# 24MDT0184_Experiment10

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# 1 Data Mining and machine Learning

# 2 Experiment 10

## 2.1 26 March

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## 4.1 Q1. Download the dataset provided to you. The dataset 'data.csv' gives you a dataset collected regarding the heart disease of a few individuals. '1' in the target column represents that the person has disease and '0' represents that the person doesn't have heart disease

### 4.1.1 Importing thenecessary libraries

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from sklearn.model_selection import train_test_split
```

### 4.1.2 Loading the dataset

[2]:
```
df = pd.read_csv(r"D:\study material\VIT_Data_Science\Winter_Sem\Data Mining␣
↪and Machine Learning Lab\Class_notes\ML_exp10\data.csv")
df.head()
```

[2]:

| | age | sex | cp | trestbps | chol | fbs | restecg | thalach | exang | oldpeak | slope | ca | thal | target |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 48 | 1 | 2 | 124 | 255 | 1 | 1 | 175 | 0 | 0.0 | 2 | 2 | 2 | 1 |
| 1 | 68 | 0 | 2 | 120 | 211 | 0 | 0 | 115 | 0 | 1.5 | 1 | | | |
| 2 | 46 | 1 | 0 | 120 | 249 | 0 | 0 | 144 | 0 | 0.8 | 2 | | | |
| 3 | 60 | 1 | 0 | 130 | 253 | 0 | 1 | 144 | 1 | 1.4 | 2 | | | |
| 4 | 43 | 1 | 0 | 115 | 303 | 0 | 1 | 181 | 0 | 1.2 | 1 | | | |

```
1   0     2       1
2   0     3       0
3   1     3       0
4   0     2       1
```

[3]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 212 entries, 0 to 211
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   age       212 non-null    int64
 1   sex       212 non-null    int64
 2   cp        212 non-null    int64
 3   trestbps  212 non-null    int64
 4   chol      212 non-null    int64
 5   fbs       212 non-null    int64
 6   restecg   212 non-null    int64
 7   thalach   212 non-null    int64
 8   exang     212 non-null    int64
 9   oldpeak   212 non-null    float64
 10  slope     212 non-null    int64
 11  ca        212 non-null    int64
 12  thal      212 non-null    int64
 13  target    212 non-null    int64
dtypes: float64(1), int64(13)
memory usage: 23.3 KB
```

### 4.1.3 Checking for missing values

[4]:
```
df.isnull().sum()
```

[4]:
```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          0
thal        0
target      0
dtype: int64
```

#### 4.1.4 Checking for duplicate values

[5]:
```
df.duplicated().sum()
```

[5]:
```
1
```

#### 4.1.5 Dropping the duplicate record

[6]:
```
df.drop_duplicates(inplace = True)
```

[7]:
```
df.duplicated().sum()
```

[7]:
```
0
```

#### 4.1.6 Minmax scaling

[8]:
```
scaler = MinMaxScaler()
x_scaled = scaler.fit_transform(df)
```

[9]:
```
x = x_scaled[:,:-1]
y = x_scaled[:,-1]
```

[10]:
```
y
```

[10]:
```
array([1., 1., 0., 0., 1., 0., 0., 1., 1., 1., 1., 1., 0., 1., 0., 0., 0.,
       0., 1., 1., 1., 0., 0., 1., 1., 0., 1., 1., 0., 0., 1., 0., 0., 1.,
       1., 0., 1., 1., 1., 0., 0., 0., 0., 1., 1., 1., 1., 1., 0., 1., 0.,
       0., 0., 0., 0., 0., 0., 1., 1., 0., 1., 1., 1., 0., 1., 1., 0., 1.,
       1., 1., 0., 0., 0., 1., 1., 0., 0., 0., 0., 1., 1., 1., 1., 1., 1.,
       1., 0., 1., 0., 1., 1., 1., 0., 1., 0., 0., 1., 0., 0., 0., 0., 1.,
       1., 1., 0., 1., 1., 0., 1., 0., 0., 1., 0., 0., 0., 0., 0., 0., 1.,
       0., 0., 1., 0., 1., 0., 1., 1., 1., 1., 1., 1., 0., 0., 1., 1., 1.,
       1., 1., 0., 1., 0., 1., 1., 1., 1., 1., 1., 0., 1., 1., 1., 1., 1.,
       0., 0., 0., 0., 1., 1., 1., 1., 0., 1., 1., 0., 0., 1., 1., 0., 0.,
       0., 1., 1., 0., 0., 1., 0., 0., 1., 1., 0., 1., 0., 1., 1., 1., 0.,
       0., 0., 1., 0., 1., 0., 0., 0., 1., 0., 0., 1., 0., 1., 1., 0., 1.,
       1., 1., 0., 1., 0., 1., 0.])
```

