Danny_Xia_HW5

February 9, 2025

[69]:
```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.feature_selection import SequentialFeatureSelector
import matplotlib.pyplot as plt
```

[70]:
```
df = pd.read_csv("heart.csv")
display(df)
```

```
     age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak  \
0     63    1   3       145   233    1        0      150      0      2.3
1     37    1   2       130   250    0        1      187      0      3.5
2     41    0   1       130   204    0        0      172      0      1.4
3     56    1   1       120   236    0        1      178      0      0.8
4     57    0   0       120   354    0        1      163      1      0.6
..   …   …   ..      …   …   …      …     …    …      …
298   57    0   0       140   241    0        1      123      1      0.2
299   45    1   3       110   264    0        1      132      0      1.2
300   68    1   0       144   193    1        1      141      0      3.4
301   57    1   0       130   131    0        1      115      1      1.2
302   57    0   1       130   236    0        0      174      0      0.0

     slope  ca  thal  target
0        0   0     1       1
1        0   0     2       1
2        2   0     2       1
3        2   0     2       1
4        2   0     2       1
..     …  ..   …     …
298      1   0     3       0
299      1   0     3       0
300      1   2     3       0
301      1   1     3       0
302      1   1     2       0
```

```
[303 rows x 14 columns]
```

[71]:
```python
X=df.drop('target', axis=1)
y=df['target']

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=103/303,␣
 ↪random_state=42)
```

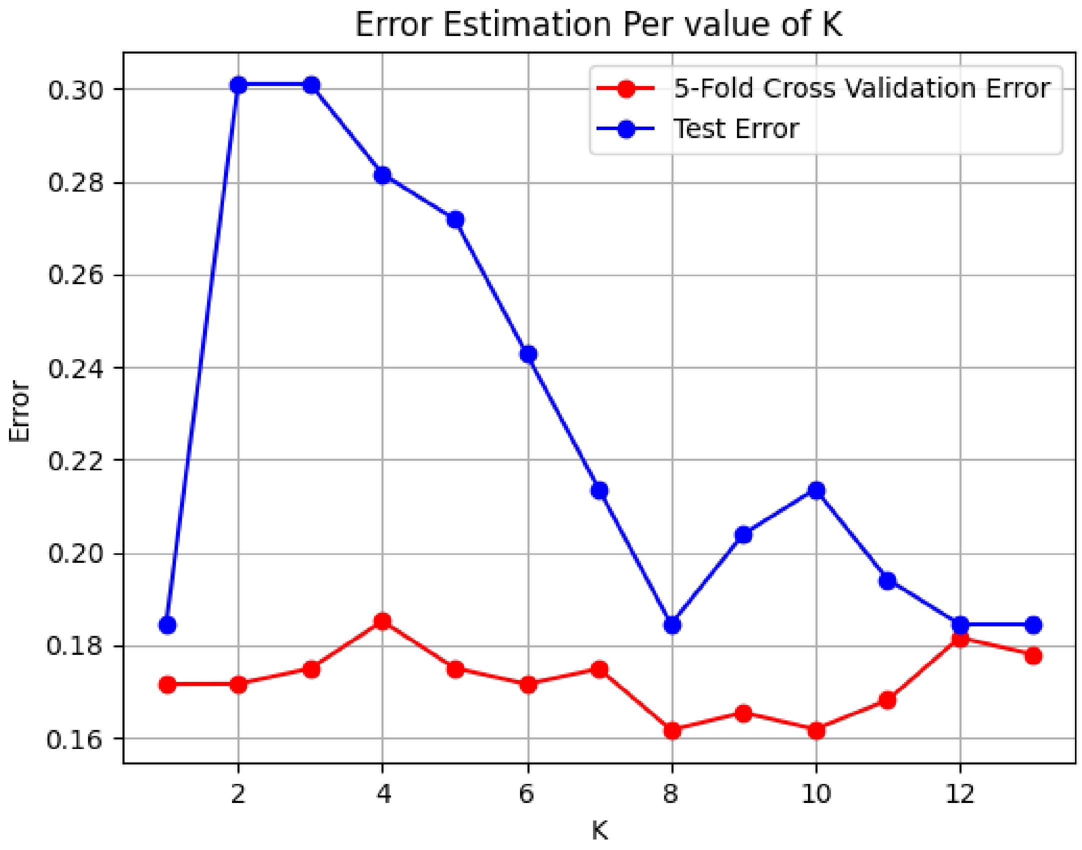
[72]:
```python
def ErrorEstimate(X_train_selected,X_test_selected, y_train, y_test):
    model = LogisticRegression(max_iter=3000,penalty = None)
    model.fit(X_train_selected, y_train)

    kf= KFold(n_splits=5, shuffle=True)
    cv= cross_val_score(model, X, y, cv=kf)
    print(f'Error From K-Fold Cross-Validation with {k} features::')
    print(1 - np.mean(cv))
    error = 1 - np.mean(cv)
    accuracy = model.score(X_test_selected, y_test)
    print(f"Accuracy: {accuracy}")
    test_error = 1 - accuracy
    return error, test_error
```

