# Heart Failure Analysis and Prediction

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# Business Background and Objectives

## Background

Cardiovascular diseases (CVDs) are the leading cause of death globally with taking an estimated 17.9 million lives each year. More than four out of five CVD deaths are due to heart attacks and one third of these deaths occur prematurely in people under 70 years of age. Heart failure is a common event caused by CVDs. Early detection and management wherein a machine learning model can be of great help.

## Objectives

- What factors affect heart failure?
- What is the best machine learning algorithm model to predict heart failure?

Image source: https://news.harvard.edu/gazette/story/2022/04/infertility-history-linked-with-increased-risk-of-heart-failure/

# Data Preparation and Feature Engineering

## Dataset Information

**918** rows

**11** features

| Numerical Feature | Categorical Feature |
|---|---|
| • Age | • Sex |
| • RestingBP | • ChestPainType |
| • Cholesterol | • RestingECG |
| • FastingBS | • ExerciseAngina |
| • MaxHR | • ST_Slope |
| • Oldpeak | |

**1** target

**Heart Disease**

Dataset source: kaagle.com

# Data Preparation and Feature Engineering

## Dataset Attribute Information

| Column name | Description |
|---|---|
| **Age** | Age of the patient [years] |
| **Sex** | Sex of the patient [M: Male, F: Female] |
| **ChestPainType** | Chest pain type [TA: Typical Angina, ATA: Atypical Angina, NAP: Non-Anginal Pain, ASY: Asymptomatic] |
| **RestingBP** | Resting blood pressure [mm Hg] |
| **Cholesterol** | Serum cholesterol [mm/dl] |
| **FastingBS** | Fasting blood sugar [1: if FastingBS > 120 mg/dl, 0: otherwise] |
| **RestingECG** | Resting electrocardiogram results [Normal: Normal, ST: having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV), LVH: showing probable or definite left ventricular hypertrophy by Estes' criteria] |
| **MaxHR** | Maximum heart rate achieved [Numeric value between 60 and 202] |
| **ExerciseAngina** | Exercise-induced angina [Y: Yes, N: No] |
| **Oldpeak** | ST [Numeric value measured in depression] |
| **ST_Slope** | The slope of the peak exercise ST segment [Up: upsloping, Flat: flat, Down: downsloping] |
| **HeartDisease** | Output class [1: heart disease, 0: Normal] |