#### 4.1.7 Perform PCA on the given data to reduce the data to 2 dimensions

[11]:
```
from sklearn.decomposition import PCA

pca = PCA(n_components = 2)
x_pca = pca.fit_transform(x)
x_pca[:5]
```

[11]:
```
array([[-0.23128005, -0.71417575],
       [-0.61962179,  0.46912865],
```

```
[-0.06426909, -0.35839476],
[ 0.69874407,  0.09173425],
[-0.05076502, -0.30982993]])
```

### 4.2 Fit different models using the given techniques to predict the target variables and compare the accuracy of the models

**train test split of the data**

[12]:
```
x_train,x_test,y_train,y_test = train_test_split(x_pca,y,test_size=0.
↪2,random_state=42)
```

#### 4.2.1 Using Logistic Regression

[13]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score
lr = LogisticRegression()
lr.fit(x_train,y_train)
y_pred_lr = lr.predict(x_test)
accuracy_lr = accuracy_score(y_test,y_pred_lr)
print(f"Accuracy using Logistic Regression model: {accuracy_lr*100:.2f}%")
```

```
Accuracy using Logistic Regression model: 79.07%
```

#### 4.2.2 Using Decision Tree

[14]:
```
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier()
dt.fit(x_train,y_train)
y_pred_dt = dt.predict(x_test)
accuracy_dt = accuracy_score(y_test,y_pred_dt)
print(f"Accuracy using Decision Tree model: {accuracy_dt*100:.2f}%")
```

```
Accuracy using Decision Tree model: 79.07%
```

#### 4.2.3 Using bagging

[15]:
```
from sklearn.ensemble import BaggingClassifier
bc = BaggingClassifier()
bc.fit(x_train,y_train)
y_pred_bc = bc.predict(x_test)
accuracy_bc = accuracy_score(y_test,y_pred_bc)
print(f"Accuracy using Bagging classifier model: {accuracy_bc*100:.2f}%")
```

```
Accuracy using Bagging classifier model: 76.74%
```

### 4.2.4 Random forest using Hyper parameter tuning

[16]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV

param_grid = {
'n_estimators': [10, 50, 100, 200, 300, 400, 500, 700],
'max_depth': [3,5,7],
'min_samples_leaf': [1, 2, 4]
}
model = RandomForestClassifier(random_state=0)
grid_search = GridSearchCV(estimator=model, param_grid=param_grid,␣
 ↪cv=5,scoring='accuracy', n_jobs=-1)
grid_search.fit(x_train, y_train)
best_params = grid_search.best_params_
best_model_rf = grid_search.best_estimator_
y_pred_rf = best_model_rf.predict(x_test)
accuracy_rf = accuracy_score(y_test, y_pred_rf)
```

[17]:
```
print("Best Parameters:", best_params)
print(f"Best Cross-validation Accuracy:{ grid_search.best_score_*100:.2f}%")
print(f"Accuracy using random forest:{ accuracy_rf*100:.2f}%")
```

```
Best Parameters: {'max_depth': 3, 'min_samples_leaf': 1, 'n_estimators': 200}
Best Cross-validation Accuracy:77.38%
Accuracy using random forest:76.74%
```

### 4.2.5 Using Adaboost with hyperparameter tuning

[18]:
```
from sklearn.ensemble import AdaBoostClassifier
param_grid = {
'n_estimators': [10, 50, 75,100,125,150, 200, 400, 500],
'estimator__max_depth':[1,2,3]
}
base_model = DecisionTreeClassifier(max_depth=1)
model = AdaBoostClassifier(estimator=base_model, random_state=0)
grid_search = GridSearchCV(estimator=model, param_grid=param_grid,␣
 ↪cv=5,scoring='accuracy', n_jobs=-1)
grid_search.fit(x_train, y_train)
best_params = grid_search.best_params_
best_model_ab = grid_search.best_estimator_
y_pred_ab = best_model_ab.predict(x_test)
```

```
C:\Users\TUFAN\AppData\Roaming\Python\Python312\site-
packages\sklearn\ensemble\_weight_boosting.py:519: FutureWarning: The SAMME.R
algorithm (the default) is deprecated and will be removed in 1.6. Use the SAMME
algorithm to circumvent this warning.
  warnings.warn(
```

[19]:
```
accuracy_ab = accuracy_score(y_test, y_pred_ab)
print("Best Parameters:", best_params)
print(f"Best Cross-validation Accuracy of Adaboost classifier: {grid_search.
  ↪best_score_*100:.2f}%")
print(f"Accuracy using Adaboost classifier:{ accuracy_ab*100:.2f}%")
```

```
Best Parameters: {'estimator__max_depth': 3, 'n_estimators': 10}
Best Cross-validation Accuracy of Adaboost classifier: 77.95%
Accuracy using Adaboost classifier:76.74%
```