[95]:
```python
model = LogisticRegression(max_iter=3000, penalty='l1', solver='liblinear')
model.fit(X_train, y_train)

coefs = model.coef_[0]
abs_coefs = np.abs(coefs)

cv_errors = []
test_errors = []

for k in range(0,13):
    indices = np.argpartition(abs_coefs, -k)[-k:]

    X_train_selected = X_train.iloc[:, indices]
    X_test_selected = X_test.iloc[:, indices]

    if k == 2:
        best_columns = X_train.columns[indices].tolist()

    cross_error, test_error = ErrorEstimate(X_train_selected, X_test_selected,␣
 ↪y_train, y_test)
    cv_errors.append(cross_error)
    test_errors.append(test_error)


features=list(range(1,14))
```

```
plt.figure
plt.plot(features, cv_errors, marker='o',linestyle='-', color='r',␣
 ↪label='5-Fold Cross Validation Error')
plt.plot(features, test_errors ,marker='o', linestyle='-', color='b',␣
 ↪label='Test Error')
plt.xlabel('K')
plt.ylabel('Error')
plt.title('Error Estimation Per value of K')
plt.legend()
plt.grid(True)
plt.show()
```

```
Estimated Error From 5-Fold Cross-Validation with 0 features::
0.17158469945355181
Accuracy with 0 features: 0.8155339805825242
Estimated Error From 5-Fold Cross-Validation with 1 features::
0.171639344262295
Accuracy with 1 features: 0.6990291262135923
Estimated Error From 5-Fold Cross-Validation with 2 features::
0.17491803278688534
Accuracy with 2 features: 0.6990291262135923
Estimated Error From 5-Fold Cross-Validation with 3 features::
0.18513661202185783
Accuracy with 3 features: 0.7184466019417476
Estimated Error From 5-Fold Cross-Validation with 4 features::
0.1750273224043717
Accuracy with 4 features: 0.7281553398058253
Estimated Error From 5-Fold Cross-Validation with 5 features::
0.17158469945355193
Accuracy with 5 features: 0.7572815533980582
Estimated Error From 5-Fold Cross-Validation with 6 features::
0.17486338797814205
Accuracy with 6 features: 0.7864077669902912
Estimated Error From 5-Fold Cross-Validation with 7 features::
0.16169398907103827
Accuracy with 7 features: 0.8155339805825242
Estimated Error From 5-Fold Cross-Validation with 8 features::
0.1654098360655738
Accuracy with 8 features: 0.7961165048543689
Estimated Error From 5-Fold Cross-Validation with 9 features::
0.1618579234972678
Accuracy with 9 features: 0.7864077669902912
Estimated Error From 5-Fold Cross-Validation with 10 features::
0.1680874316939891
Accuracy with 10 features: 0.8058252427184466
Estimated Error From 5-Fold Cross-Validation with 11 features::
```

