Tools & Techniques Lab Project

KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY

CardiPredict: A Machine Learning Solution to predict Heart Disease using SVM Algorithm

Introduction

- Heart Disease causes around 12 million deaths globally every year.
- Early detection of heart disease is crucial for making informed decisions about lifestyle changes and reducing the risk of complications.
- This project aims to use machine learning algorithms to analyze patient data.
- The goal is to predict the likelihood of future heart disease using these algorithms.

Objectives

The main objective of developing this project are:

- To develop a machine learning model to predict the future possibility of heart disease by implementing Support Vector Machine(SVM).
- To determine significant risk factors based on medical dataset which may lead to heart disease.
- To analyze feature selection methods and understand their working principle.

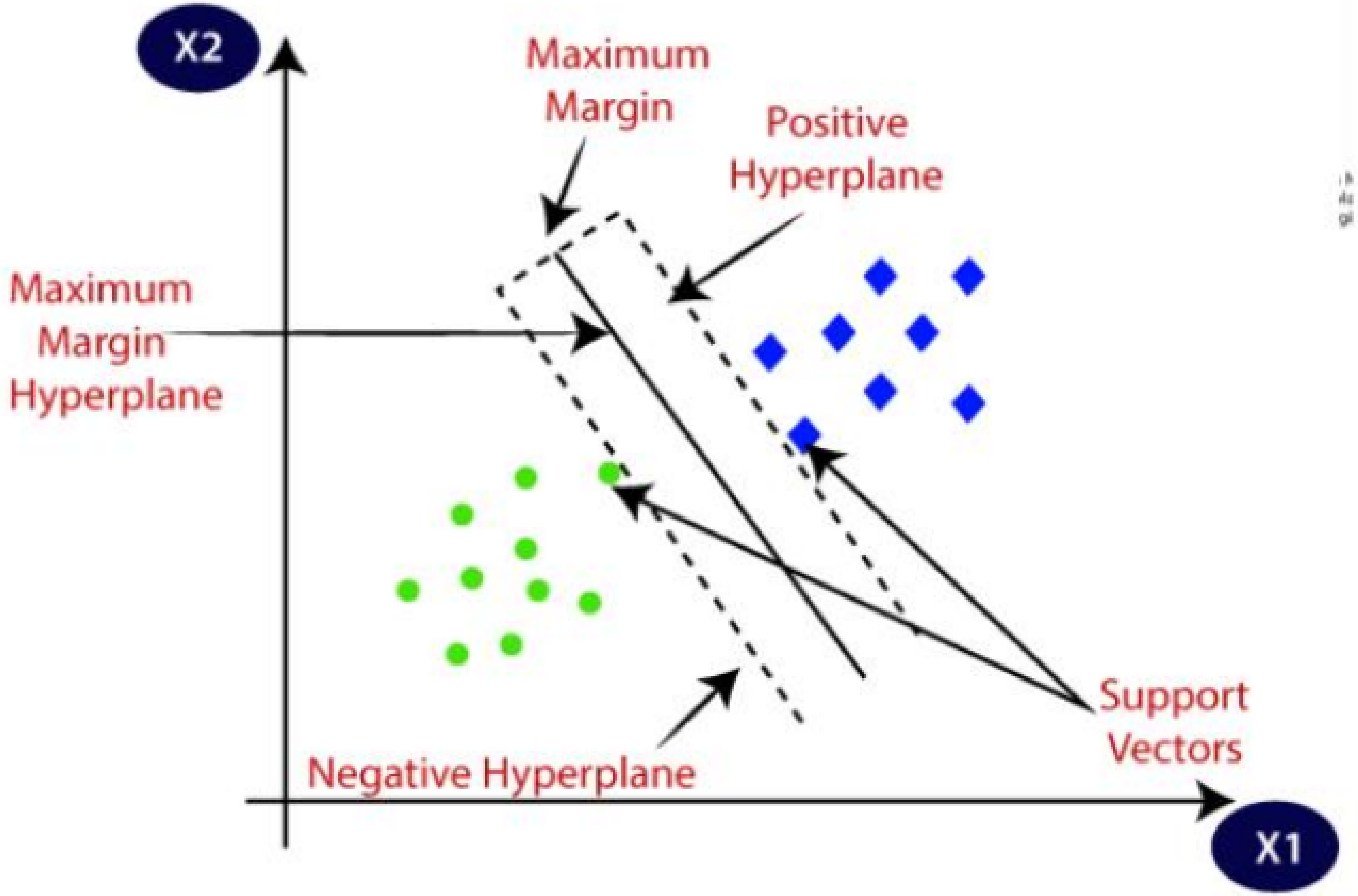
DATASETS

- The dataset is part of an ongoing cardiovascular study on residents of Framingham, Massachusetts.
- The dataset contains over 4000 records and 14 attributes.