### 4.2.6 Gradient boosting with hyper parameter tuning

[20]:
```
from sklearn.ensemble import GradientBoostingClassifier
param_grid = {
'n_estimators' : [25,50,100,200,250,300,400,450,500,700],
'learning_rate' : [0.1,0.5,0.01,0.05,0.08,0.001,0.005,0.008,0.0001,0.0005],
'max_depth' : [1,2,3,4,5,6,7,8,9,10],
}
gbc_model = GradientBoostingClassifier()
grid_search = GridSearchCV(estimator=gbc_model,␣
  ↪param_grid=param_grid,cv=5,scoring='accuracy', n_jobs=-1)
grid_search.fit(x_train, y_train)
```

[20]:
```
GridSearchCV(cv=5, estimator=GradientBoostingClassifier(), n_jobs=-1,
             param_grid={'learning_rate': [0.1, 0.5, 0.01, 0.05, 0.08, 0.001,
                                           0.005, 0.008, 0.0001, 0.0005],
                         'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10],
                         'n_estimators': [25, 50, 100, 200, 250, 300, 400, 450,
                                          500, 700]},
             scoring='accuracy')
```

[21]:
```
best_params = grid_search.best_params_
best_model_gb = grid_search.best_estimator_
y_pred_gb = best_model_gb.predict(x_test)
print(f"Best parameters:\n{best_params}")
print(f"Best model:\n{best_model_gb}")
print(f"\nAccuracy score after hyperparameter tuning:
  ↪{accuracy_score(y_test,y_pred_gb)*100:.2f} %")
```

```
Best parameters:
{'learning_rate': 0.005, 'max_depth': 1, 'n_estimators': 700}
Best model:
GradientBoostingClassifier(learning_rate=0.005, max_depth=1, n_estimators=700)

Accuracy score after hyperparameter tuning:79.07 %
```

### 4.2.7 Find out the predictions in each case and print them

[22]:
```
print(f"Accuracy using Logistic Regression model: {accuracy_lr*100:.2f}%")
print(f"Accuracy using Decision Tree model: {accuracy_dt*100:.2f}%")
print(f"Accuracy using Bagging classifier model: {accuracy_bc*100:.2f}%")
print(f"Accuracy using random forest:{ accuracy_rf*100:.2f}%")
print(f"Accuracy using Adaboost classifier:{ accuracy_ab*100:.2f}%")
print(f"Accuracy score GradientBooting classifier:
 ↪{accuracy_score(y_test,y_pred_gb)*100:.2f} %")
```

```
Accuracy using Logistic Regression model: 79.07%
Accuracy using Decision Tree model: 79.07%
Accuracy using Bagging classifier model: 76.74%
Accuracy using random forest:76.74%
Accuracy using Adaboost classifier:76.74%
Accuracy score GradientBooting classifier:79.07 %
```

### 4.2.8 Also evaluate the model based on suitable performance measures other than accuracy

[23]:
```
from sklearn.metrics import␣
 ↪precision_score,recall_score,confusion_matrix,f1_score

## For Logistic regression
print("Logistic Regression:")
precision_lr = precision_score(y_test,y_pred_lr)
print(f"Precision of Logistic Regression model: {precision_lr*100:.2f}%")
recall_lr = recall_score(y_test,y_pred_lr)
print(f"Recall of Logistic Regression model: {recall_lr*100:.2f}%")
print(f"F1 score of Logistic regression model:{f1_score(y_test,y_pred_lr)*100:.
 ↪2f}%")
print("Confusion matrix of Logistic regression model:
 ↪\n",confusion_matrix(y_test,y_pred_lr))
print()
##For decision tree
print("Decision Tree:")
precision_dt = precision_score(y_test,y_pred_dt)
print(f"Precision of Decision Tree model: {precision_dt*100:.2f}%")
recall_dt = recall_score(y_test,y_pred_dt)
print(f"Recall of Decision Tree model: {recall_dt*100:.2f}%")
print(f"F1 score of Decision Tree model:{f1_score(y_test,y_pred_dt)*100:.2f}%")
print("Confusion matrix of Decision Tree model:
 ↪\n",confusion_matrix(y_test,y_pred_dt))
print()
## For Bagging
print("Bagging classifier:")
precision_bg = precision_score(y_test,y_pred_bc)
print(f"Precision of Bagging classifier model: {precision_bg*100:.2f}%")
```