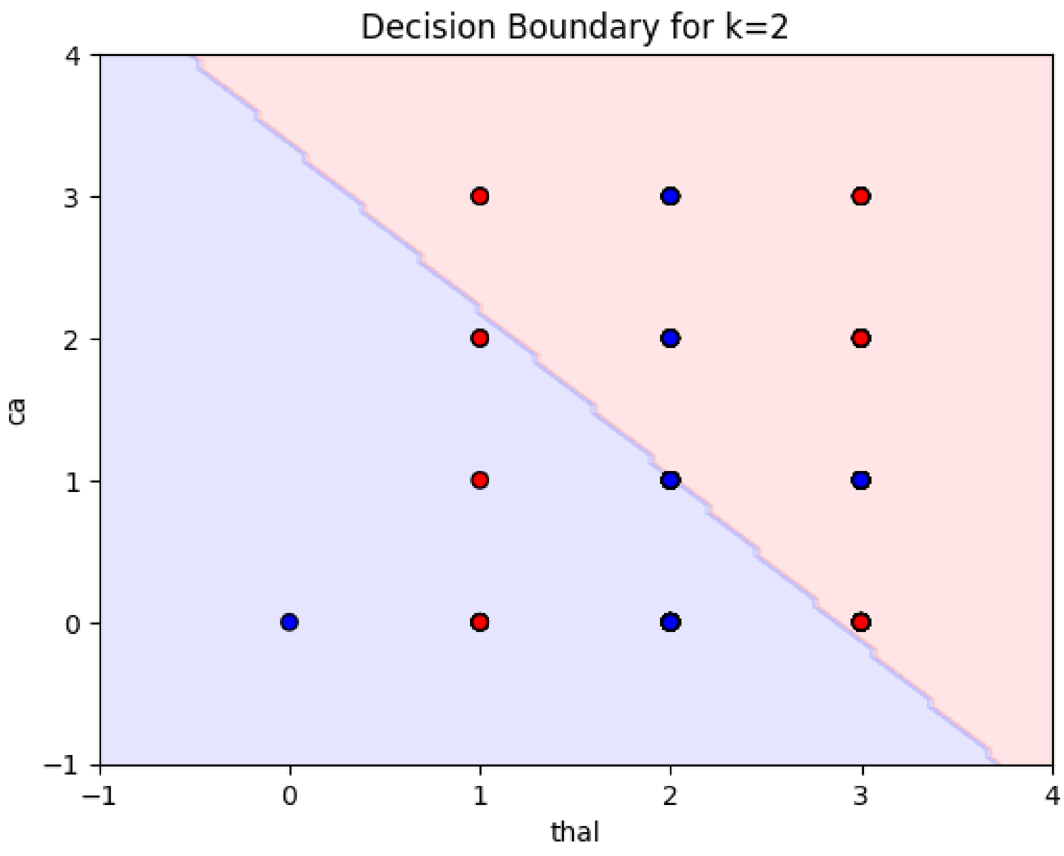
```
0.18158469945355193
Accuracy with 11 features: 0.8155339805825242
Estimated Error From 5-Fold Cross-Validation with 12 features::
0.17803278688524604
Accuracy with 12 features: 0.8155339805825242
```



[98]:
```
from matplotlib.colors import ListedColormap

def plot_decision_boundary(X, y, model, selected_features):
    X_selected = X[selected_features]
    x_min, x_max = X_selected.iloc[:, 0].min() - 1, X_selected.iloc[:, 0].max()␣
 ↪+ 1
    y_min, y_max = X_selected.iloc[:, 1].min() - 1, X_selected.iloc[:, 1].max()␣
 ↪+ 1
    xx, yy = np.meshgrid(np.linspace(x_min, x_max, 100), np.linspace(y_min,␣
 ↪y_max, 100))

    Z = model.predict(np.c_[xx.ravel(), yy.ravel()])
    Z = Z.reshape(xx.shape)
    plt.contourf(xx, yy, Z, alpha=0.3, cmap=ListedColormap(['#FFAAAA',␣
↪'#AAAAFF']))
    plt.scatter(X_selected.iloc[:, 0], X_selected.iloc[:, 1], c=y,␣
↪edgecolors='k', cmap=ListedColormap(['#FF0000', '#0000FF']))
    plt.xlabel(selected_features[0])
    plt.ylabel(selected_features[1])
    plt.title("Decision Boundary for k=2")
    plt.show()

print(best_columns)
model = LogisticRegression(max_iter=1500, penalty=None)
model.fit(X_train[best_columns], y_train)

plot_decision_boundary(X_train, y_train, model, best_columns)
```

```
['thal', 'ca']
```

```
/Library/Frameworks/Python.framework/Versions/3.12/lib/python3.12/site-
packages/sklearn/utils/validation.py:2739: UserWarning: X does not have valid
feature names, but LogisticRegression was fitted with feature names
  warnings.warn(
```



```
[ ]:
```