Performing Cross validation, Feature selection and PCA on German dataset.

Import libraries

```
import pandas as pd
from sklearn.preprocessing import LabelEncoder
from sklearn.feature_selection import SelectKBest, chi2
from sklearn.decomposition import PCA
from sklearn.model_selection import cross_val_score, train_test_split, KFold
from sklearn.metrics import accuracy_score, recall_score, precision_score, f1_score, classification_report
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
import matplotlib.pyplot as plt
import seaborn as sns
```

loading dataset

```
df = pd.read_csv('/content/german .csv')
```

```
df.head()
```

	Status of existing checking account	Duration in month	Credit history	Purpose	Credit amount	Savings account	Present employment since	Present residence since	Persona statu and se
0	1	48	2	4	5951	0	2	2	
1	3	12	4	7	2096	0	3	2	
2	0	42	2	3	7882	0	3	2	
3	0	24	3	0	4870	0	2	3	
4	3	36	2	7	9055	4	2	2	

5 rows × 21 columns

```
df.nunique()
```

```
Status of existing checking account                    4
Duration in month                                     33
Credit history                                         5
Purpose                                               10
Credit amount                                        921
Savings account                                        5
Present employment since                               5
Present residence since                                4
Personal status and sex                                4
Other debtors                                          3
Installment rate in percentage of disposable income    4
Property                                               4
Age in years                                          53
Other installment plans                                3
Housing                                                3
Number of existing credits at this bank                4
Job                                                    4
Number of dependents                                   2
Telephone                                              2
Foreign worker                                         2
target                                                 2
dtype: int64
```

```
df.tail()
```

	Status of existing checking account	Duration in month	Credit history	Purpose	Credit amount	Savings account	Present employment since	Present residence since	Persc sta and
994	3	12	2	3	1736	0	3	3	
995	0	30	2	1	3857	0	2	4	
996	3	12	2	4	804	0	4	4	
997	0	45	2	4	1845	0	2	4	
998	1	45	4	1	4576	1	0	3	

5 rows × 21 columns

Column mapping

```
column_mapping = {
    "A11": "Status of existing checking account",
    "6": "Duration in month",
    "A34": "Credit history",
    "A43": "Purpose",
    "1169": "Credit amount",
    "A65": "Savings account",
    "A75": "Present employment since",
    "4.1": "Installment rate in percentage of disposable income",
    "A93": "Personal status and sex",
    "A101": "Other debtors",
    "4": "Present residence since",
    "A121": "Property",
    "67": "Age in years",
    "A143": "Other installment plans",
    "A152": "Housing",
    "2": "Number of existing credits at this bank",
    "A173": "Job",
    "1": "Number of dependents",
    "A192": "Telephone",
    "A201": "Foreign worker",
    "1.1": "target"
}
df.rename(columns=column_mapping, inplace=True)
```

Encode categorical features as numbers and Separate features and target

```
label_encoders = {}
for column in df.columns:
    if df[column].dtype == 'object':
        le = LabelEncoder()
        df[column] = le.fit_transform(df[column])
        label_encoders[column] = le

X = df.drop('target', axis=1)
y = df['target']
```

Feature selection

```
chi2_selector = SelectKBest(chi2, k='all')
X_kbest = chi2_selector.fit_transform(X, y)
feature_scores = chi2_selector.scores_

feature_scores_df = pd.DataFrame({'Feature': X.columns, 'Score': feature_scores})
feature_scores_df = feature_scores_df.sort_values(by='Score', ascending=False).reset_index(drop=True)
print(feature_scores_df)
```

```
                                        Feature         Score
0                                 Credit amount  57882.977758
1                               Duration in month    318.524204
2           Status of existing checking account    123.841565
3                                 Savings account     71.521074
4                                    Age in years     29.048836
5                                 Credit history     23.942493
6                                       Property     16.296790
7                         Present employment since      8.117739
8                                   Foreign worker      6.504378
9                          Other installment plans      3.565349
10                         Personal status and sex      2.301708
11                         Present residence since      2.243163
12                                  Other debtors      1.008648
13                                      Telephone      0.759778
14      Number of existing credits at this bank      0.481447
15                                            Job      0.241727
16                                        Housing      0.112262
17                                        Purpose      0.006517
18  Installment rate in percentage of disposable i...      0.005714
19                           Number of dependents      0.001232
```