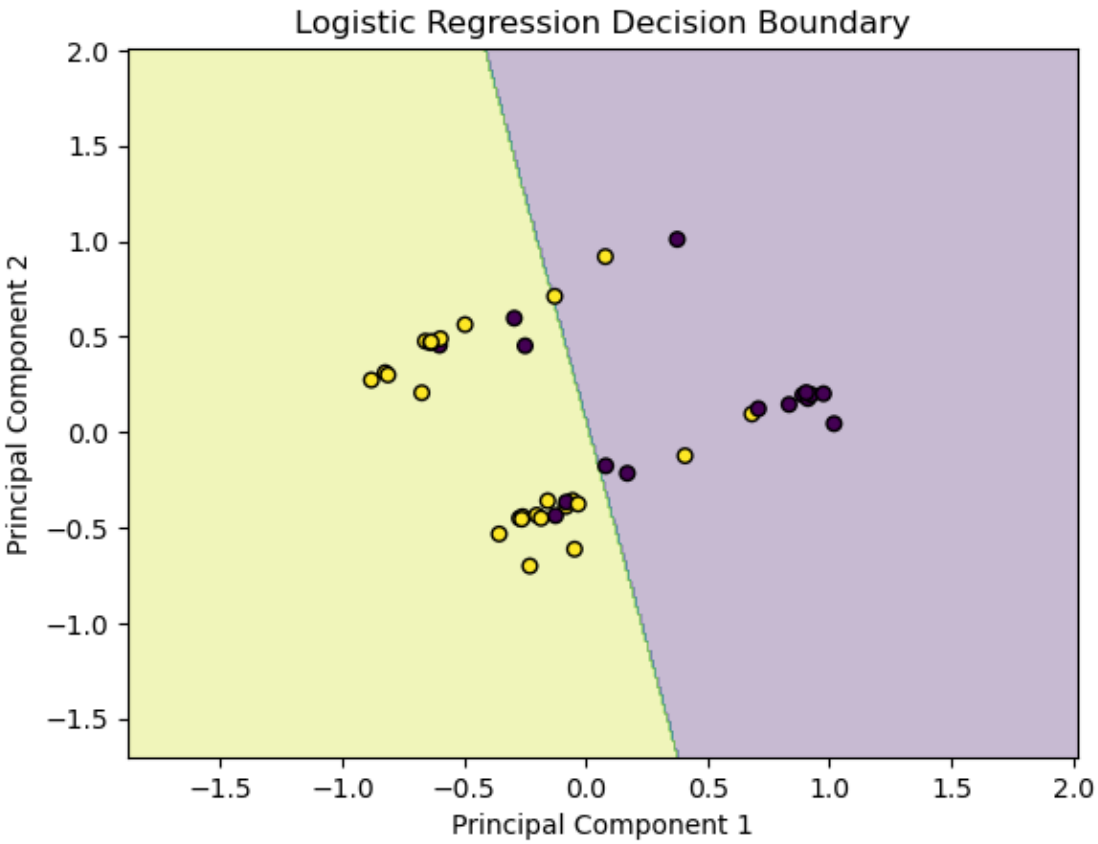
```
recall_bg = recall_score(y_test,y_pred_bc)
print(f"Recall of Bagging classifier model: {recall_bg*100:.2f}%")
print(f"F1 score of Bagging classifier model:{f1_score(y_test,y_pred_bc)*100:.
 ↪2f}%")
print("Confusion matrix of Bagging classifier model:
 ↪\n",confusion_matrix(y_test,y_pred_bc))
print()
## For Random Forest
print("Random Forest:")
precision_rf = precision_score(y_test,y_pred_rf)
print(f"Precision of Random Forest model: {precision_rf*100:.2f}%")
recall_rf = recall_score(y_test,y_pred_rf)
print(f"Recall of Random Forest model: {recall_rf*100:.2f}%")
print(f"F1 score of Random Forest model:{f1_score(y_test,y_pred_rf)*100:.2f}%")
print("Confusion matrix of Random Forest model:
 ↪\n",confusion_matrix(y_test,y_pred_rf))
print()
## For Adaboost Classifier
print("Adaboost Classifier:")
precision_ab = precision_score(y_test,y_pred_ab)
print(f"Precision of Adaboost Classifier model: {precision_ab*100:.2f}%")
recall_ab = recall_score(y_test,y_pred_ab)
print(f"Recall of Adaboost Classifier model: {recall_ab*100:.2f}%")
print(f"F1 score of Adaboost Classifier model:{f1_score(y_test,y_pred_ab)*100:.
 ↪2f}%")
print("Confusion matrix of Adaboost Classifier model:
 ↪\n",confusion_matrix(y_test,y_pred_ab))
print()
## For GradientBoosting Classifier
print("GradientBoosting Classifier:")
precision_gb = precision_score(y_test,y_pred_gb)
print(f"Precision of GradientBoosting Classifier model: {precision_gb*100:.
 ↪2f}%")
recall_gb = recall_score(y_test,y_pred_gb)
print(f"Recall of GradientBoosting Classifier model: {recall_gb*100:.2f}%")
print(f"F1 score of GradientBoosting Classifier model:
 ↪{f1_score(y_test,y_pred_gb)*100:.2f}%")
print("Confusion matrix of GradientBoosting Classifier model:
 ↪\n",confusion_matrix(y_test,y_pred_gb))
print()
```

