In [ ]:

```
import pandas as pd
import re
import numpy as np
import itertools
```

In [ ]:

```
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).
```

In [ ]:

```
file_path = '/content/drive/MyDrive/bk/processed.hungarian.data'
```

In [ ]:

```
with open(file_path, encoding='Latin1') as file:
    lines = [line.strip() for line in file]
```

In [ ]:

```
lines[0:10]
```

Out[ ]:

```
['1254 0 40 1 1 0 0',
 '-9 2 140 0 289 -9 -9 -9',
 '0 -9 -9 0 12 16 84 0',
 '0 0 0 0 150 18 -9 7',
 '172 86 200 110 140 86 0 0',
 '0 -9 26 20 -9 -9 -9 -9',
 '-9 -9 -9 -9 -9 -9 -9 12',
 '20 84 0 -9 -9 -9 -9 -9',
 '-9 -9 -9 -9 -9 1 1 1',
 '1 1 -9. -9. name']
```

In [ ]:

```
data = itertools.takewhile(
    lambda x: len(x) == 76,
    (' '.join(lines[i:(i+10)]).split() for i in range(0, len(lines), 10))
)

df = pd.DataFrame(data)
df.head(10)
```

Out[ ]:

	0	1	2	3	4	5	6	7	8	9	...	66	67	68	69	70	71	72	73	74	75
0	1254	0	40	1	1	0	0	-9	2	140	...	-9	-9	1	1	1	1	1	-9.	-9.	name
1	1255	0	49	0	1	0	0	-9	3	160	...	-9	-9	1	1	1	1	1	-9.	-9.	name
2	1256	0	37	1	1	0	0	-9	2	130	...	-9	-9	1	1	1	1	1	-9.	-9.	name
3	1257	0	48	0	1	1	1	-9	4	138	...	2	-9	1	1	1	1	1	-9.	-9.	name
4	1258	0	54	1	1	0	1	-9	3	150	...	1	-9	1	1	1	1	1	-9.	-9.	name
5	1259	0	39	1	1	0	1	-9	3	120	...	-9	-9	1	1	1	1	1	-9.	-9.	name
6	1260	0	45	0	0	1	0	-9	2	130	...	-9	-9	1	1	1	1	1	-9.	-9.	name
7	1261	0	54	1	1	0	0	-9	2	110	...	-9	-9	1	1	1	1	1	-9.	-9.	name
8	1262	0	37	1	1	1	1	-9	4	140	...	-9	-9	1	1	1	1	1	-9.	-9.	name

	0	1	2	3	4	5	6	7	8	9	...	66	67	68	69	70	71	72	73	74	75
9	1263	0	48	0	1	0	0	-9	2	120	...	-9	-9	1	1	1	1	1	-9.	-9.	name

10 rows × 76 columns

In [ ]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 294 entries, 0 to 293
Data columns (total 76 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   0       294 non-null    object
 1   1       294 non-null    object
 2   2       294 non-null    object
 3   3       294 non-null    object
 4   4       294 non-null    object
 5   5       294 non-null    object
 6   6       294 non-null    object
 7   7       294 non-null    object
 8   8       294 non-null    object
 9   9       294 non-null    object
 10  10      294 non-null    object
 11  11      294 non-null    object
 12  12      294 non-null    object
 13  13      294 non-null    object
 14  14      294 non-null    object
 15  15      294 non-null    object
 16  16      294 non-null    object
 17  17      294 non-null    object
 18  18      294 non-null    object
 19  19      294 non-null    object
 20  20      294 non-null    object
 21  21      294 non-null    object
 22  22      294 non-null    object
 23  23      294 non-null    object
 24  24      294 non-null    object
 25  25      294 non-null    object
 26  26      294 non-null    object
 27  27      294 non-null    object
 28  28      294 non-null    object
 29  29      294 non-null    object
 30  30      294 non-null    object
 31  31      294 non-null    object
 32  32      294 non-null    object
 33  33      294 non-null    object
 34  34      294 non-null    object
 35  35      294 non-null    object
 36  36      294 non-null    object
 37  37      294 non-null    object
 38  38      294 non-null    object
 39  39      294 non-null    object
 40  40      294 non-null    object
 41  41      294 non-null    object
 42  42      294 non-null    object
 43  43      294 non-null    object
 44  44      294 non-null    object
 45  45      294 non-null    object
 46  46      294 non-null    object
 47  47      294 non-null    object
 48  48      294 non-null    object
 49  49      294 non-null    object
 50  50      294 non-null    object
 51  51      294 non-null    object
 52  52      294 non-null    object
 53  53      294 non-null    object
 54  54      294 non-null    object
 55  55      294 non-null    object
 56  56      294 non-null    object
 57  57      294 non-null    object
```

```
 58  58      294 non-null    object
 59  59      294 non-null    object
 60  60      294 non-null    object
 61  61      294 non-null    object
 62  62      294 non-null    object
 63  63      294 non-null    object
 64  64      294 non-null    object
 65  65      294 non-null    object
 66  66      294 non-null    object
 67  67      294 non-null    object
 68  68      294 non-null    object
 69  69      294 non-null    object
 70  70      294 non-null    object
 71  71      294 non-null    object
 72  72      294 non-null    object
 73  73      294 non-null    object
 74  74      294 non-null    object
 75  75      294 non-null    object
dtypes: object(76)
memory usage: 174.7+ KB
```

In [ ]:

```
df = df.iloc[:,:-1]
df = df.drop(df.columns[0], axis=1)
df = df.astype(float)

df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 294 entries, 0 to 293
Data columns (total 74 columns):
 #   Column  Non-Null Count  Dtype  
---  ------  --------------  -----  
 0   1       294 non-null    float64
 1   2       294 non-null    float64
 2   3       294 non-null    float64
 3   4       294 non-null    float64
 4   5       294 non-null    float64
 5   6       294 non-null    float64
 6   7       294 non-null    float64
 7   8       294 non-null    float64
 8   9       294 non-null    float64
 9   10      294 non-null    float64
 10  11      294 non-null    float64
 11  12      294 non-null    float64
 12  13      294 non-null    float64
 13  14      294 non-null    float64
 14  15      294 non-null    float64
 15  16      294 non-null    float64
 16  17      294 non-null    float64
 17  18      294 non-null    float64
 18  19      294 non-null    float64
 19  20      294 non-null    float64
 20  21      294 non-null    float64
 21  22      294 non-null    float64
 22  23      294 non-null    float64
 23  24      294 non-null    float64
 24  25      294 non-null    float64
 25  26      294 non-null    float64
 26  27      294 non-null    float64
 27  28      294 non-null    float64
 28  29      294 non-null    float64
 29  30      294 non-null    float64
 30  31      294 non-null    float64
 31  32      294 non-null    float64
 32  33      294 non-null    float64
 33  34      294 non-null    float64
 34  35      294 non-null    float64
 35  36      294 non-null    float64
 36  37      294 non-null    float64
 37  38      294 non-null    float64
```

```
 38  39      294 non-null    float64
 39  40      294 non-null    float64
 40  41      294 non-null    float64
 41  42      294 non-null    float64
 42  43      294 non-null    float64
 43  44      294 non-null    float64
 44  45      294 non-null    float64
 45  46      294 non-null    float64
 46  47      294 non-null    float64
 47  48      294 non-null    float64
 48  49      294 non-null    float64
 49  50      294 non-null    float64
 50  51      294 non-null    float64
 51  52      294 non-null    float64
 52  53      294 non-null    float64
 53  54      294 non-null    float64
 54  55      294 non-null    float64
 55  56      294 non-null    float64
 56  57      294 non-null    float64
 57  58      294 non-null    float64
 58  59      294 non-null    float64
 59  60      294 non-null    float64
 60  61      294 non-null    float64
 61  62      294 non-null    float64
 62  63      294 non-null    float64
 63  64      294 non-null    float64
 64  65      294 non-null    float64
 65  66      294 non-null    float64
 66  67      294 non-null    float64
 67  68      294 non-null    float64
 68  69      294 non-null    float64
 69  70      294 non-null    float64
 70  71      294 non-null    float64
 71  72      294 non-null    float64
 72  73      294 non-null    float64
 73  74      294 non-null    float64
dtypes: float64(74)
memory usage: 170.1 KB
```

In [ ]:

```
df.replace(-9.0, np.nan, inplace=True)
```

In [ ]:

```
df_selected = df.iloc[:, [1, 2, 7, 8, 10, 14, 17, 30, 36, 38, 39, 42, 49, 56]]
df_selected.head()
```

Out[ ]:

	2	3	8	9	11	15	18	31	37	39	40	43	50	57
0	40.0	1.0	2.0	140.0	289.0	0.0	0.0	172.0	0.0	0.0	NaN	NaN	NaN	0.0
1	49.0	0.0	3.0	160.0	180.0	0.0	0.0	156.0	0.0	1.0	2.0	NaN	NaN	1.0
2	37.0	1.0	2.0	130.0	283.0	0.0	1.0	98.0	0.0	0.0	NaN	NaN	NaN	0.0
3	48.0	0.0	4.0	138.0	214.0	0.0	0.0	108.0	1.0	1.5	2.0	NaN	NaN	3.0
4	54.0	1.0	3.0	150.0	NaN	0.0	0.0	122.0	0.0	0.0	NaN	NaN	NaN	0.0

In [ ]:

```
column_mapping = {
    2: 'age',
    3: 'sex',
    8: 'cp',
    9: 'trestbps',
    11: 'chol',
    15: 'fbs',
    18: 'restecg',
```

```
    31: 'thalach',
    37: 'exang',
    39: 'oldpeak',
    40: 'slope',
    43: 'ca',
    50: 'thal',
    57: 'target'
}

df_selected.rename(columns=column_mapping, inplace=True)
df_selected.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 294 entries, 0 to 293
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       294 non-null    float64
 1   sex       294 non-null    float64
 2   cp        294 non-null    float64
 3   trestbps  293 non-null    float64
 4   chol      271 non-null    float64
 5   fbs       286 non-null    float64
 6   restecg   293 non-null    float64
 7   thalach   293 non-null    float64
 8   exang     293 non-null    float64
 9   oldpeak   294 non-null    float64
 10  slope     104 non-null    float64
 11  ca        4 non-null      float64
 12  thal      28 non-null     float64
 13  target    294 non-null    float64
dtypes: float64(14)
memory usage: 32.3 KB
```

```
<ipython-input-385-b35476392aaf>:18: SettingWithCopyWarning: 
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_g
uide/indexing.html#returning-a-view-versus-a-copy
  df_selected.rename(columns=column_mapping, inplace=True)
```

In [ ]:

```
df_selected.value_counts()
```

Out[ ]:

```
age   sex  cp   trestbps  chol   fbs  restecg  thalach  exang  oldpeak  slope  ca   thal 
target
47.0  1.0  4.0  150.0     226.0  0.0  0.0      98.0     1.0    1.5      2.0    0.0  7.0  
1.0       1
dtype: int64
```

In [ ]:

```
df_selected.isnull().sum()
```

Out[ ]:

```
age           0
sex           0
cp            0
trestbps      1
chol         23
fbs           8
restecg       1
thalach       1
exang         1
oldpeak       0
slope       190
ca          290
thal        266
target        0
```

```
dtype: int64
```

In [ ]:

```
columns_to_drop = ['ca', 'slope', 'thal']
df_selected = df_selected.drop(columns_to_drop, axis=1)
```

In [ ]:

```
df_selected.isnull().sum()
```

Out[ ]:

```
age          0
sex          0
cp           0
trestbps     1
chol        23
fbs          8
restecg      1
thalach      1
exang        1
oldpeak      0
target       0
dtype: int64
```

In [ ]:

```
meanTBPS = round(df_selected['trestbps'].dropna().astype(float).mean())
meanChol = round(df_selected['chol'].dropna().astype(float).mean())
meanFbs = round(df_selected['fbs'].dropna().astype(float).mean())
meanRestEcg = round(df_selected['restecg'].dropna().astype(float).mean())
meanThalach = round(df_selected['thalach'].dropna().astype(float).mean())
meanExang = round(df_selected['exang'].dropna().astype(float).mean())

fill_values = {
    'trestbps': meanTBPS,
    'chol': meanChol,
    'fbs': meanFbs,
    'thalach': meanThalach,
    'exang': meanExang,
    'restecg': meanRestEcg
}
df_clean = df_selected.fillna(value=fill_values)
df_clean.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 294 entries, 0 to 293
Data columns (total 11 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   age       294 non-null    float64
 1   sex       294 non-null    float64
 2   cp        294 non-null    float64
 3   trestbps  294 non-null    float64
 4   chol      294 non-null    float64
 5   fbs       294 non-null    float64
 6   restecg   294 non-null    float64
 7   thalach   294 non-null    float64
 8   exang     294 non-null    float64
 9   oldpeak   294 non-null    float64
 10  target    294 non-null    float64
dtypes: float64(11)
memory usage: 25.4 KB
```

In [ ]:

```
df_clean.isnull().sum()
```

Out[ ]:

```
age         0
sex         0
```

```
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
target      0
dtype: int64
```

In [ ]:

```
duplicate_rows = df_clean.duplicated()
df_clean[duplicate_rows]
```

Out[ ]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	target
163	49.0	0.0	2.0	110.0	251.0	0.0	0.0	160.0	0.0	0.0	0.0

In [ ]:

```
df_clean = df_clean.drop_duplicates()
df_clean[df_clean.duplicated(keep=False)]
```

Out[ ]:

age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	target

In [ ]:

```
df_clean.corr()
```

Out[ ]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	target
age	1.000000	0.014516	0.146616	0.246571	0.087101	0.181130	0.050672	-0.460514	0.239223	0.178172	0.210429
sex	0.014516	1.000000	0.245769	0.082064	0.027695	0.044372	-0.108656	-0.106959	0.154925	0.115959	0.220732
cp	0.146616	0.245769	1.000000	0.081293	0.134697	0.031930	-0.016372	-0.367819	0.494674	0.351735	0.427536
trestbps	0.246571	0.082064	0.081293	1.000000	0.080818	0.096222	0.011256	-0.181824	0.211507	0.204000	0.214898
chol	0.087101	0.027695	0.134697	0.080818	1.000000	0.107686	0.048081	-0.122038	0.161055	0.106743	0.256027
fbs	0.181130	0.044372	0.031930	0.096222	0.107686	1.000000	0.047988	-0.069722	0.115503	0.063179	0.154319
restecg	0.050672	-0.108656	-0.016372	0.011256	0.048081	0.047988	1.000000	0.006084	0.041290	0.042193	0.042643
thalach	-0.460514	-0.106959	-0.367819	-0.181824	-0.122038	-0.069722	0.006084	1.000000	-0.400508	-0.300458	-0.367525
exang	0.239223	0.154925	0.494674	0.211507	0.161055	0.115503	0.041290	-0.400508	1.000000	0.624965	0.571710
oldpeak	0.178172	0.115959	0.351735	0.204000	0.106743	0.063179	0.042193	-0.300458	0.624965	1.000000	0.580732
target	0.210429	0.220732	0.427536	0.214898	0.256027	0.154319	0.042643	-0.367525	0.571710	0.580732	1.000000

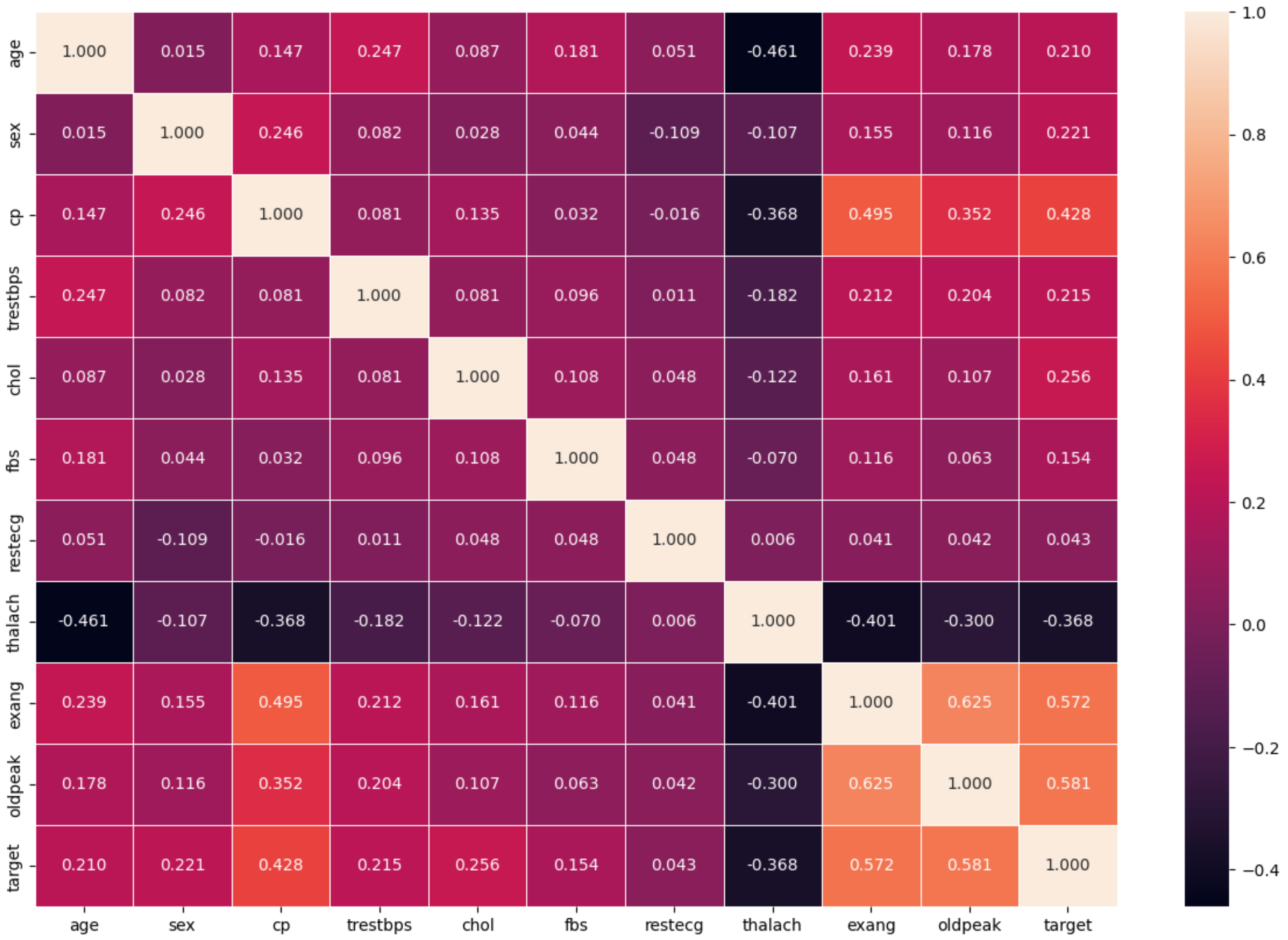
In [ ]:

```python
import seaborn as sns
import matplotlib.pyplot as plt

corr_mat = df_clean.corr()
fig, ax = plt.subplots(figsize=(15, 10))
sns.heatmap(corr_mat, annot=True, linewidths=0.5, fmt=".3f")
```

Out[ ]:

```
<Axes: >
```



In [ ]:

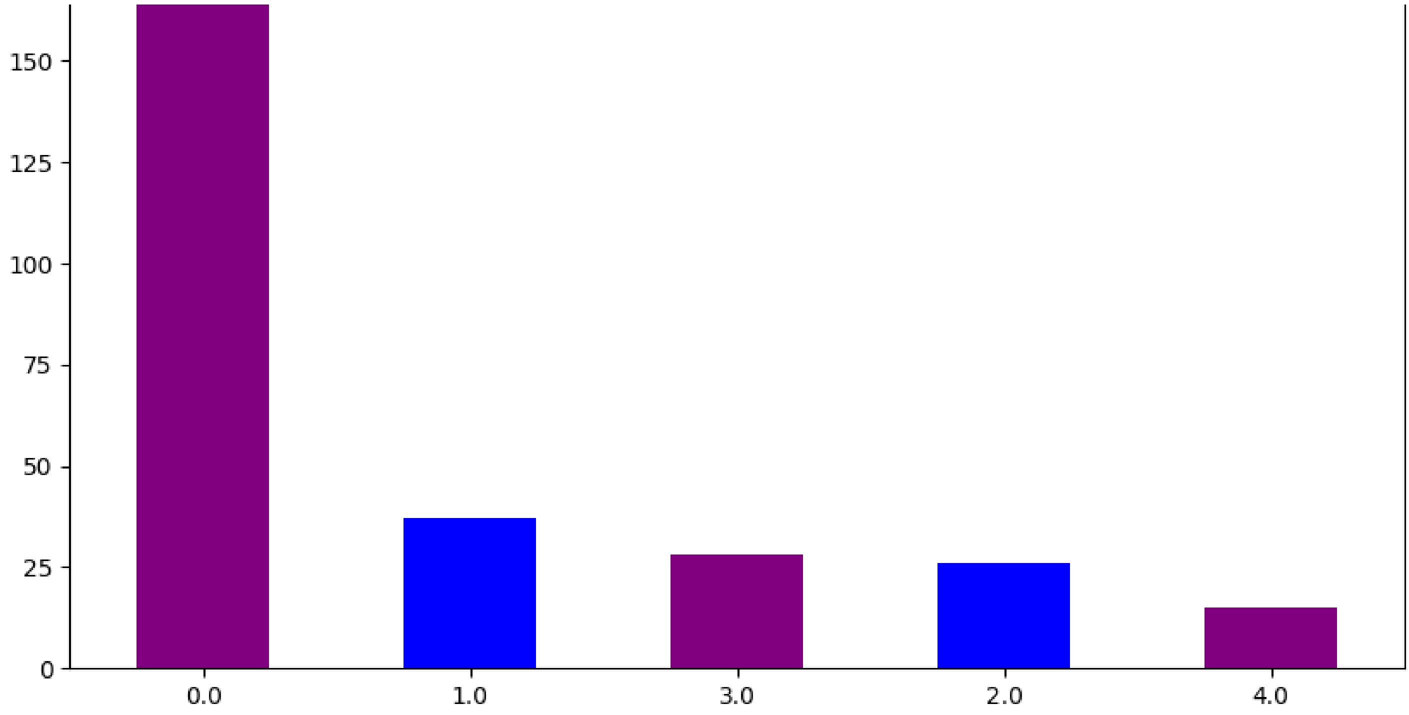
```python
X = df_clean.drop("target", axis=1).values
y = df_clean.iloc[:, -1]
```

In [ ]:

```python
df_clean['target'].value_counts().plot(kind='bar', figsize=(10,6), color=['purple', 'blu
e'])
plt.title("Count target")
plt.xticks(rotation=0)
```

Out[ ]:

```
(array([0, 1, 2, 3, 4]),
 [Text(0, 0, '0.0'),
  Text(1, 0, '1.0'),
  Text(2, 0, '3.0'),
  Text(3, 0, '2.0'),
  Text(4, 0, '4.0')])
```



In [ ]:

```
from imblearn.over_sampling import SMOTE

smote = SMOTE(random_state=42)
X_smote_resampled, y_smote_resampled = smote.fit_resample(X, y)

new_df1 = pd.DataFrame(data=y)
new_df2 = pd.DataFrame(data=y_smote_resampled)
```

In [ ]:

```
from sklearn.preprocessing import MinMaxScaler

scaler = MinMaxScaler()

X_smote_resampled_normal = scaler.fit_transform(X_smote_resampled)
```

In [ ]:

```
df_check1 = pd.DataFrame(X_smote_resampled_normal)
df_check1.describe()
```

Out[ ]:

	0	1	2	3	4	5	6	7	8	
count	935.000000	935.000000	935.000000	935.000000	935.000000	935.000000	935.000000	935.000000	935.000000	935.0000
mean	0.563739	0.842507	0.818224	0.403413	0.341027	0.094277	0.117938	0.453354	0.598398	0.2270
std	0.174873	0.332492	0.274211	0.147493	0.110990	0.252030	0.199527	0.197232	0.450288	0.2012
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
25%	0.473283	1.000000	0.666667	0.305556	0.267954	0.000000	0.000000	0.312720	0.000000	0.0000
50%	0.578947	1.000000	1.000000	0.387952	0.330240	0.000000	0.000000	0.440606	0.962447	0.2000
75%	0.683363	1.000000	1.000000	0.487481	0.393811	0.000000	0.201473	0.593629	1.000000	0.3861
max	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.0000

In [ ]:

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X_smote_resampled, y_smote_resampled
```

```
, test_size=0.2, random_state=42, stratify=y_smote_resampled)
X_train_normal, X_test_normal, y_train_normal, y_test_normal = train_test_split(X_smote_r
esampled_normal, y_smote_resampled, test_size=0.2, random_state=42, stratify=y_smote_res
ampled)
```

In [ ]:

```
from sklearn.metrics import accuracy_score, recall_score, f1_score, precision_score, roc_
auc_score, confusion_matrix, precision_score

def evaluation(y_test, y_pred):
    return print({
        'accuracy': round(accuracy_score(y_test, y_pred), 3),
        'recall': round(recall_score(y_test, y_pred, average='weighted'), 3),
        'f1_score': round(f1_score(y_test, y_pred, average='weighted'), 3),
        'precision_score': round(precision_score(y_test, y_pred, average='weighted'), 3)
    })
```

In [ ]:

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import accuracy_score, classification_report
```

In [ ]:

```
knn_model = KNeighborsClassifier(n_neighbors=3)
knn_model.fit(X_train, y_train)
```

Out[ ]:

```
▾ KNeighborsClassifier
KNeighborsClassifier(n_neighbors=3)
```

In [ ]:

```
y_pred_knn = knn_model.predict(X_test)
```

In [ ]:

```
print("KNN Model:")
accuracy_knn_smote = round(accuracy_score(y_test, y_pred_knn), 3)
print("Accuracy: ", accuracy_knn_smote)
print("Classification Report: ")
print(classification_report(y_test, y_pred_knn))
```

```
KNN Model:
Accuracy:  0.754
Classification Report:
              precision    recall  f1-score   support