PCA

```
pca = PCA(n_components=2)
X_pca = pca.fit_transform(X)
```

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

Defining Classifiers

```
classifiers = {
    'Logistic Regression': LogisticRegression(max_iter=1000),
    'Decision Tree': DecisionTreeClassifier(),
    'Random Forest': RandomForestClassifier(),
    'SVM': SVC(),
    'K-Nearest Neighbors': KNeighborsClassifier()
}
```

Evaluate model and classifiers

```
def evaluate_model(model, X_train, X_test, y_train, y_test):
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    accuracy = accuracy_score(y_test, y_pred)
    recall = recall_score(y_test, y_pred, average='weighted')
    precision = precision_score(y_test, y_pred, average='weighted')
    f1 = f1_score(y_test, y_pred, average='weighted')
    return accuracy, recall, precision, f1

    results = {}
for name, clf in classifiers.items():
    accuracy, recall, precision, f1 = evaluate_model(clf, X_train, X_test, y_train, y_test)
    results[name] = {'Accuracy': accuracy, 'Recall': recall, 'Precision': precision, 'F1 Score': f1}

results_df = pd.DataFrame(results).T
print(results_df)
```

```
                     Accuracy  Recall  Precision  F1 Score
    Logistic Regression     0.725   0.725   0.707206  0.690990
    Decision Tree           0.675   0.675   0.663071  0.667668
    Random Forest           0.735   0.735   0.725922  0.695679
    SVM                     0.700   0.700   0.729744  0.598264
    K-Nearest Neighbors     0.650   0.650   0.600220  0.608726
```

K-fold Cross Validation

```
kf = KFold(n_splits=10, random_state=42, shuffle=True)
cv_results = {}
for name, clf in classifiers.items():
    cv_scores = cross_val_score(clf, X, y, cv=kf, scoring='accuracy')
    cv_results[name] = cv_scores.mean()

cv_results_df = pd.DataFrame(cv_results, index=['Cross-Validation Accuracy']).T
print(cv_results_df)

bias_columns = ['Foreign worker', 'Personal status and sex']
X_bias_removed = X.drop(bias_columns, axis=1)
X_train_bias_removed, X_test_bias_removed, y_train, y_test = train_test_split(X_bias_removed, y, test_size=0.2, random_state=42)

bias_results = {}
for name, clf in classifiers.items():
    accuracy, recall, precision, f1 = evaluate_model(clf, X_train_bias_removed, X_test_bias_removed, y_train, y_test)
    bias_results[name] = {'Accuracy': accuracy, 'Recall': recall, 'Precision': precision, 'F1 Score': f1}

bias_results_df = pd.DataFrame(bias_results).T
print(bias_results_df)
```

```
                     Cross-Validation Accuracy
    Logistic Regression                 0.757778
    Decision Tree                       0.690677
    Random Forest                       0.771778
    SVM                                 0.708717
    K-Nearest Neighbors                 0.657616
                     Accuracy  Recall  Precision  F1 Score
    Logistic Regression     0.725   0.725   0.706548  0.694107
    Decision Tree           0.660   0.660   0.654259  0.656872
    Random Forest           0.740   0.740   0.728150  0.709339
    SVM                     0.700   0.700   0.729744  0.598264
    K-Nearest Neighbors     0.650   0.650   0.600220  0.608726
```

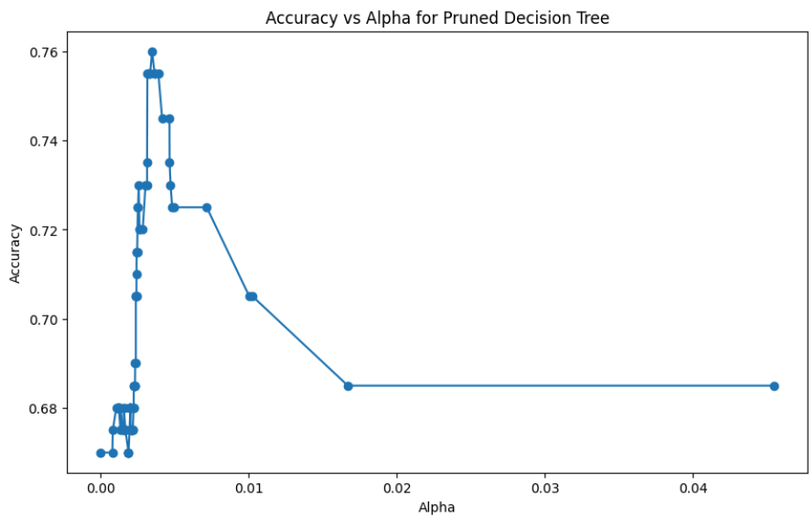
Decision Tree Pruning

```
clf = DecisionTreeClassifier(random_state=42)
clf.fit(X_train, y_train)
path = clf.cost_complexity_pruning_path(X_train, y_train)
ccp_alphas = path.ccp_alphas

pruned_results = []
for ccp_alpha in ccp_alphas:
    clf_pruned = DecisionTreeClassifier(random_state=42, ccp_alpha=ccp_alpha)
    clf_pruned.fit(X_train, y_train)
    y_pred = clf_pruned.predict(X_test)
    pruned_results.append((ccp_alpha, accuracy_score(y_test, y_pred)))
```