- The attributes include age, sex, chest pain type, resting blood pressure, serum cholesterol, fasting blood sugar, resting electrocardiograph results, maximum heart rate, exercise-induced angina, ST depression induced by exercise, slope of the peak exercise, number of major vessels, and target ranging from 0 to 2, where 0 indicates the absence of heart disease.
- The dataset is in CSV format and is prepared as a data frame using the Pandas library in Python.

METHODS AND ALGORITHMS USED

Support Vector Machine

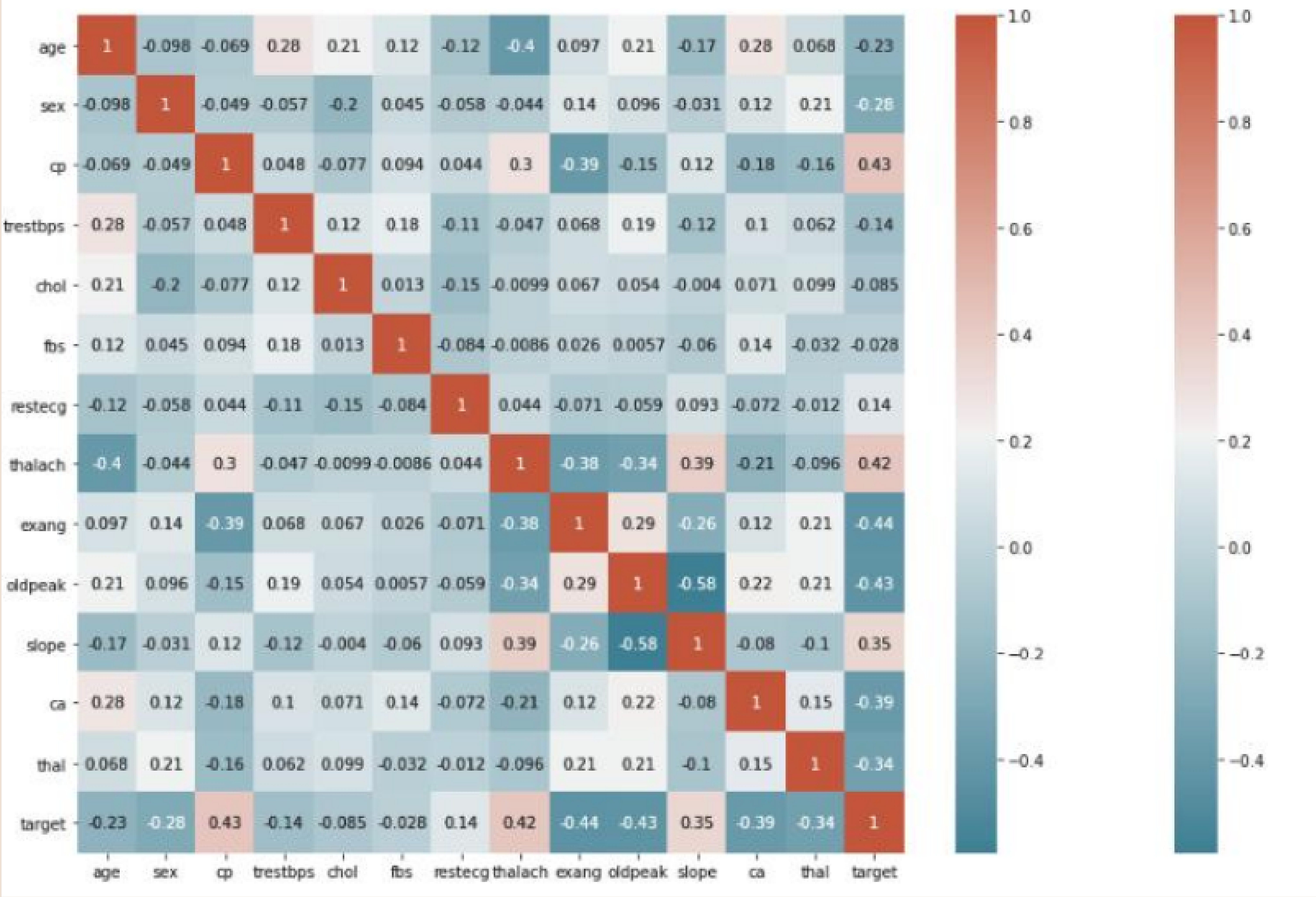
- The goal of Support Vector Machine (SVM) is to create the best line or decision boundary that can separate n-dimensional space into classes.
- The purpose of the decision boundary is to classify new data points into the correct category in the future.
- The decision boundary is called a hyperplane, and SVM selects extreme points/vectors that help in creating the hyperplane.
- The extreme cases are called support vectors, and hence the algorithm is named Support Vector Machine.
- SVM uses support vectors to classify data points into different categories.
- The diagram provided shows two different categories classified using a decision boundary or hyperplane.