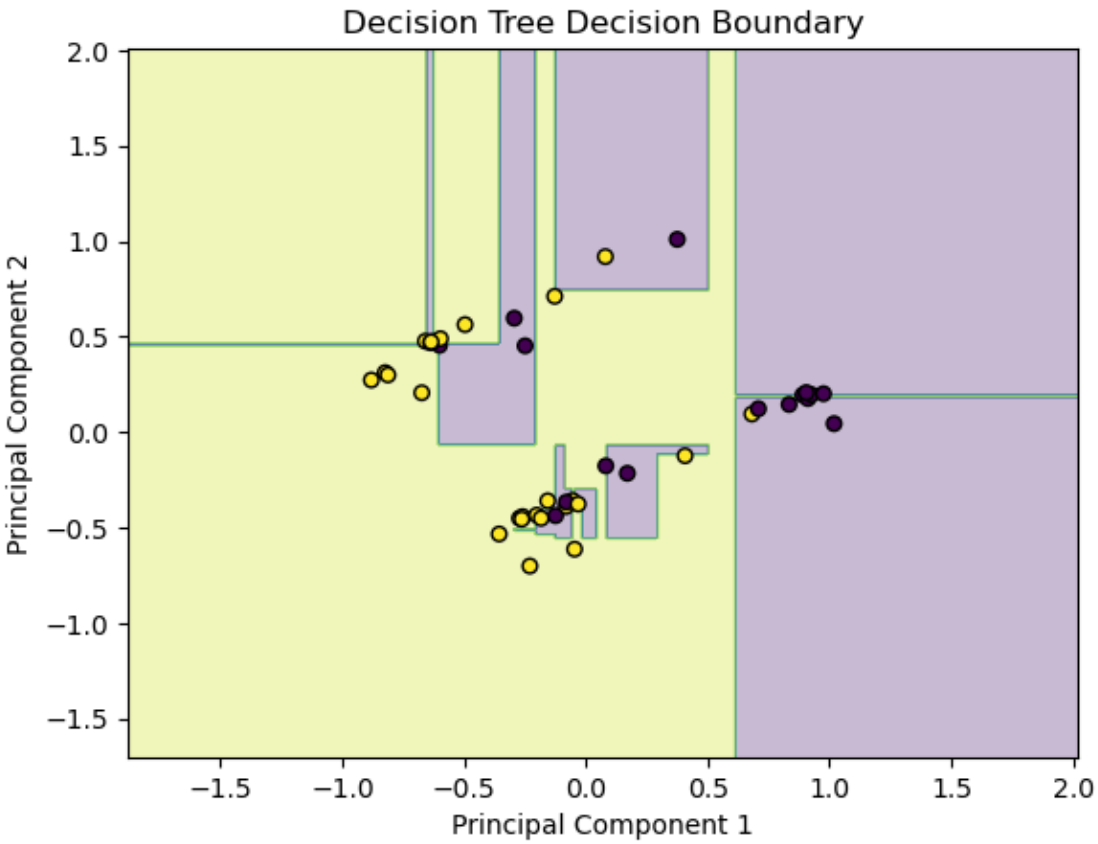
```
Logistic Regression:
Precision of Logistic Regression model: 81.48%
Recall of Logistic Regression model: 84.62%
F1 score of Logistic regression model:83.02%
Confusion matrix of Logistic regression model:
 [[12  5]
```