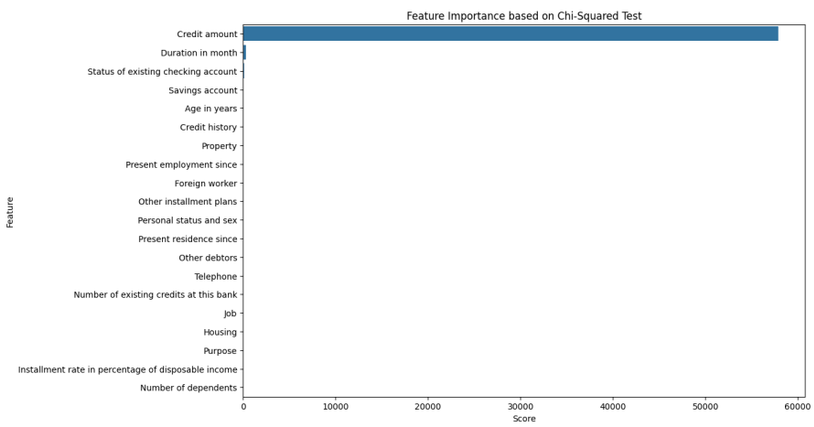
Plot accuracy vs. alpha for pruning

```
pruned_results = pd.DataFrame(pruned_results, columns=['Alpha', 'Accuracy'])
plt.figure(figsize=(10, 6))
plt.plot(pruned_results['Alpha'], pruned_results['Accuracy'], marker='o')
plt.xlabel('Alpha')
plt.ylabel('Accuracy')
plt.title('Accuracy vs Alpha for Pruned Decision Tree')
plt.show()
```



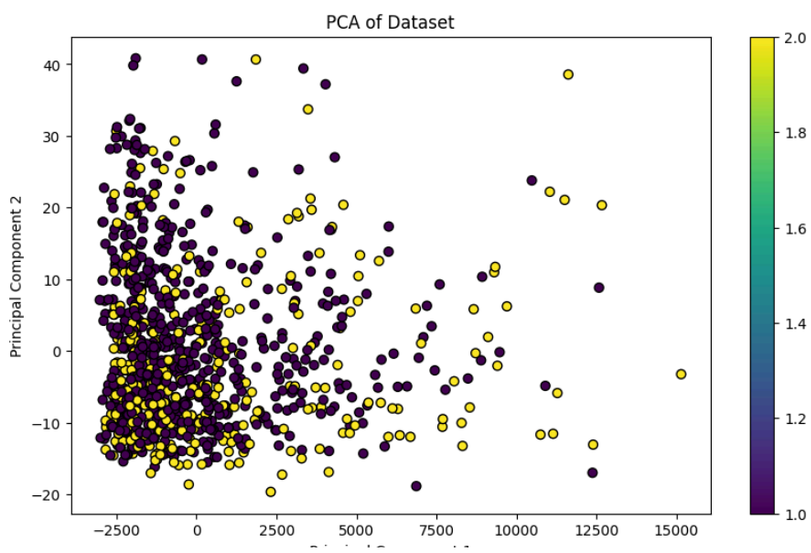
Visualizing feature importance

```
plt.figure(figsize=(12, 8))
sns.barplot(x='Score', y='Feature', data=feature_scores_df)
plt.title('Feature Importance based on Chi-Squared Test')
plt.show()
```



Visualizing PCA results

```
plt.figure(figsize=(10, 6))
plt.scatter(X_pca[:, 0], X_pca[:, 1], c=y, cmap='viridis', edgecolor='k', s=40)
plt.xlabel('Principal Component 1')
plt.ylabel('Principal Component 2')
plt.title('PCA of Dataset')
plt.colorbar()
plt.show()
```


PCA of Dataset
Principal Component 2
40
30
20
10
0
−10
−20
−2500
0
2500
5000
7500
10000
12500
15000
2.0
1.8
1.6
1.4
1.2
1.0