X2
Maximum Margin
Positive Hyperplane
Maximum Margin Hyperplane
Support Vectors
Negative Hyperplane
X1

EXPLORATORY DATA ANALYSIS

Correlations

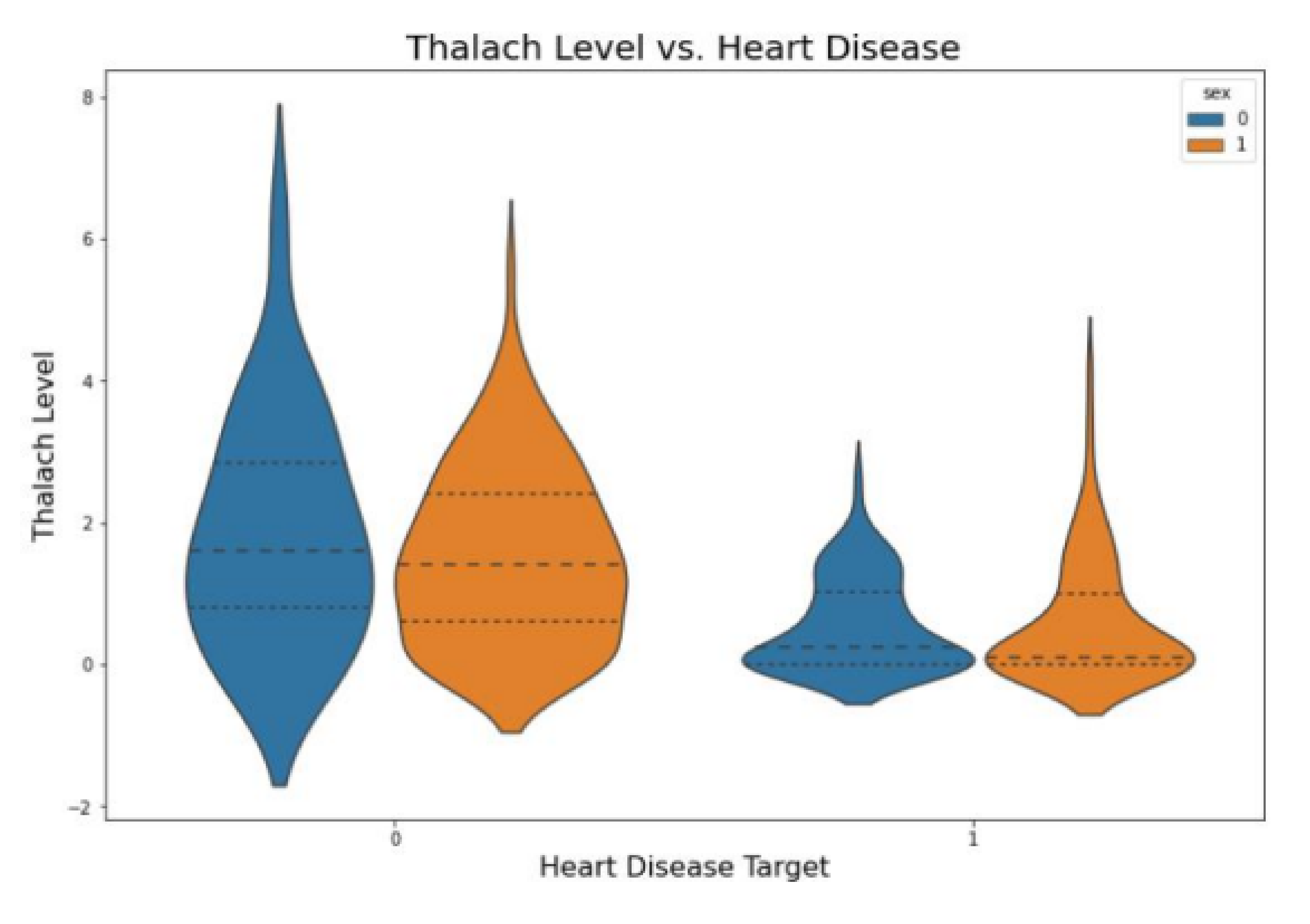
- A correlation matrix is a table that displays correlation coefficients for different variables, allowing for the identification and visualization of patterns in data.
- In the given dataset, there is a positive correlation between chest pain (cp) and the target variable, which makes sense since a greater amount of chest pain increases the chance of heart disease.
- There is a negative correlation between exercise-induced angina and the target variable, which also makes sense because narrowed arteries can slow down blood flow during exercise.
- Pair plots are another way to visualize correlations between variables, but in this case, only continuous features were used to avoid clutter.
- ST segment depression can contribute to heart disease, with low ST depression indicating greater risk.
- The "slope" hue in the plots refers to the peak exercise ST segment, with both positive and negative heart disease patients exhibiting similar distributions across the three slope categories.

