get_support()]
print("Selected Features:", selected_features)
```

Selected Features: Index(['Id', 'PetalLengthCm', 'PetalWidthCm'],  
dtype='object')

```
[94]: from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test = train_test_split(
    X_selected, y, test_size=0.2, random_state=42, stratify=y
)
```

```
print(X_train.shape, X_test.shape)
```

```
(120, 3) (30, 3)
```

## Inference Table

Dataset	Type of ML Task	Feature Selection Technique	Suitable ML Algorithm
Iris Dataset	Multi-class Classification	ANOVA, SelectKBest	K-Nearest Neighbour
Loan Amount Prediction	Regression	ANOVA, SelectKBest	Linear Regression
Predicting Diabetes	Classification	ANOVA, SelectKBest	Logistic Regression
Classification of Email Spam	Binary Classification	ANOVA, SelectKBest	Naive Bayes
Handwritten Character Recognition / MNIST	Multi-class Classification	ANOVA, SelectKBest	SVM

## Learning Outcomes

Through this experiment, the following learning outcomes were achieved:

- Gained a clear understanding of different types of machine learning tasks such as classification and regression.
- Learned how to identify suitable machine learning algorithms based on dataset characteristics.
- Understood the importance of feature selection techniques like ANOVA, Chi-Square test, and PCA.
- Acquired practical experience in working with multiple real-world datasets.
- Improved knowledge of the complete machine learning workflow including data loading, preprocessing, visualization, and evaluation.