         0.0       0.65      0.39      0.49        38
         1.0       0.73      0.81      0.77        37
         2.0       0.80      0.86      0.83        37
         3.0       0.77      0.87      0.81        38
         4.0       0.78      0.84      0.81        37

    accuracy                           0.75       187
   macro avg       0.75      0.76      0.74       187
weighted avg       0.74      0.75      0.74       187
```

In [ ]:

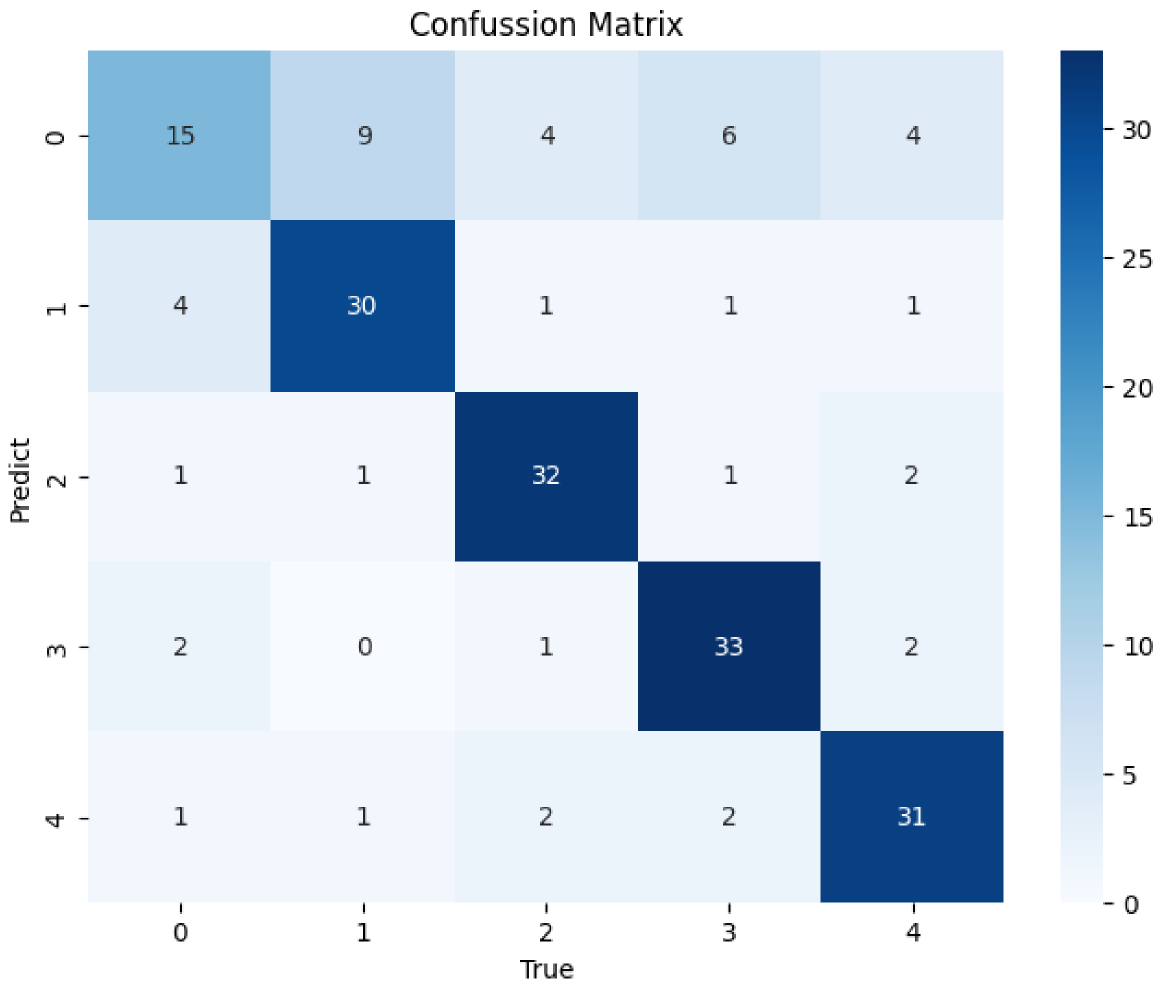
```
evaluation(y_test, y_pred_knn)
```

```
{'accuracy': 0.754, 'recall': 0.754, 'f1_score': 0.741, 'precision_score': 0.745}
```

In [ ]:

```
cm = confusion_matrix(y_test, y_pred_knn)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```



In [ ]:

```
rf_model = RandomForestClassifier(n_estimators=100, random_state=42)
rf_model.fit(X_train, y_train)
```

Out[ ]:

```
▾ RandomForestClassifier
RandomForestClassifier(random_state=42)
```

In [ ]:

```
y_pred_rf = rf_model.predict(X_test)
```

In [ ]:

```
print("Random Forest Model:")
accuracy_rf_smote = round(accuracy_score(y_test, y_pred_rf), 3)
print("Accuracy: ", accuracy_rf_smote)
print("Classification Report: ")
print(classification_report(y_test, y_pred_rf))
```

```
Random Forest Model:
Accuracy:  0.92
Classification Report:
              precision    recall  f1-score   support
```

```
         0.0       0.94      0.89      0.92        38
         1.0       0.85      0.92      0.88        37
         2.0       0.89      0.89      0.89        37
         3.0       0.95      0.97      0.96        38
         4.0       0.97      0.92      0.94        37

    accuracy                           0.92       187
   macro avg       0.92      0.92      0.92       187
weighted avg       0.92      0.92      0.92       187
```

In [ ]:

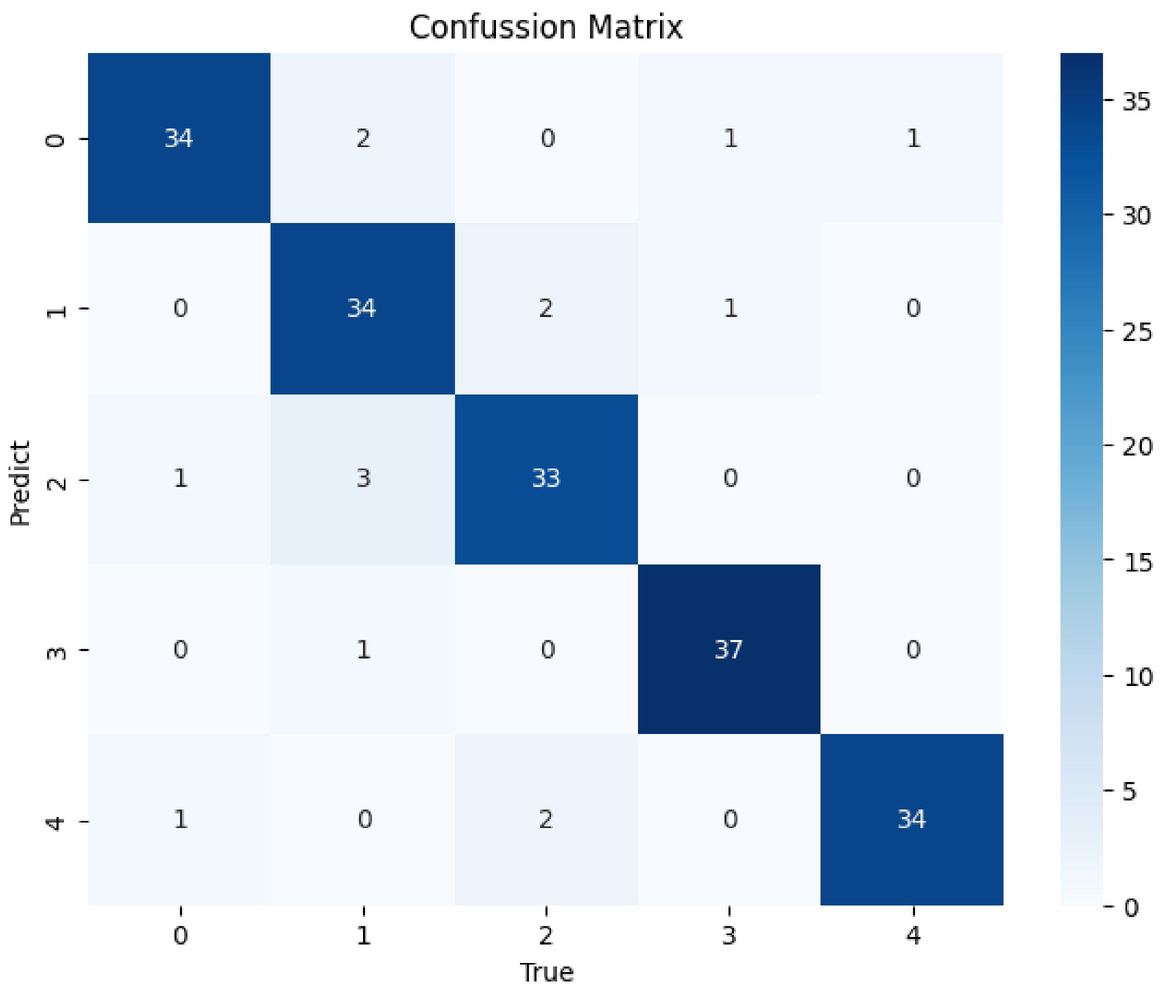
```
evaluation(y_test, y_pred_rf)
```

```
{'accuracy': 0.92, 'recall': 0.92, 'f1_score': 0.92, 'precision_score': 0.922}
```

In [ ]:

```
cm = confusion_matrix(y_test, y_pred_rf)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```



In [ ]:

```
xgb_model = XGBClassifier(learning_rate=0.1, n_estimators=100, random_state=42)
xgb_model.fit(X_train, y_train)
```

Out[ ]:

```
XGBClassifier
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
```

```
                colsample_bytree=None, device=None, early_stopping_rounds=Non
e,
                enable_categorical=False, eval_metric=None, feature_types=Non
e,
                gamma=None, grow_policy=None, importance_type=None,
                interaction_constraints=None, learning_rate=0.1, max_bin=None
,
                max_cat_threshold=None, max_cat_to_onehot=None,
```

In [ ]:

```
y_pred_xgb = xgb_model.predict(X_test)
```

In [ ]:

```
print("XGBoost Model:")
accuracy_xgb_smote = round(accuracy_score(y_test, y_pred_xgb), 3)
print("Accuracy: ", accuracy_xgb_smote)
print("Classification Report: ")
print(classification_report(y_test, y_pred_xgb))
```

```
XGBoost Model:
Accuracy:  0.904
Classification Report:
              precision    recall  f1-score   support

         0.0       0.92      0.89      0.91        38
         1.0       0.94      0.84      0.89        37
         2.0       0.85      0.89      0.87        37
         3.0       0.88      0.97      0.93        38
         4.0       0.94      0.92      0.93        37

    accuracy                           0.90       187
   macro avg       0.91      0.90      0.90       187
weighted avg       0.91      0.90      0.90       187
```

In [ ]:

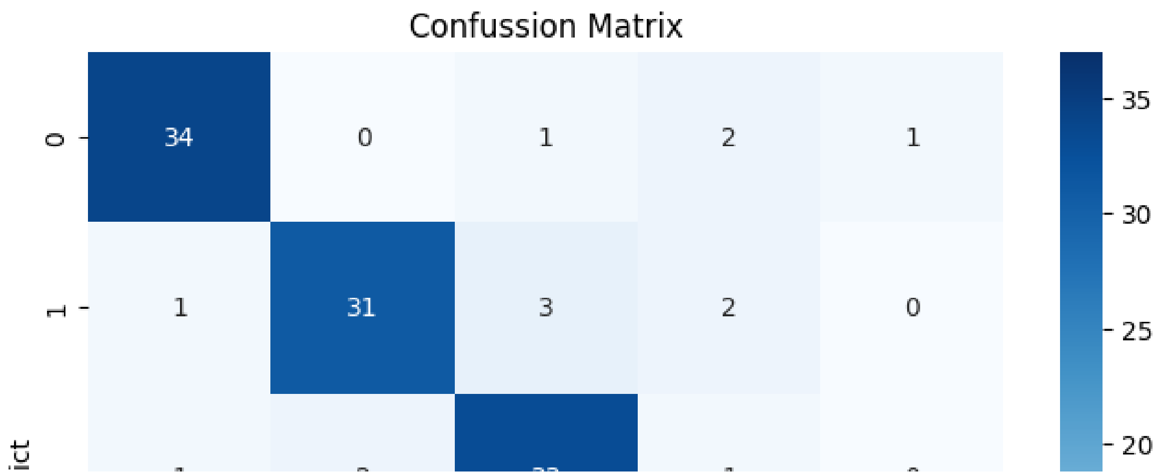
```
evaluation(y_test, y_pred_xgb)
```

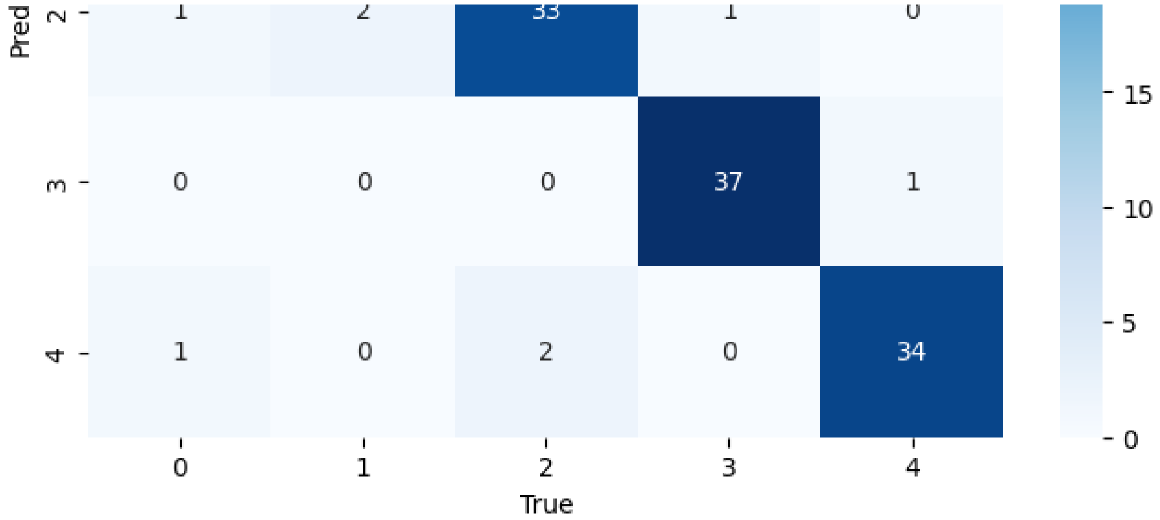
```
{'accuracy': 0.904, 'recall': 0.904, 'f1_score': 0.904, 'precision_score': 0.906}
```

In [ ]:

```
cm = confusion_matrix(y_test, y_pred_xgb)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```





In [ ]:

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import accuracy_score, classification_report
```

In [ ]:

```
knn_model = KNeighborsClassifier(n_neighbors=3)
knn_model.fit(X_train_normal, y_train_normal)
```

Out[ ]:

```
▾        KNeighborsClassifier
KNeighborsClassifier(n_neighbors=3)
```

In [ ]:

```
y_pred_knn = knn_model.predict(X_test_normal)
```

In [ ]:

```
print("KNN Model:")
accuracy_knn_smote_normal = round(accuracy_score(y_test_normal, y_pred_knn), 3)
print("Accuracy: ", accuracy_knn_smote_normal)
print("Classification Report: ")
print(classification_report(y_test_normal, y_pred_knn))
```

```
KNN Model:
Accuracy:  0.861
Classification Report:
              precision    recall  f1-score   support

         0.0       0.88      0.76      0.82        38
         1.0       0.78      0.84      0.81        37
         2.0       0.87      0.92      0.89        37
         3.0       0.92      0.87      0.89        38
         4.0       0.87      0.92      0.89        37

    accuracy                           0.86       187
   macro avg       0.86      0.86      0.86       187
weighted avg       0.86      0.86      0.86       187
```

In [ ]:

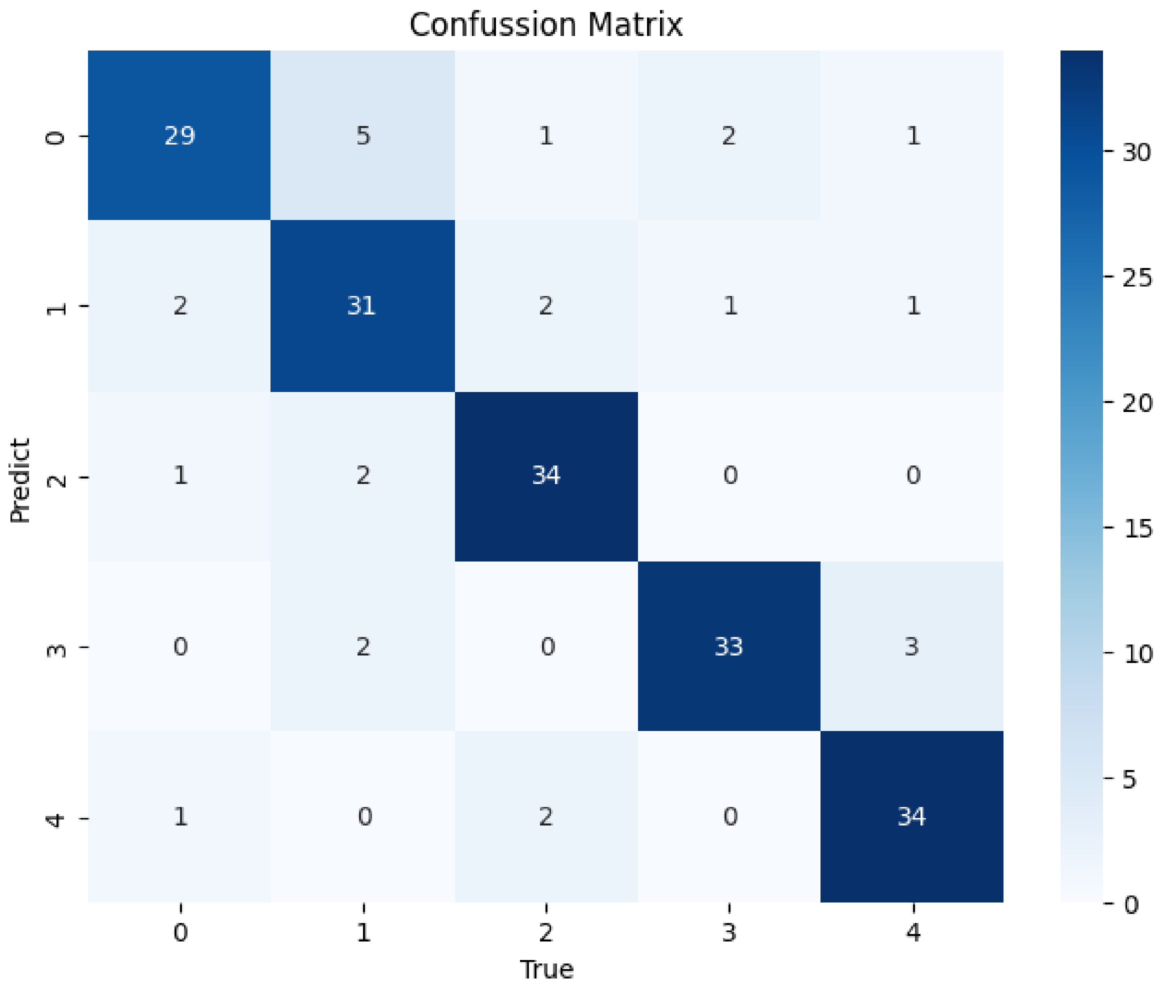
```
evaluation(y_test_normal, y_pred_knn)
```

```
{'accuracy': 0.861, 'recall': 0.861, 'f1_score': 0.861, 'precision_score': 0.863}
```

In [ ]:

```python
cm = confusion_matrix(y_test_normal, y_pred_knn)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```



In [ ]:

```python
rf_model = RandomForestClassifier(n_estimators=100, random_state=42)
rf_model.fit(X_train, y_train)
```

Out[ ]:

```
▾ RandomForestClassifier
RandomForestClassifier(random_state=42)
```

In [ ]:

```python
y_pred_rf = rf_model.predict(X_test)
```

In [ ]:

```python
print("Random Forest Model:")
accuracy_rf_smote = round(accuracy_score(y_test, y_pred_rf), 3)
print("Accuracy: ", accuracy_rf_smote)
print("Classification Report: ")
print(classification_report(y_test, y_pred_rf))
```

```
Random Forest Model:
Accuracy:  0.92
Classification Report:
              precision    recall  f1-score   support
```

```
         0.0       0.94      0.89      0.92        38
         1.0       0.85      0.92      0.88        37
         2.0       0.89      0.89      0.89        37
         3.0       0.95      0.97      0.96        38
         4.0       0.97      0.92      0.94        37

    accuracy                           0.92       187
   macro avg       0.92      0.92      0.92       187
weighted avg       0.92      0.92      0.92       187
```

In [ ]:

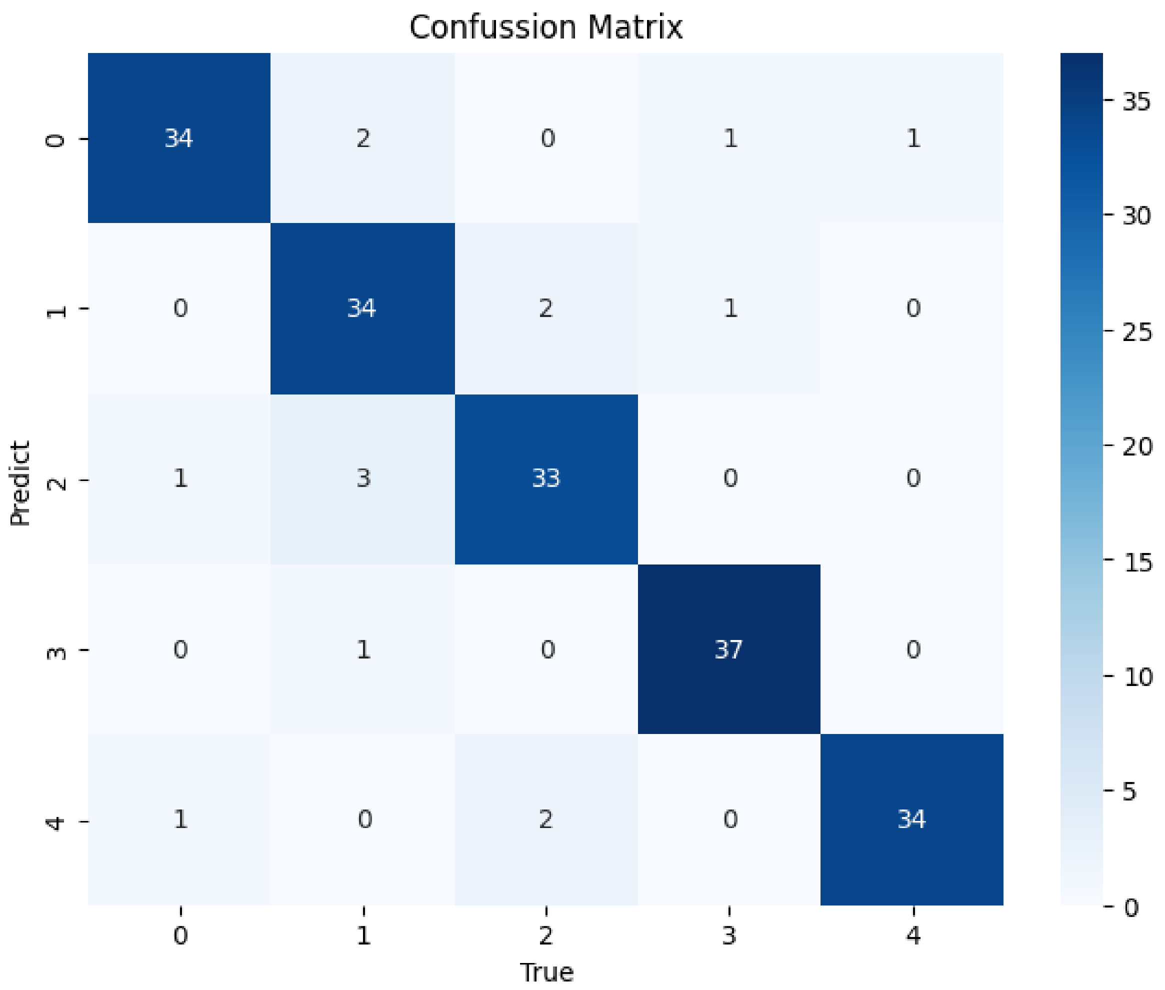
```
evaluation(y_test, y_pred_rf)
```

```
{'accuracy': 0.92, 'recall': 0.92, 'f1_score': 0.92, 'precision_score': 0.922}
```

In [ ]:

```
cm = confusion_matrix(y_test, y_pred_rf)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```



In [ ]:

```
xgb_model = XGBClassifier(learning_rate=0.1, n_estimators=100, random_state=42)
xgb_model.fit(X_train, y_train)
```

Out[ ]:

```
▾                              XGBClassifier
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
```

```
                colsample_bytree=None, device=None, early_stopping_rounds=Non
e,
                enable_categorical=False, eval_metric=None, feature_types=Non
e,
                gamma=None, grow_policy=None, importance_type=None,
                interaction_constraints=None, learning_rate=0.1, max_bin=None
,
                max_cat_threshold=None, max_cat_to_onehot=None,
```

In [ ]:

```
y_pred_xgb = xgb_model.predict(X_test)
```

In [ ]:

```
print("XGBoost Model:")
accuracy_xgb_smote = round(accuracy_score(y_test, y_pred_xgb), 3)
print("Accuracy: ", accuracy_xgb_smote)
print("Classification Report: ")
print(classification_report(y_test, y_pred_xgb))
```

```
XGBoost Model:
Accuracy:  0.904
Classification Report:
              precision    recall  f1-score   support