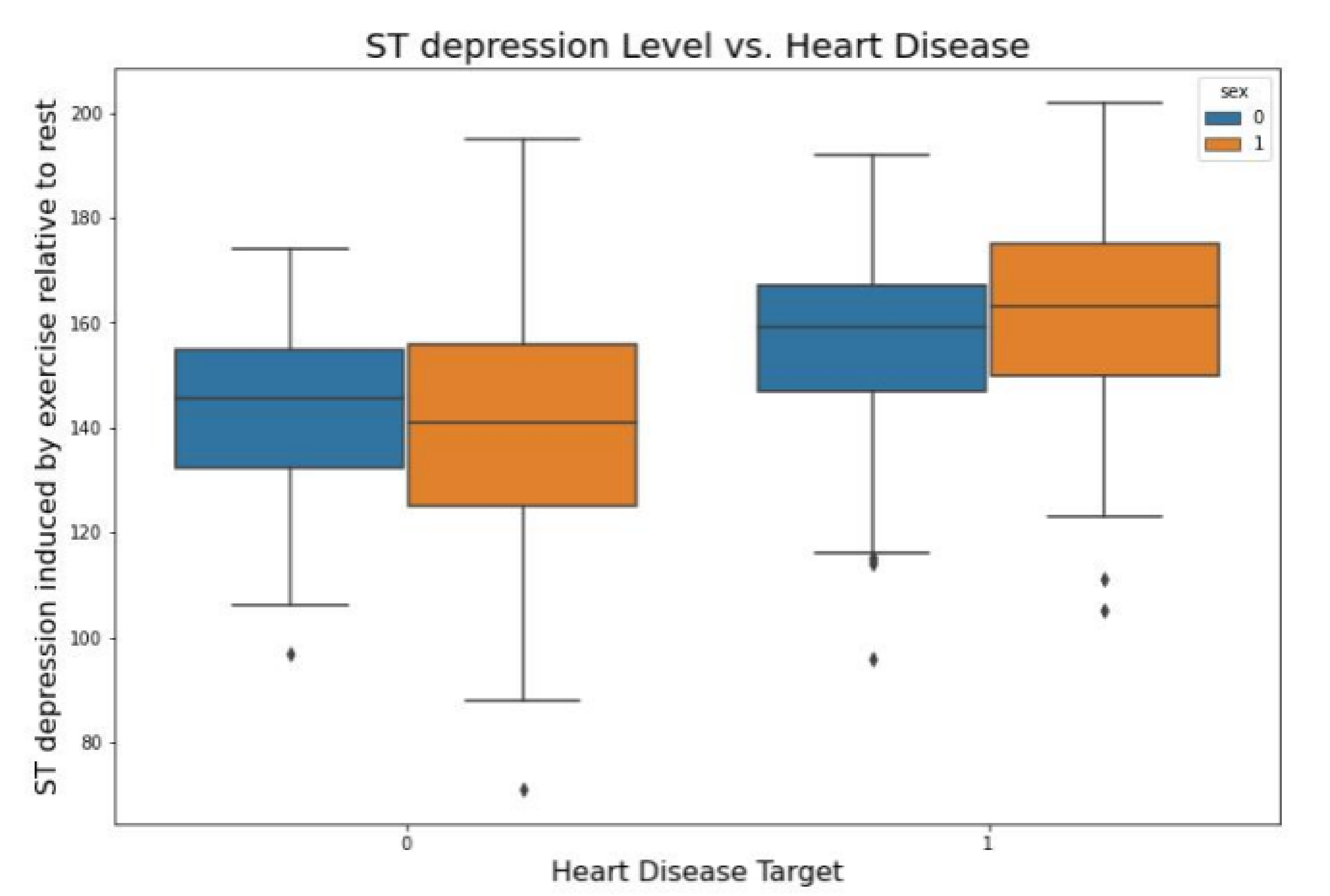

age 1 -0.098 -0.069 0.28 0.21 0.12 -0.12 -0.4 0.097 0.21 -0.17 0.28 0.068 -0.23
sex -0.098 1 -0.049 -0.057 -0.2 0.045 -0.058 -0.044 0.14 0.096 -0.031 0.12 0.21 -0.28
cp -0.069 -0.049 1 0.048 -0.077 0.094 0.044 0.3 -0.39 -0.15 0.12 -0.18 -0.16 0.43
trestbps 0.28 -0.057 0.048 1 0.12 0.18 -0.11 -0.047 0.068 0.19 -0.12 0.1 0.062 -0.14
chol 0.21 -0.2 -0.077 0.12 1 0.013 -0.15 -0.0099 0.067 0.054 -0.004 0.071 0.099 -0.085
fbs 0.12 0.045 0.094 0.18 0.013 1 -0.084 -0.0086 0.026 0.0057 -0.06 0.14 -0.032 -0.028
restecg -0.12 -0.058 0.044 -0.11 -0.15 -0.084 1 0.044 -0.071 -0.059 0.093 -0.072 -0.012 0.14
thalach -0.4 -0.044 0.3 -0.047 -0.0099 -0.0086 0.044 1 -0.38 -0.34 0.39 -0.21 -0.096 0.42