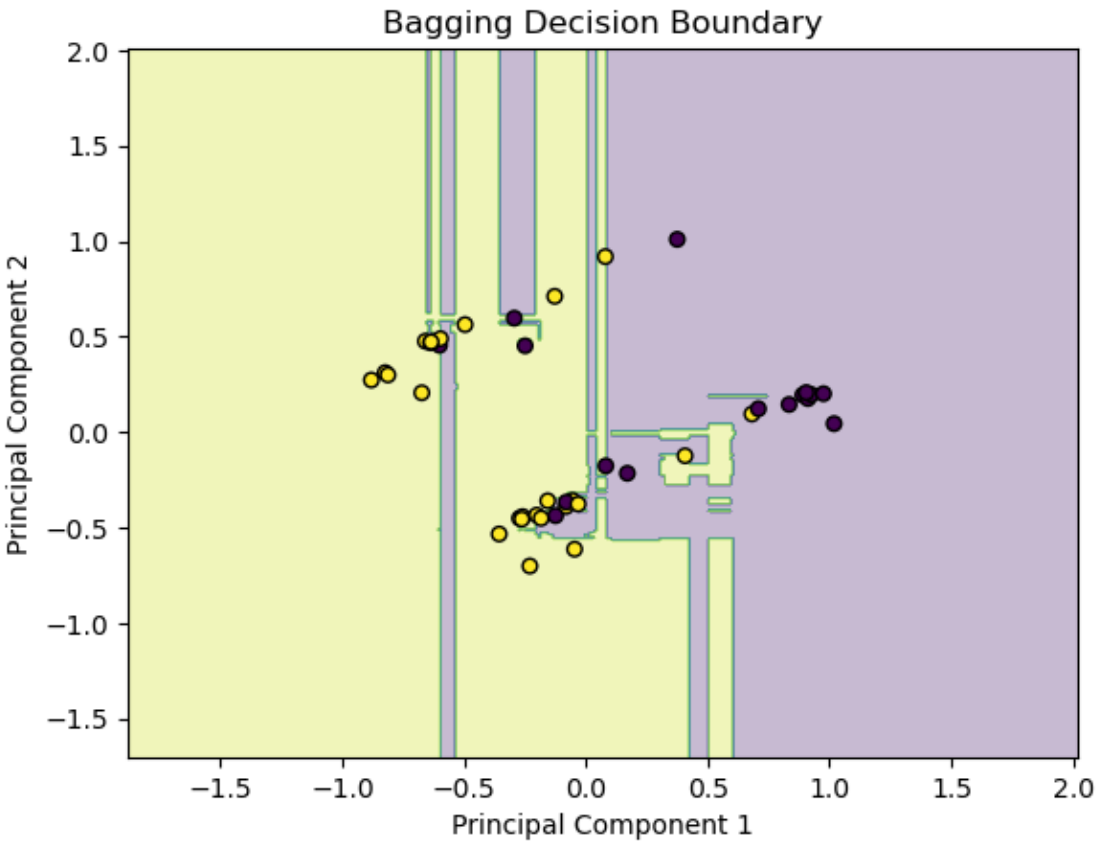
```
 [ 4 22]]

Decision Tree:
Precision of Decision Tree model: 94.74%
Recall of Decision Tree model: 69.23%
F1 score of Decision Tree model:80.00%
Confusion matrix of Decision Tree model:
 [[16  1]
 [ 8 18]]

Bagging classifier:
Precision of Bagging classifier model: 86.36%
Recall of Bagging classifier model: 73.08%
F1 score of Bagging classifier model:79.17%
Confusion matrix of Bagging classifier model:
 [[14  3]
 [ 7 19]]

Random Forest:
Precision of Random Forest model: 86.36%
Recall of Random Forest model: 73.08%
F1 score of Random Forest model:79.17%
Confusion matrix of Random Forest model:
 [[14  3]
 [ 7 19]]

Adaboost Classifier:
Precision of Adaboost Classifier model: 86.36%
Recall of Adaboost Classifier model: 73.08%
F1 score of Adaboost Classifier model:79.17%
Confusion matrix of Adaboost Classifier model:
 [[14  3]
 [ 7 19]]

GradientBoosting Classifier:
Precision of GradientBoosting Classifier model: 86.96%
Recall of GradientBoosting Classifier model: 76.92%
F1 score of GradientBoosting Classifier model:81.63%
Confusion matrix of GradientBoosting Classifier model:
 [[14  3]
 [ 6 20]]
```

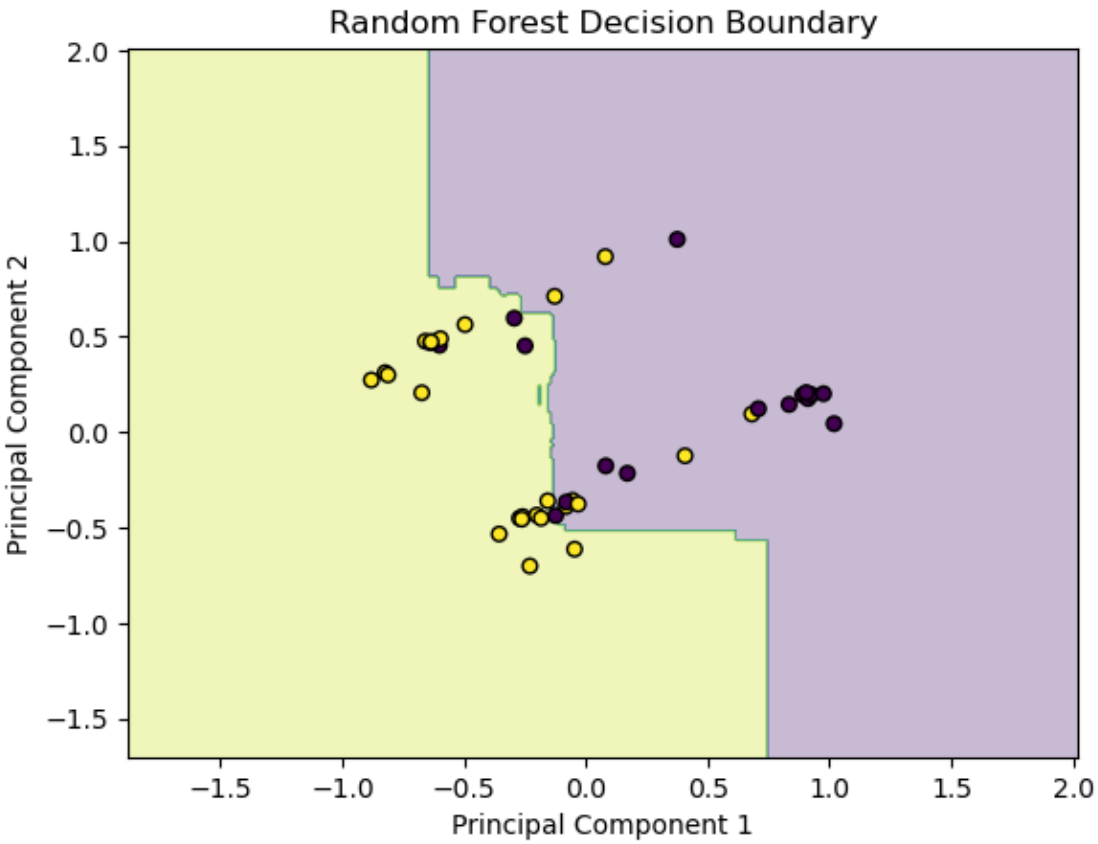
[ ]:
```
def plot_decision_boundary(model, X, y, title):
    x_min, x_max = X[:, 0].min() - 1, X[:, 0].max() + 1
    y_min, y_max = X[:, 1].min() - 1, X[:, 1].max() + 1
    xx, yy = np.meshgrid(np.linspace(x_min, x_max, 500),
```