         0.0       0.92      0.89      0.91        38
         1.0       0.94      0.84      0.89        37
         2.0       0.85      0.89      0.87        37
         3.0       0.88      0.97      0.93        38
         4.0       0.94      0.92      0.93        37

    accuracy                           0.90       187
   macro avg       0.91      0.90      0.90       187
weighted avg       0.91      0.90      0.90       187
```

In [ ]:

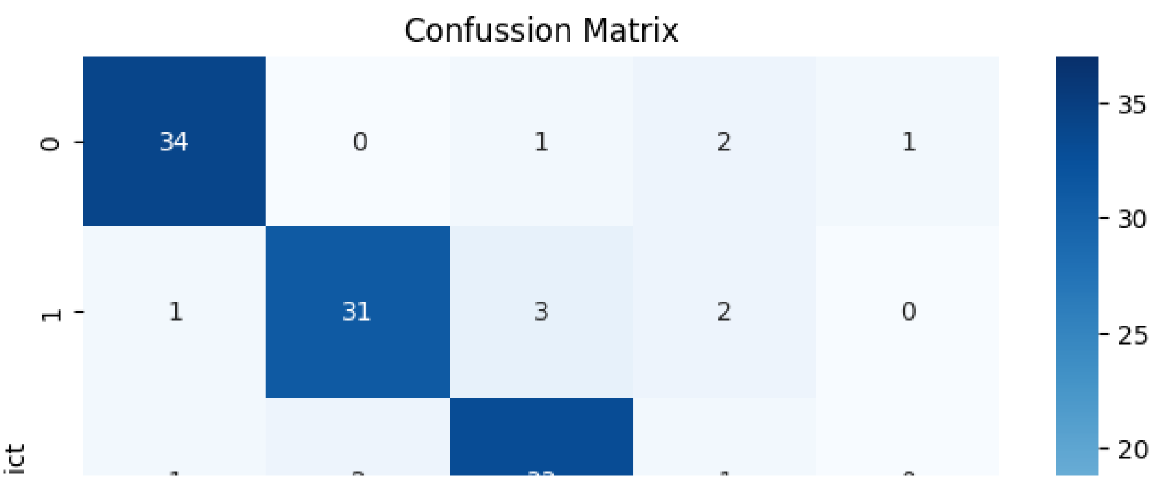
```
evaluation(y_test, y_pred_xgb)
```

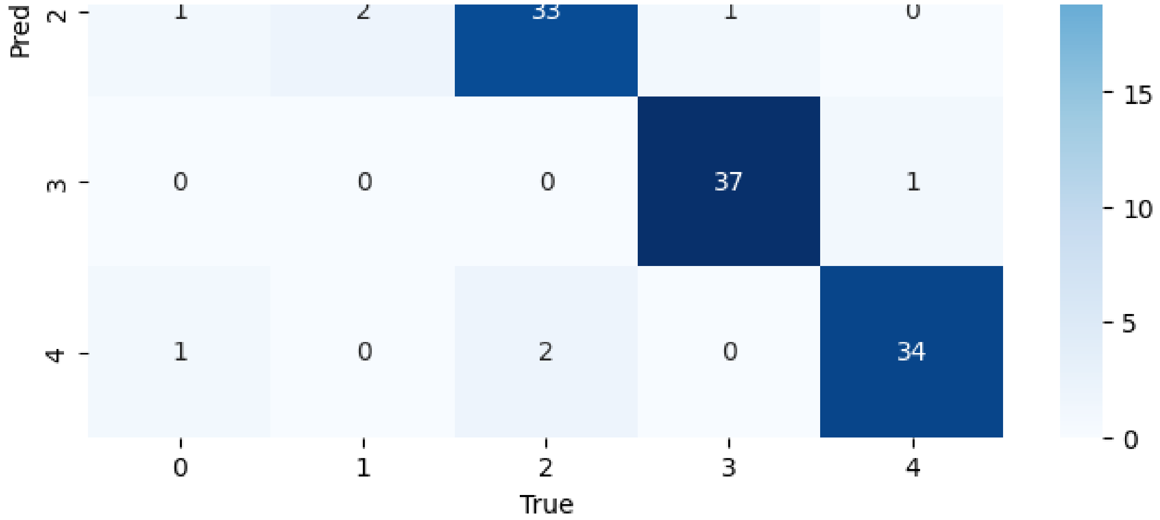
```
{'accuracy': 0.904, 'recall': 0.904, 'f1_score': 0.904, 'precision_score': 0.906}
```

In [ ]:

```
cm = confusion_matrix(y_test, y_pred_xgb)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```





In [ ]:

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import accuracy_score, classification_report
```

In [ ]:

```
knn_model = KNeighborsClassifier(n_neighbors=3)
knn_model.fit(X_train_normal, y_train_normal)
```

Out[ ]:

```
▾        KNeighborsClassifier
KNeighborsClassifier(n_neighbors=3)
```

In [ ]:

```
y_pred_knn = knn_model.predict(X_test_normal)
```

In [ ]:

```
print("KNN Model:")
accuracy_knn_smote_normal = round(accuracy_score(y_test_normal, y_pred_knn), 3)
print("Accuracy: ", accuracy_knn_smote_normal)
print("Classification Report: ")
print(classification_report(y_test_normal, y_pred_knn))
```

```
KNN Model:
Accuracy:  0.861
Classification Report:
              precision    recall  f1-score   support

         0.0       0.88      0.76      0.82        38
         1.0       0.78      0.84      0.81        37
         2.0       0.87      0.92      0.89        37
         3.0       0.92      0.87      0.89        38
         4.0       0.87      0.92      0.89        37

    accuracy                           0.86       187
   macro avg       0.86      0.86      0.86       187
weighted avg       0.86      0.86      0.86       187
```

In [ ]:

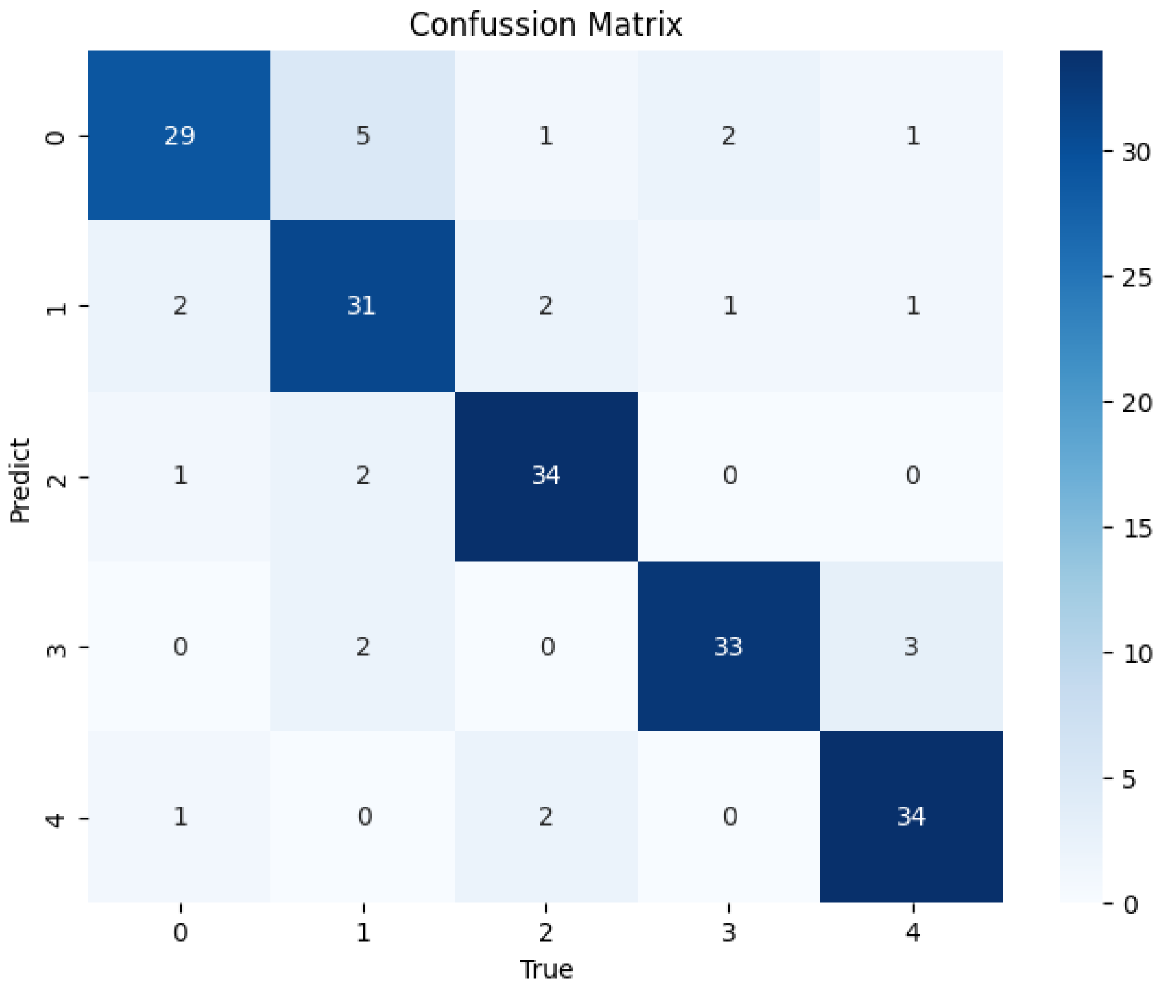
```
evaluation(y_test_normal, y_pred_knn)
```

```
{'accuracy': 0.861, 'recall': 0.861, 'f1_score': 0.861, 'precision_score': 0.863}
```

In [ ]:

```
cm = confusion_matrix(y_test_normal, y_pred_knn)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```



In [ ]:

```
rf_model = RandomForestClassifier(n_estimators=100, random_state=42)
rf_model.fit(X_train_normal, y_train_normal)
```

Out[ ]:

```
▾ RandomForestClassifier
RandomForestClassifier(random_state=42)
```

In [ ]:

```
y_pred_rf = rf_model.predict(X_test_normal)
```

In [ ]:

```
print("Random Forest Model:")
accuracy_rf_smote_normal = round(accuracy_score(y_test_normal, y_pred_rf), 3)
print("Accuracy: ", accuracy_rf_smote_normal)
print("Classification Report: ")
print(classification_report(y_test_normal, y_pred_rf))
```

```
Random Forest Model:
Accuracy:  0.92
Classification Report:
              precision    recall  f1-score   support
```

```
         0.0       0.94      0.89      0.92        38
         1.0       0.85      0.92      0.88        37
         2.0       0.89      0.89      0.89        37
         3.0       0.95      0.97      0.96        38
         4.0       0.97      0.92      0.94        37

    accuracy                           0.92       187
   macro avg       0.92      0.92      0.92       187
weighted avg       0.92      0.92      0.92       187
```

In [ ]:

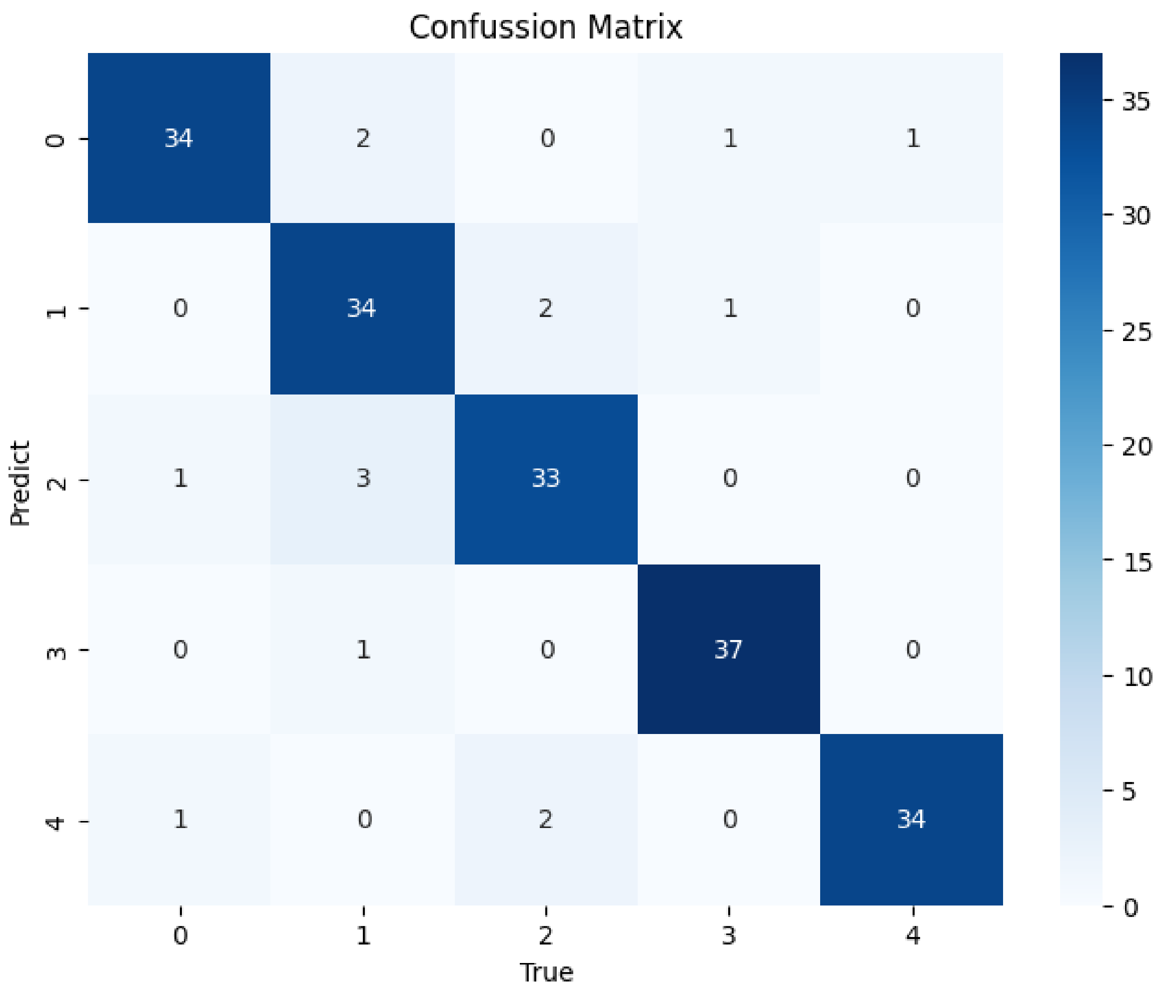
```
evaluation(y_test_normal, y_pred_rf)
```

```
{'accuracy': 0.92, 'recall': 0.92, 'f1_score': 0.92, 'precision_score': 0.922}
```