exang 0.097 0.14 -0.39 0.068 0.067 0.026 -0.071 -0.38 1 0.29 -0.26 0.12 0.21 -0.44
oldpeak 0.21 0.096 -0.15 0.19 0.054 0.0057 -0.059 -0.34 0.29 1 -0.58 0.22 0.21 -0.43
slope -0.17 -0.031 0.12 -0.12 -0.004 -0.06 0.093 0.39 -0.26 -0.58 1 -0.08 -0.1 0.35
ca 0.28 0.12 -0.18 0.1 0.071 0.14 -0.072 -0.21 0.12 0.22 -0.08 1 0.15 -0.39
thal 0.068 0.21 -0.16 0.062 0.099 -0.032 -0.012 -0.096 0.21 0.21 -0.1 0.15 1 -0.34
target -0.23 -0.28 0.43 -0.14 -0.085 -0.028 0.14 0.42 -0.44 -0.43 0.35 -0.39 -0.34 1
age sex cp trestbps chol fbs restecg thalach exang oldpeak slope ca thal target
1.0 0.8 0.6 0.4 0.2 0.0 −0.2 −0.4
1.0 0.8 0.6 0.4 0.2 0.0 −0.2 −0.4

EXPLORATORY DATA ANALYSIS

Violin and Box-plots

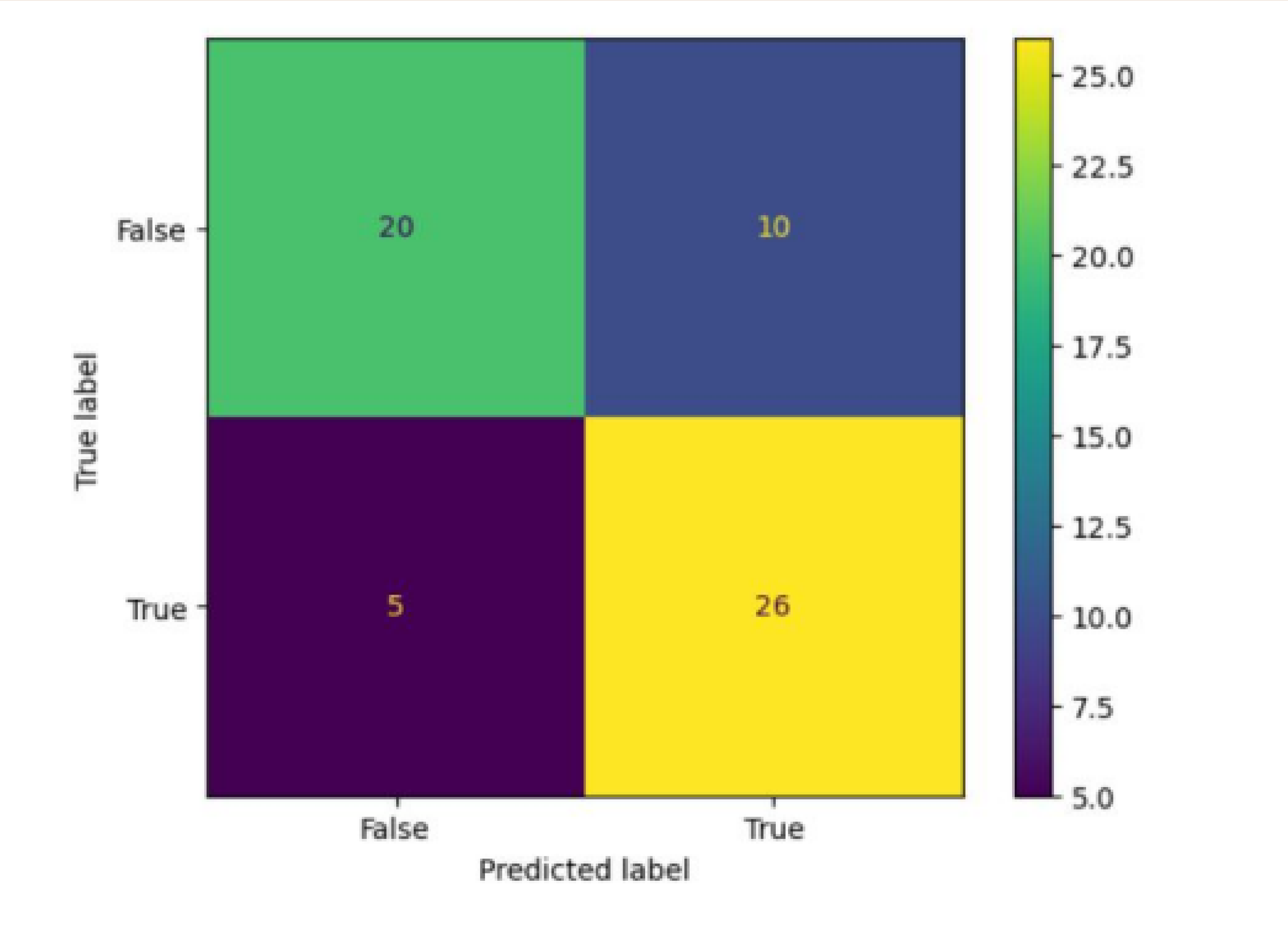
- Box and violin plots are useful for displaying the basic statistics and distribution of data, as well as identifying outliers.
- They can be used to compare the distribution of a variable across different categories.
- Positive and negative patients have different distributions of ST depression levels, with positive patients having a lower median and a greater concentration of data between 0 and 2, while negative patients have a median between 1 and 3.
- There are no major differences between male and female target outcomes, except that males have slightly larger ranges of ST depression.