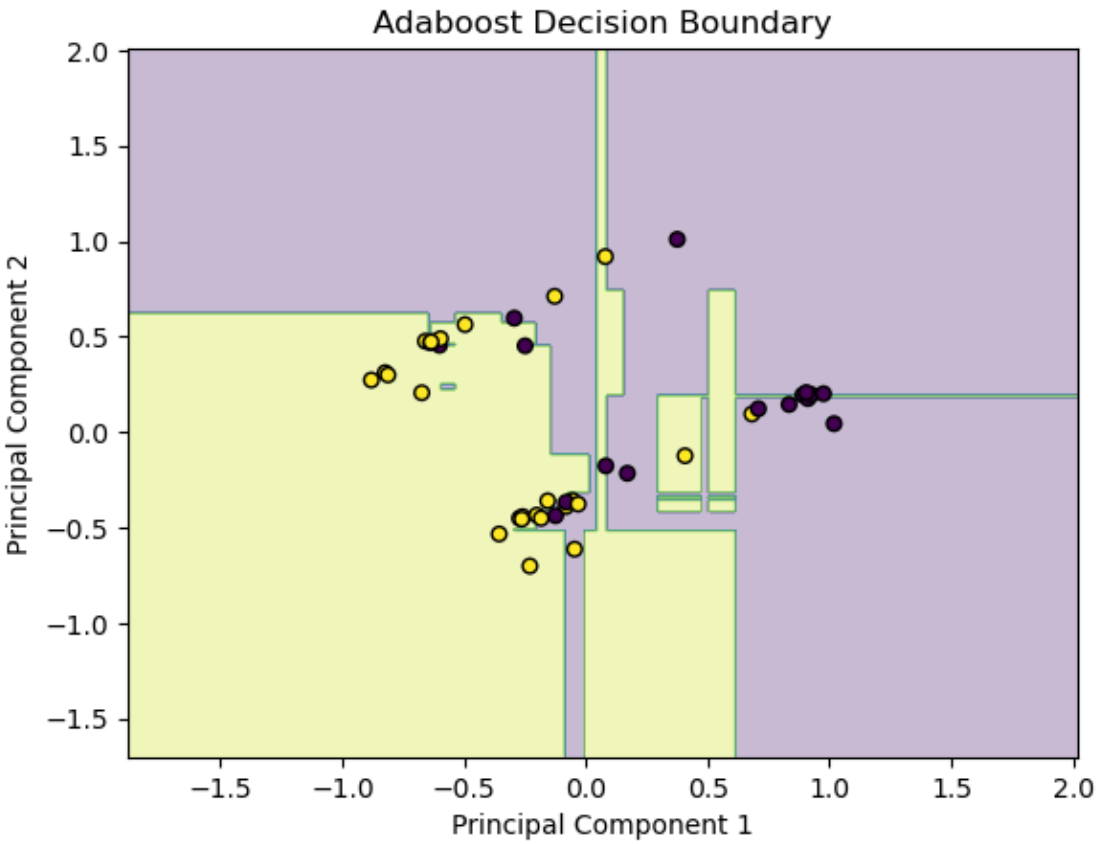
```
                          np.linspace(y_min, y_max, 500))

    Z = model.predict(np.c_[xx.ravel(), yy.ravel()])
    Z = Z.reshape(xx.shape)

    plt.contourf(xx, yy, Z, alpha=0.3, cmap= 'viridis')
    plt.scatter(X[:, 0], X[:, 1], c=y, s=30, edgecolor='k', cmap='viridis')
    plt.title(title)
    plt.xlabel('Principal Component 1')
    plt.ylabel('Principal Component 2')
    plt.show()

# Plot for each model
plot_decision_boundary(lr, x_test, y_test, "Logistic Regression Decision␣
 ↪Boundary")
plot_decision_boundary(dt, x_test, y_test, "Decision Tree Decision Boundary")
plot_decision_boundary(bc, x_test, y_test, "Bagging Decision Boundary")
plot_decision_boundary(best_model_rf, x_test, y_test, "Random Forest Decision␣
 ↪Boundary")
plot_decision_boundary(best_model_ab, x_test, y_test, "Adaboost Decision␣
 ↪Boundary")
plot_decision_boundary(best_model_gb, x_test, y_test, "Gradient Boosting␣
 ↪Decision Boundary")
```