In [ ]:

```
cm = confusion_matrix(y_test_normal, y_pred_rf)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```



In [ ]:

```
xgb_model = XGBClassifier(learning_rate=0.1, n_estimators=100, random_state=42)
xgb_model.fit(X_train_normal, y_train_normal)
```

Out[ ]:

```
XGBClassifier
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
```

```
                colsample_bytree=None, device=None, early_stopping_rounds=Non
e,
                enable_categorical=False, eval_metric=None, feature_types=Non
e,
                gamma=None, grow_policy=None, importance_type=None,
                interaction_constraints=None, learning_rate=0.1, max_bin=None
,
                max_cat_threshold=None, max_cat_to_onehot=None,
```

In [ ]:

```
y_pred_xgb = xgb_model.predict(X_test_normal)
```

In [ ]:

```
print("XGBoost Model:")
accuracy_xgb_smote_normal = round(accuracy_score(y_test_normal, y_pred_xgb), 3)
print("Accuracy: ", accuracy_xgb_smote_normal)
print("Classification Report: ")
print(classification_report(y_test, y_pred_xgb))
```

```
XGBoost Model:
Accuracy:  0.904
Classification Report:
              precision    recall  f1-score   support

         0.0       0.92      0.89      0.91        38
         1.0       0.94      0.84      0.89        37
         2.0       0.85      0.89      0.87        37
         3.0       0.88      0.97      0.93        38
         4.0       0.94      0.92      0.93        37

    accuracy                           0.90       187
   macro avg       0.91      0.90      0.90       187
weighted avg       0.91      0.90      0.90       187
```

In [ ]:

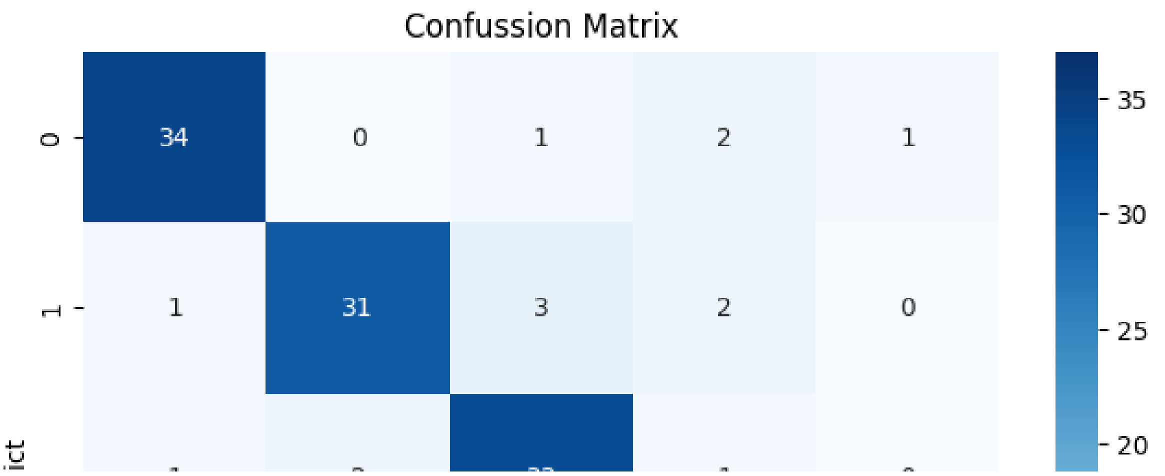
```
evaluation(y_test_normal, y_pred_xgb)
```

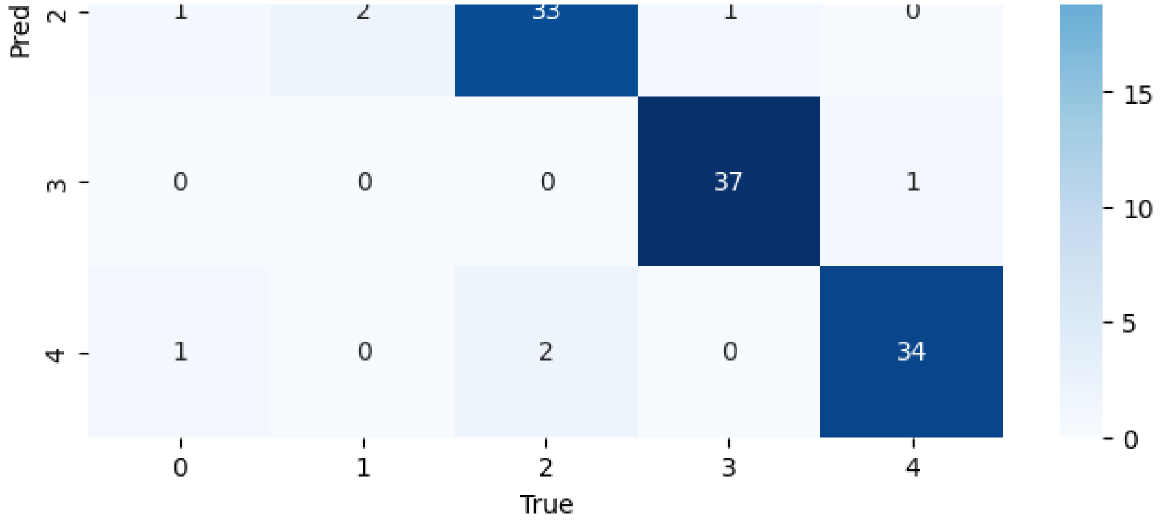
```
{'accuracy': 0.904, 'recall': 0.904, 'f1_score': 0.904, 'precision_score': 0.906}
```

In [ ]:

```
cm = confusion_matrix(y_test_normal, y_pred_xgb)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```





In [ ]:

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import accuracy_score, classification_report
from sklearn.model_selection import RandomizedSearchCV
```

In [ ]:

```
knn_model = KNeighborsClassifier()

param_grid = {
    "n_neighbors": range(3, 21),
    "metric": ["euclidean", "manhattan", "chebyshev"],
    "weights": ["uniform", "distance"],
    "algorithm": ["auto", "ball_tree", "kd_tree"],
    "leaf_size": range(10, 61),
}

knn_model = RandomizedSearchCV(estimator=knn_model, param_distributions=param_grid, n_ite
r=100, scoring="accuracy", cv=5)

knn_model.fit(X_train_normal, y_train_normal)

best_params = knn_model.best_params_
print(f"Best Parameters: {best_params}")
```

```
Best Parameters: {'weights': 'distance', 'n_neighbors': 4, 'metric': 'manhattan', 'leaf_s
ize': 52, 'algorithm': 'auto'}
```

In [ ]:

```
y_pred_knn = knn_model.predict(X_test_normal)
```

In [ ]:

```
print("KNN Model:")
accuracy_knn_smote_normal_tunning = round(accuracy_score(y_test_normal, y_pred_knn), 3)
print("Accuracy: ", accuracy_knn_smote_normal_tunning)
print("Classification Report: ")
print(classification_report(y_test_normal, y_pred_knn))
```

```
KNN Model:
Accuracy:  0.93
Classification Report:
              precision    recall  f1-score   support

         0.0       0.94      0.89      0.92        38
         1.0       0.86      0.86      0.86        37
         2.0       0.92      0.92      0.92        37
         3.0       0.97      0.97      0.97        38
         4.0       0.95      1.00      0.97        37
```

```
    accuracy                          0.93       187
   macro avg       0.93      0.93     0.93       187
weighted avg       0.93      0.93     0.93       187
```

In [ ]:

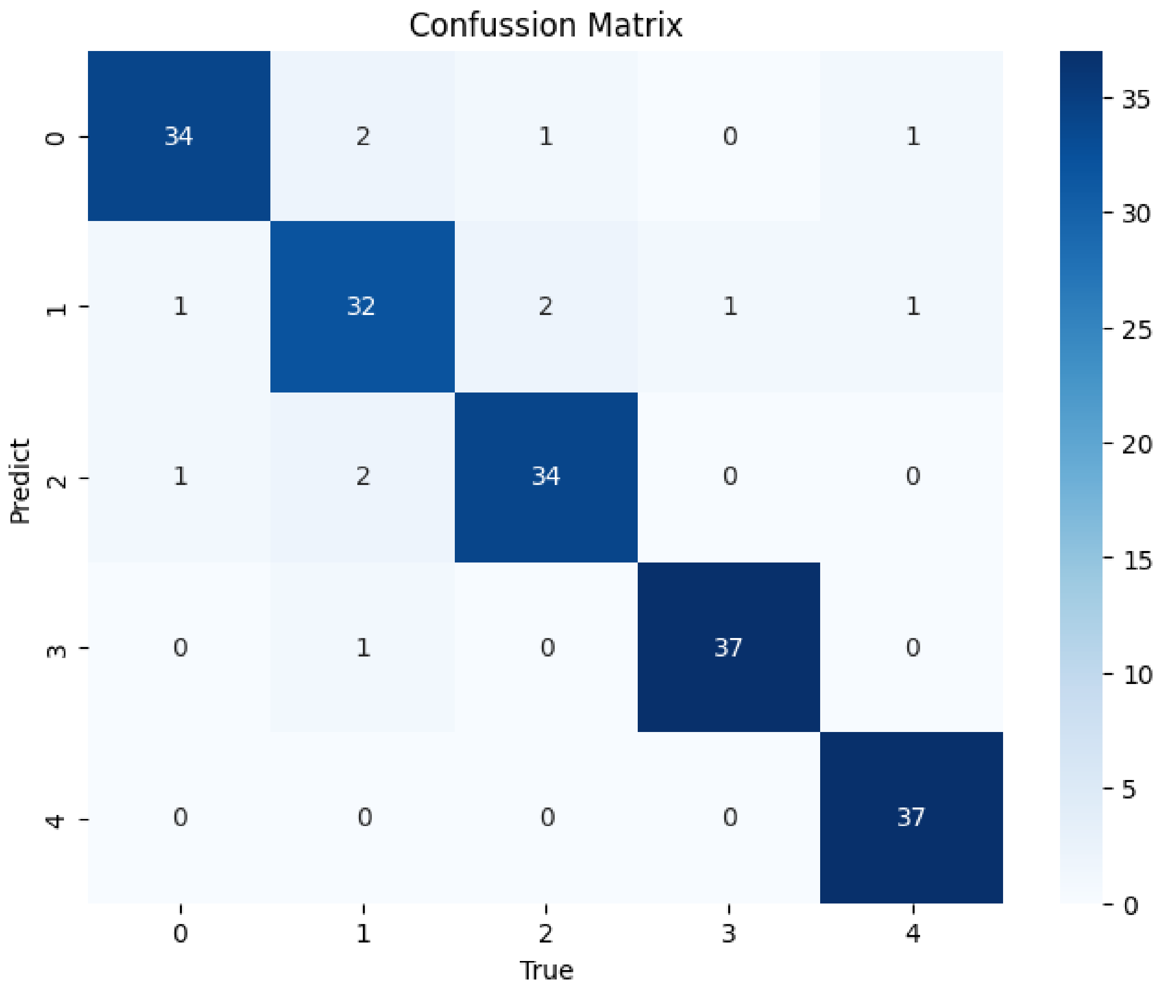
```
evaluation(y_test_normal, y_pred_knn)
```

```
{'accuracy': 0.93, 'recall': 0.93, 'f1_score': 0.93, 'precision_score': 0.93}
```

In [ ]:

```
cm = confusion_matrix(y_test_normal, y_pred_knn)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```



In [ ]:

```
rf_model = RandomForestClassifier()

param_grid = {
    "n_estimators": [100, 200],
    "max_depth": [10, 15],
    "min_samples_leaf": [1, 2],
    "min_samples_split": [2, 5],
    "max_features": ["sqrt", "log2"],
}

rf_model = RandomizedSearchCV(rf_model, param_grid, n_iter=100, cv=5, n_jobs=-1)

rf_model.fit(X_train_normal, y_train_normal)
```

```
best_params = rf_model.best_params_
print(f"Best Parameters: {best_params})")
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/model_selection/_search.py:305: UserWarni
ng: The total space of parameters 32 is smaller than n_iter=100. Running 32 iterations. F
or exhaustive searches, use GridSearchCV.
  warnings.warn(
```

```
Best Parameters: {'n_estimators': 200, 'min_samples_split': 2, 'min_samples_leaf': 1, 'ma
x_features': 'sqrt', 'max_depth': 15})
```

In [ ]:

```
y_pred_rf = rf_model.predict(X_test_normal)
```

In [ ]:

```
print("Random Forest Model:")
accuracy_rf_smote_normal_tunning = round(accuracy_score(y_test_normal, y_pred_rf), 3)
print("Accuracy: ", accuracy_rf_smote_normal_tunning)
print("Classification Report: ")
print(classification_report(y_test_normal, y_pred_rf))
```

```
Random Forest Model:
Accuracy:  0.909
Classification Report:
              precision    recall  f1-score   support

         0.0       0.95      0.92      0.93        38
         1.0       0.86      0.84      0.85        37
         2.0       0.85      0.89      0.87        37
         3.0       0.93      0.97      0.95        38
         4.0       0.97      0.92      0.94        37

    accuracy                           0.91       187
   macro avg       0.91      0.91      0.91       187
weighted avg       0.91      0.91      0.91       187
```