Thalach Level vs. Heart Disease
sex
0
1
8
6
4
2
0
−2
Thalach Level
0
1
Heart Disease Target


ST depression Level vs. Heart Disease
sex
0
1
200
180
160
140
120
100
80
ST depression induced by exercise relative to rest
0
1
Heart Disease Target

Evaluation Metrics

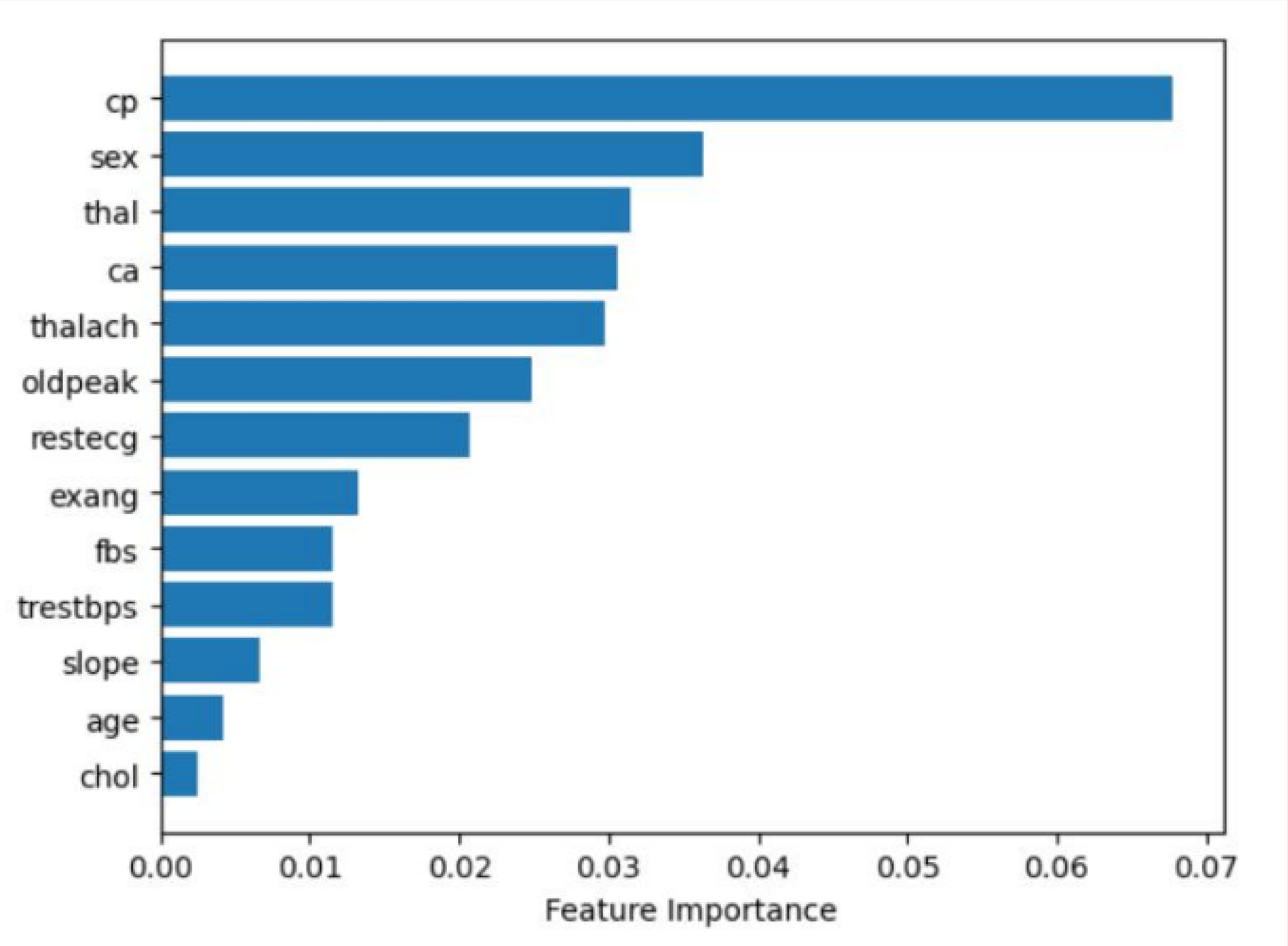
Confusion Matrix



Evaluation Metrics

Feature Importance

Feature Importance provides a score that indicates how helpful each feature was in our model. The higher the Feature Score, the more that feature is used to make key decisions & thus the more important it is



PREDICTIONS

Scenario:

- A patient develops cardiac symptoms & you input his vitals into the Machine Learning Algorithm.
- He is a 20 year old male, with a chest pain value of 2 (atypical angina), with resting blood pressure of 110.
- In addition he has a serum cholestoral of 230 mg/dl.
- He is fasting blood sugar > 120 mg/dl.
- He has a resting electrocardiographic result of 1.
- The patients maximum heart rate achieved is 140.
- Also, he was exercise induced angina.
- His ST depression induced by exercise relative to rest value was 2.2.
- The slope of the peak exercise ST segment is flat.
- He has no major vessels colored by fluoroscopy, and in addition his maximum heart rate achieved is a reversable defect.
- Based on this information, can you classify this patient with Heart Disease?

```
print(model3.predict(sc.transform([[20,1,2,110,230,1,1,140,1,2.2,2,0,2]])))
[1]
```

Yes! Our machine learning algorithm has classified this patient with Heart Disease. Now we can properly diagnose him, & get him the help he needs to recover. By diagnosing him early, we may prevent worse symptoms from arising later.

CONCLUSION

- The SVM algorithm has an accuracy of 75%, which is considered good but we need to be careful of over-fitting.
- Among the 13 features examined, the top 4 significant features that helped in classifying between positive and negative diagnosis were chest pain type (cp), gender (sex), maximum heart rate achieved (thal), and number of major vessels (ca).
- With the machine learning algorithm, we can now classify patients with heart disease and diagnose them properly. Early detection of these features may prevent worse symptoms from arising later.