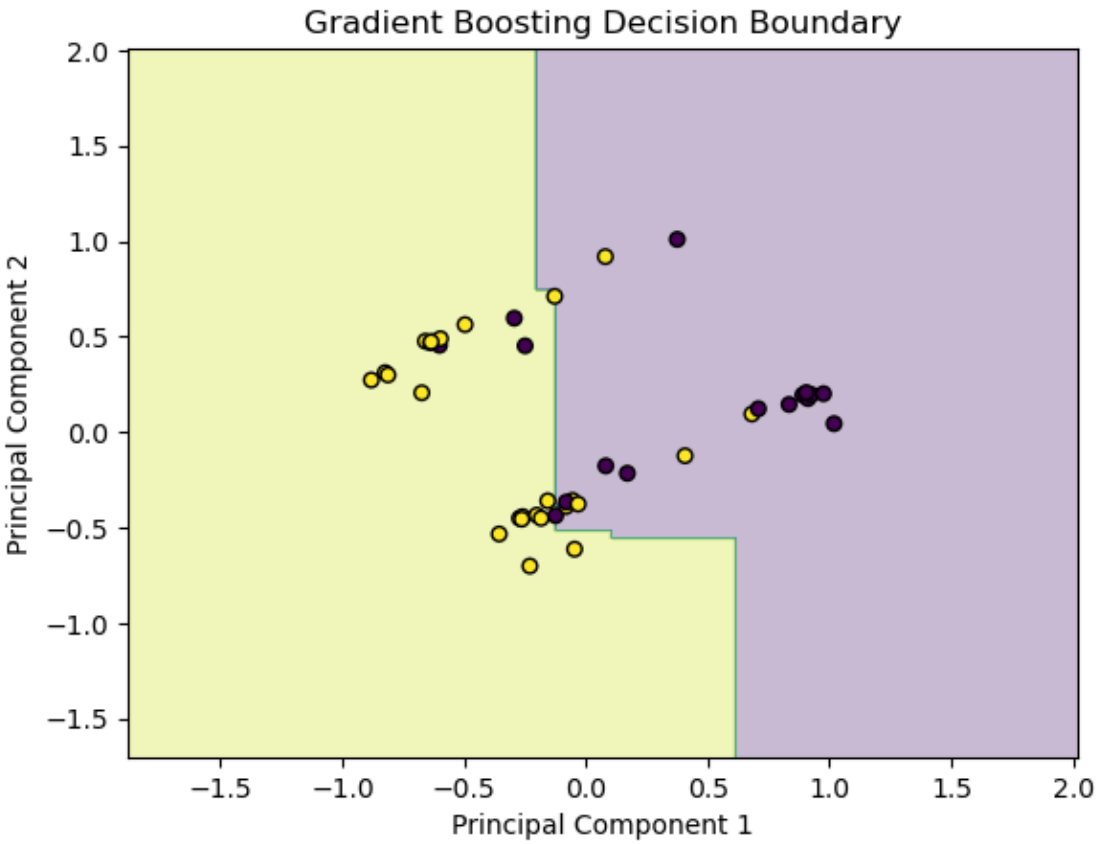

Logistic Regression Decision Boundary
Principal Component 2
Principal Component 1
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0


Decision Tree Decision Boundary
Principal Component 2
Principal Component 1
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0


Bagging Decision Boundary
Principal Component 2
Principal Component 1
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0


Random Forest Decision Boundary
Principal Component 2
Principal Component 1
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0


Adaboost Decision Boundary
Principal Component 2
Principal Component 1
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0


Gradient Boosting Decision Boundary
Principal Component 2
Principal Component 1
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0