In [ ]:

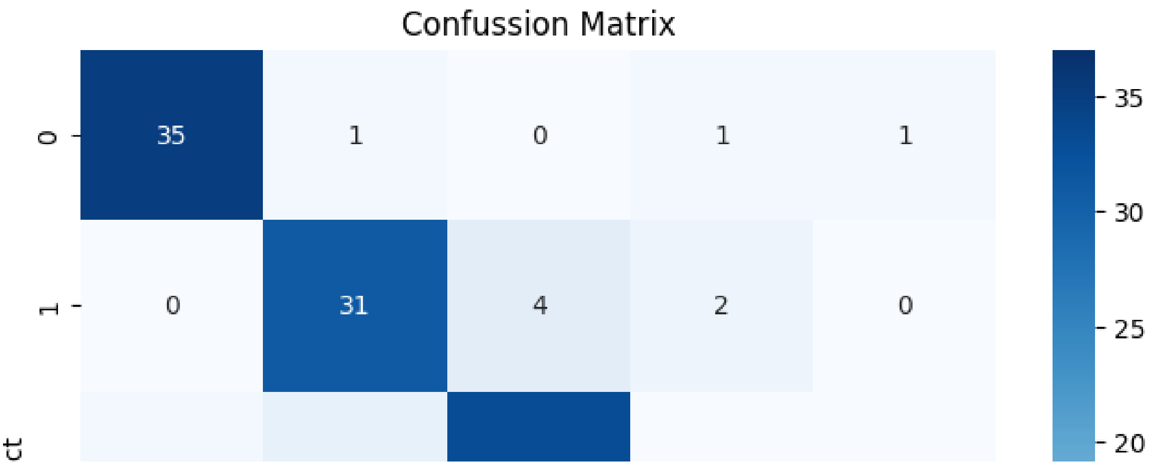
```
evaluation(y_test_normal, y_pred_rf)
```

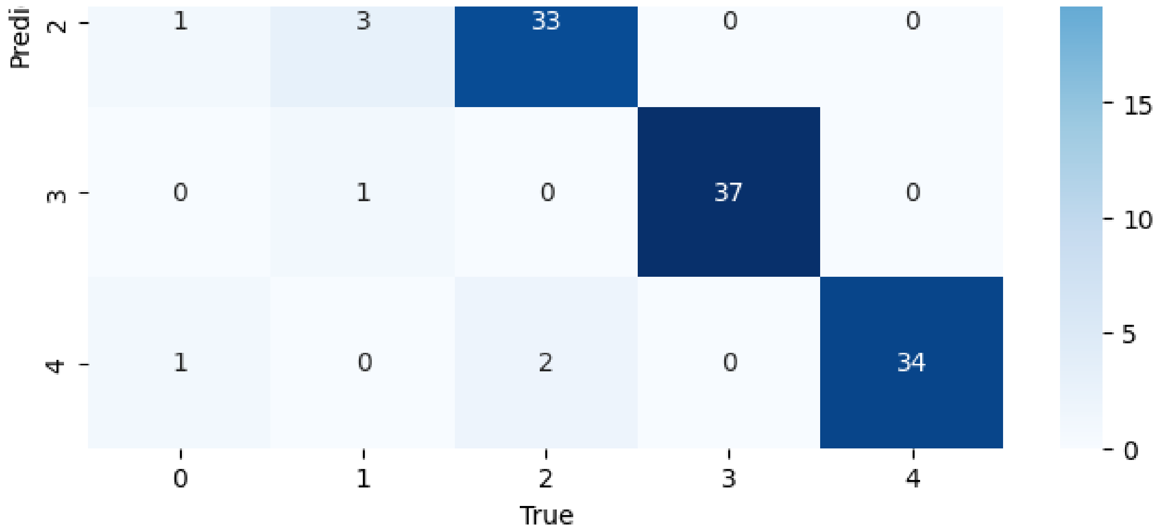
```
{'accuracy': 0.909, 'recall': 0.909, 'f1_score': 0.909, 'precision_score': 0.91}
```

In [ ]:

```
cm = confusion_matrix(y_test_normal, y_pred_rf)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```





In [ ]:

```
xgb_model = XGBClassifier()

param_grid = {
    "max_depth": [3, 5, 7],
    "learning_rate": [0.01, 0.1],
    "n_estimators": [100, 200],
    "gamma": [0, 0.1],
    "colsample_bytree": [0.7, 0.8],
}

xgb_model = RandomizedSearchCV(xgb_model, param_grid, n_iter=10, cv=5, n_jobs=-1)

xgb_model.fit(X_train_normal, y_train_normal)

best_params = xgb_model.best_params_
print(f"Best Parameters: {best_params})")
```

```
Best Parameters: {'n_estimators': 100, 'max_depth': 7, 'learning_rate': 0.1, 'gamma': 0,
'colsample_bytree': 0.7})
```

In [ ]:

```
y_pred_xgb = xgb_model.predict(X_test_normal)
```

In [ ]:

```
print("XGBoost Model:")
accuracy_xgb_smote_normal_tunning = round(accuracy_score(y_test_normal, y_pred_xgb), 3)
print("Accuracy: ", accuracy_xgb_smote_normal_tunning)
print("Classification Report: ")
print(classification_report(y_test, y_pred_xgb))
```

```
XGBoost Model:
Accuracy:  0.92
Classification Report:
              precision    recall  f1-score   support

         0.0       0.90      0.95      0.92        38
         1.0       0.91      0.86      0.89        37
         2.0       0.89      0.86      0.88        37
         3.0       0.93      1.00      0.96        38
         4.0       0.97      0.92      0.94        37

    accuracy                           0.92       187
   macro avg       0.92      0.92      0.92       187
weighted avg       0.92      0.92      0.92       187
```

In [ ]:

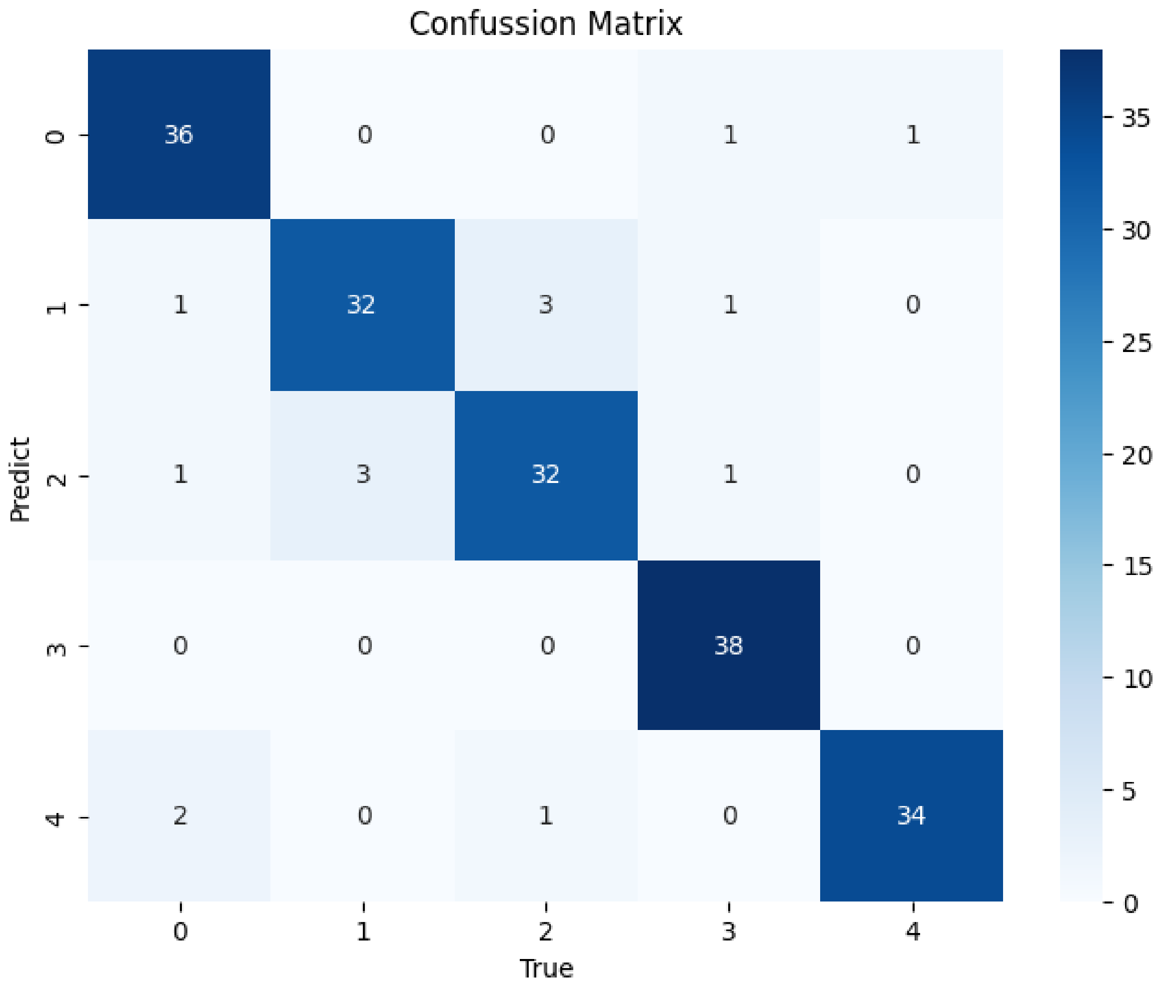
```
evaluation(y_test_normal, y_pred_xgb)
```

```
{'accuracy': 0.92, 'recall': 0.92, 'f1_score': 0.919, 'precision_score': 0.92}
```

In [ ]:

```
cm = confusion_matrix(y_test_normal, y_pred_xgb)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confussion Matrix")
plt.xlabel('True')
plt.ylabel('Predict')
plt.show()
```



In [ ]:

```
import matplotlib.pyplot as plt
```

In [ ]:

```
model_comp1 = pd.DataFrame({
    'Model': [
        'KNN',
        'Random Forest',
        'XGBoost'
    ],
    'Accuracy': [
        accuracy_knn_smote*100,
        accuracy_rf_smote*100,
        accuracy_xgb_smote*100
    ]
})

model_comp1.head()
```

Out[ ]:

	Model	Accuracy

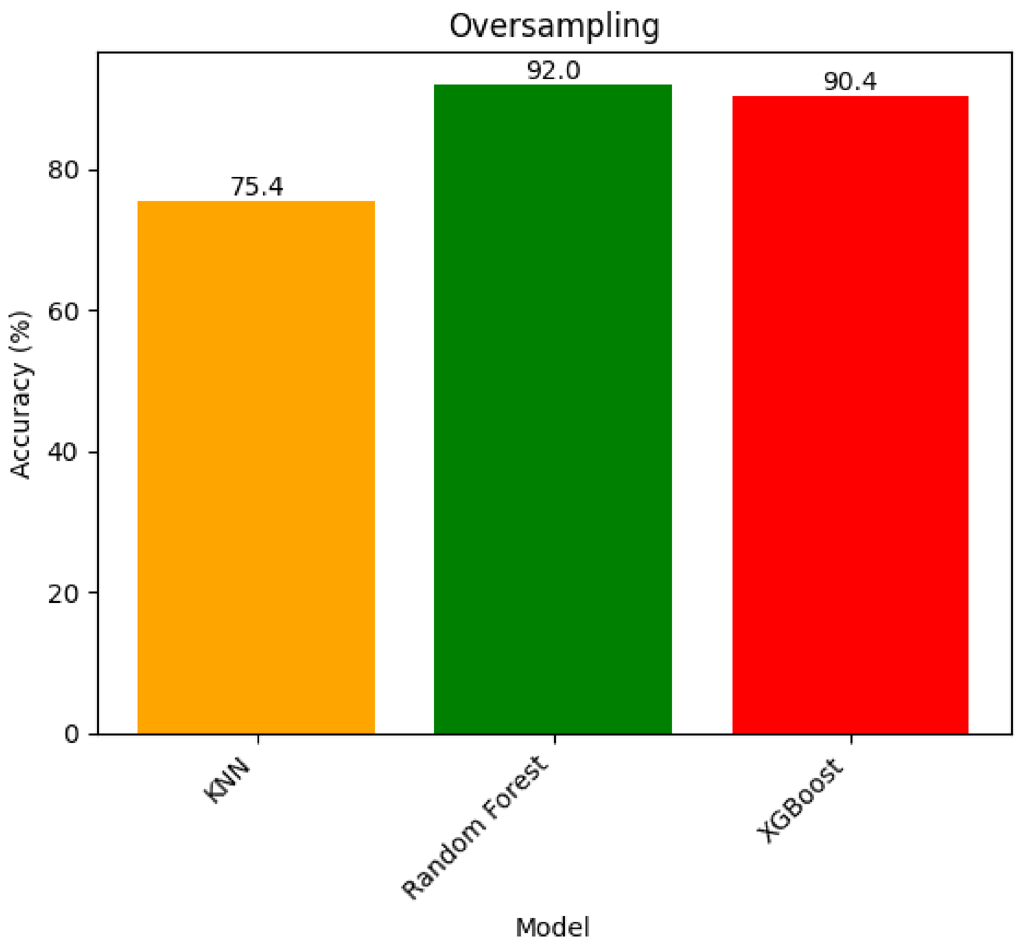
	Model	Accuracy
0	KNN	75.4
1	Random Forest	92.0
2	XGBoost	90.4

In [ ]:

```
fig, ax = plt.subplots()
bars = plt.bar(model_comp1['Model'], model_comp1['Accuracy'], color=['orange', 'green', 'red'])
plt.title("Oversampling")
plt.xlabel('Model')
plt.ylabel('Accuracy (%)')
plt.xticks(rotation=45, ha='right')

for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, yval, round(yval, 2), ha='center', va='bottom')

plt.show()
```



In [ ]:

```
model_comp2 = pd.DataFrame({
    'Model': [
        'KNN',
        'Random Forest',
        'XGBoost'
    ],
    'Accuracy': [
        accuracy_knn_smote_normal*100,
        accuracy_rf_smote_normal*100,
        accuracy_xgb_smote_normal*100
    ]
})

model_comp2.head()
```

Out[ ]:

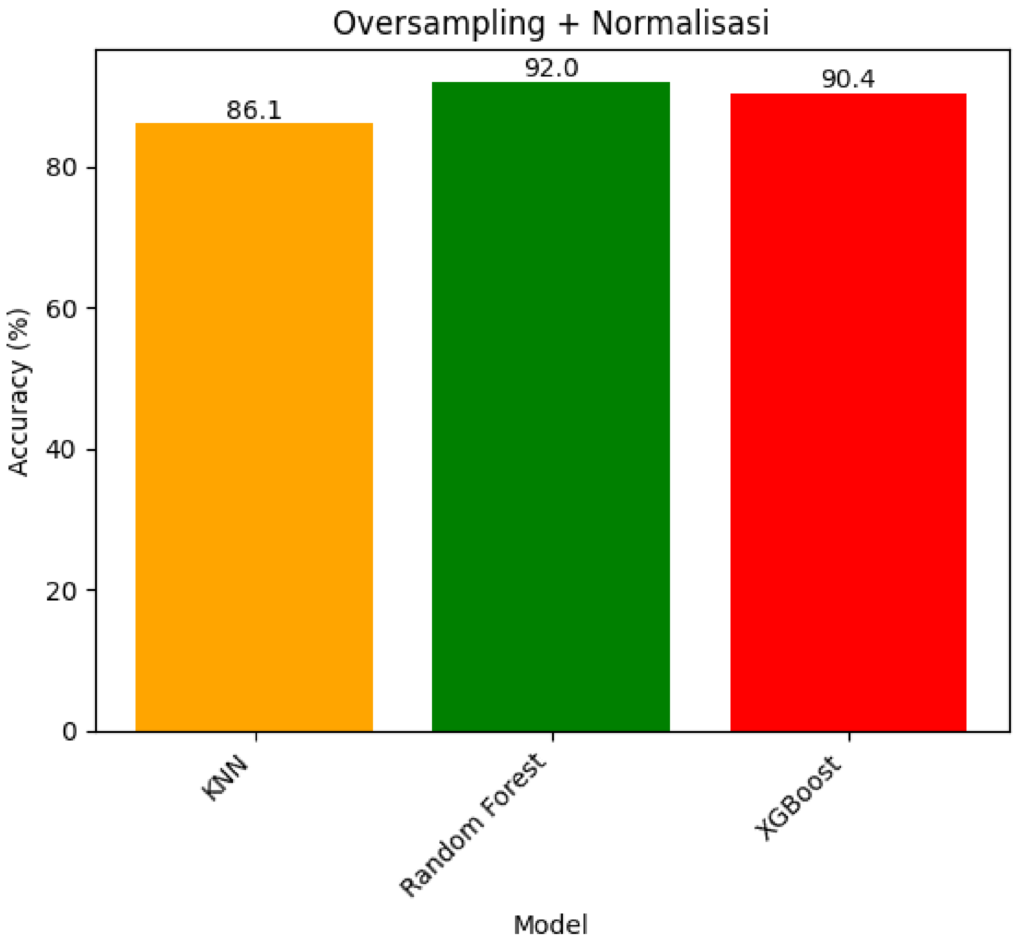
	Model	Accuracy
0	KNN	86.1
1	Random Forest	92.0
2	XGBoost	90.4

In [ ]:

```
fig, ax = plt.subplots()
bars = plt.bar(model_comp2['Model'], model_comp2['Accuracy'], color=['orange', 'green', 'red'])
plt.title("Oversampling + Normalisasi")
plt.xlabel('Model')
plt.ylabel('Accuracy (%)')
plt.xticks(rotation=45, ha='right')

for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, yval, round(yval, 2), ha='center', va='bottom')

plt.show()
```



In [ ]:

```
model_comp3 = pd.DataFrame({
    'Model': [
        'KNN',
        'Random Forest',
        'XGBoost'
    ],
    'Accuracy': [
        accuracy_knn_smote_normal_tunning*100,
        accuracy_rf_smote_normal_tunning*100,
```

```
        accuracy_xgb_smote_normal_tunning*100
    ]
})

model_comp3.head()
```

Out[ ]:

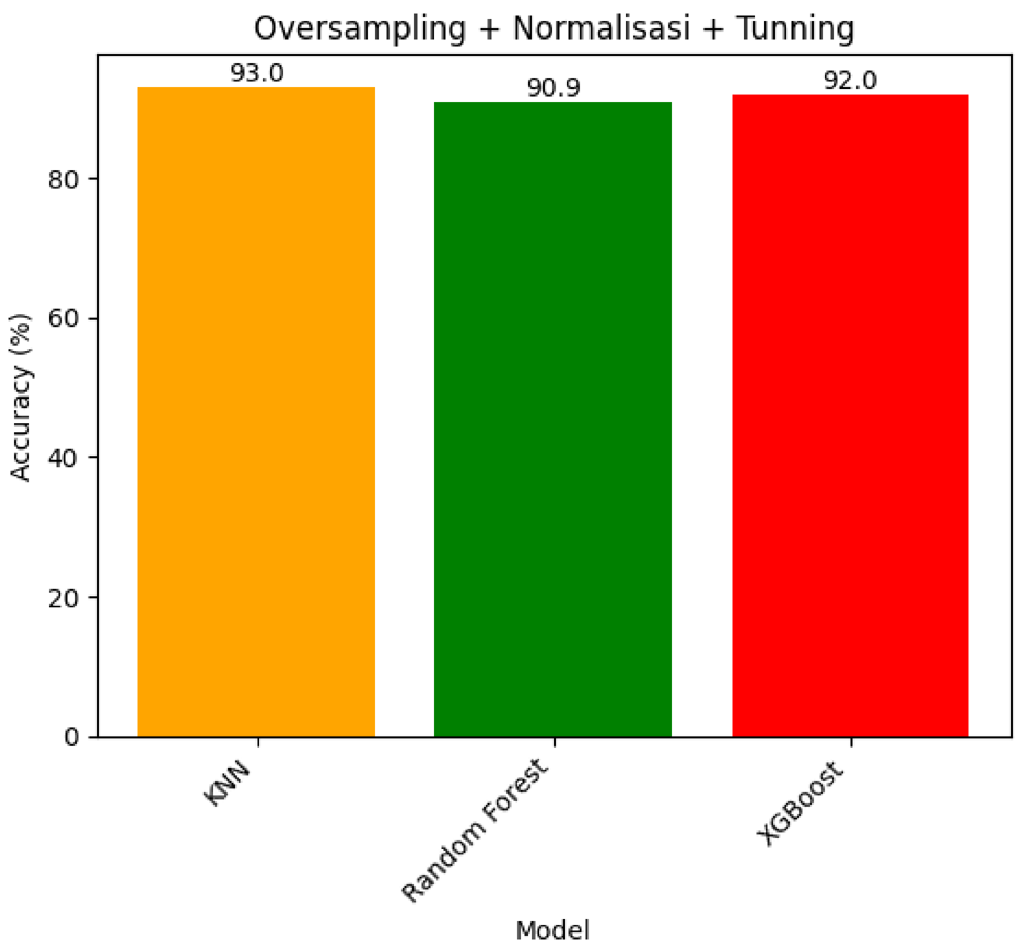
	Model	Accuracy
0	KNN	93.0
1	Random Forest	90.9
2	XGBoost	92.0

In [ ]:

```
fig, ax = plt.subplots()
bars = plt.bar(model_comp3['Model'], model_comp3['Accuracy'], color=['orange', 'green', 'red'])
plt.title("Oversampling + Normalisasi + Tunning")
plt.xlabel('Model')
plt.ylabel('Accuracy (%)')
plt.xticks(rotation=45, ha='right')

for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, yval, round(yval, 2), ha='center', va='bottom')

plt.show()
```



In [ ]:

```
model_comp_best = pd.DataFrame({
    'Model': [
        'KNN (Oversampling + Normalisasi + Tunning)',
        'Random Forest (Oversampling)',
```

```
        'XGBoost (Oversampling + Normalisasi)'
    ],
    'Accuracy': [
        accuracy_knn_smote_normal_tunning*100,
        accuracy_rf_smote*100,
        accuracy_xgb_smote_normal*100
    ]
})

model_comp_best.head()
```

Out[ ]:

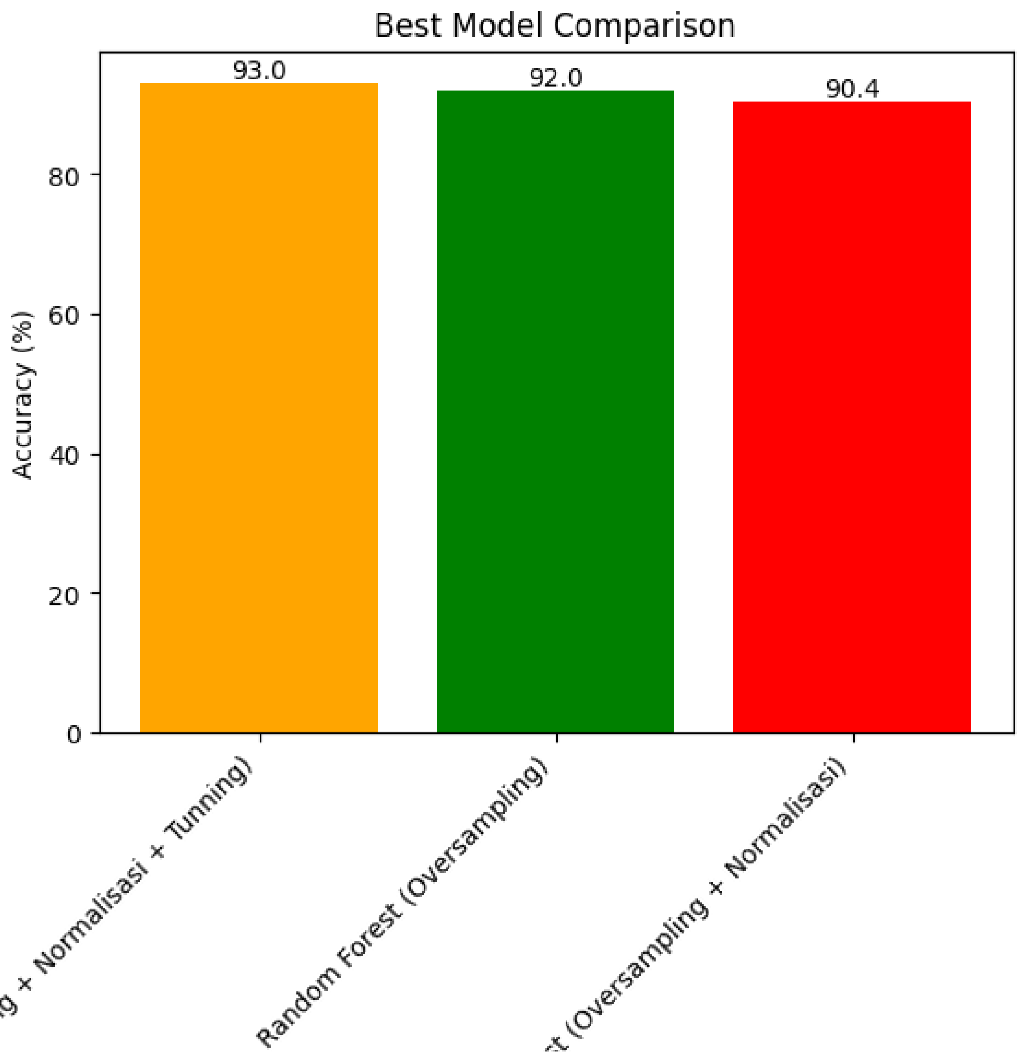
	Model	Accuracy
0	KNN (Oversampling + Normalisasi + Tunning)	93.0
1	Random Forest (Oversampling)	92.0
2	XGBoost (Oversampling + Normalisasi)	90.4

In [ ]:

```
fig, ax = plt.subplots()
bars = plt.bar(model_comp_best['Model'], model_comp_best['Accuracy'], color=['orange', '
green', 'red'])
plt.title("Best Model Comparison")
plt.xlabel('Model')
plt.ylabel('Accuracy (%)')
plt.xticks(rotation=45, ha='right')

for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, yval, round(yval, 2), ha='center', va='bot
tom')

plt.show()
```



In [ ]:

```
import joblib

joblib.dump(knn_model, 'knn.joblib')
```

Out[ ]:

```
['knn.joblib']
```

In [ ]:

```

```

In [ ]:

```

```