# Data Preparation and Feature Engineering

## General Info

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 918 entries, 0 to 917
Data columns (total 12 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   Age             918 non-null    int64
 1   Sex             918 non-null    object
 2   ChestPainType   918 non-null    object
 3   RestingBP       918 non-null    int64
 4   Cholesterol     918 non-null    int64
 5   FastingBS       918 non-null    int64
 6   RestingECG      918 non-null    object
 7   MaxHR           918 non-null    int64
 8   ExerciseAngina  918 non-null    object
 9   Oldpeak         918 non-null    float64
 10  ST_Slope        918 non-null    object
 11  HeartDisease    918 non-null    int64
dtypes: float64(1), int64(6), object(5)
memory usage: 86.2+ KB
```

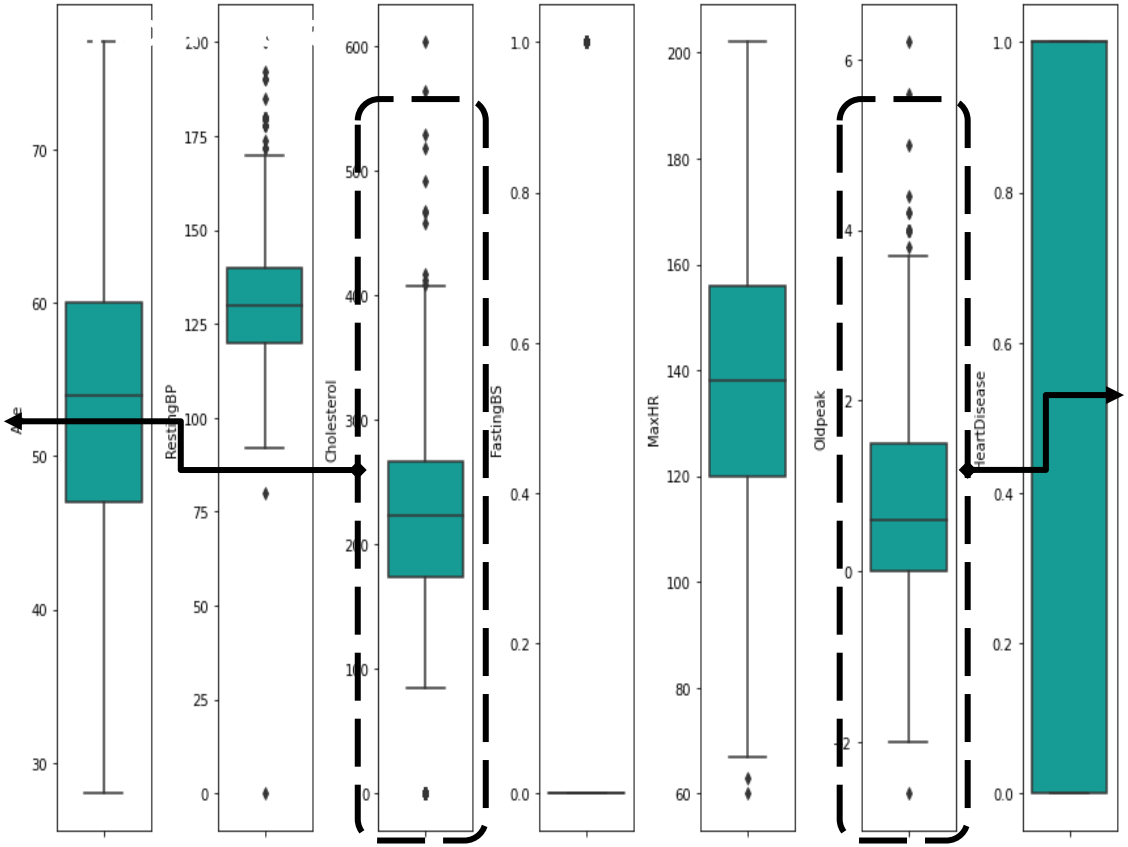
```
In [8]: data.duplicated().sum()

Out[8]: 0
```

**Result**

- **No Missing Value**
- **No Duplicated Value**

# Data Preparation and Feature Engineering

Outliers
Cholesterol
19,93%
Trim data



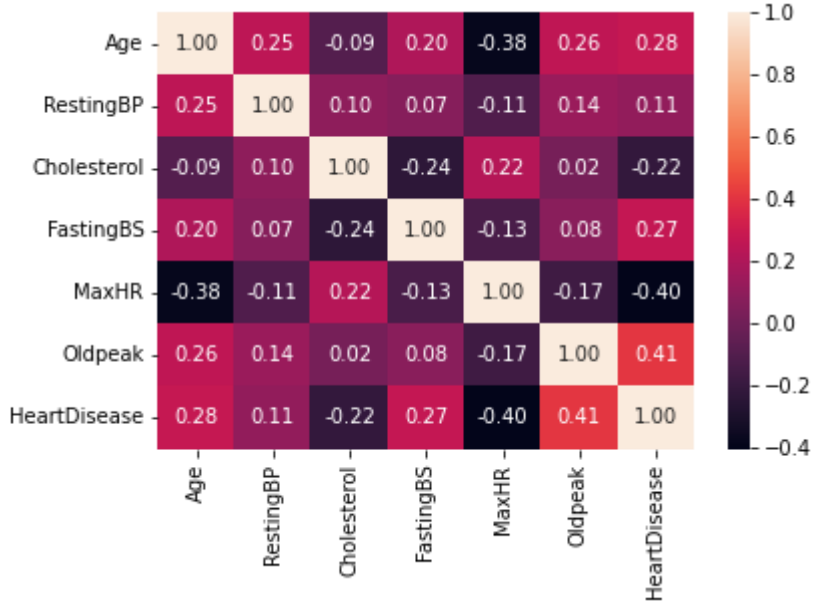

Outliers
Oldpeak
1,74%
Drop data

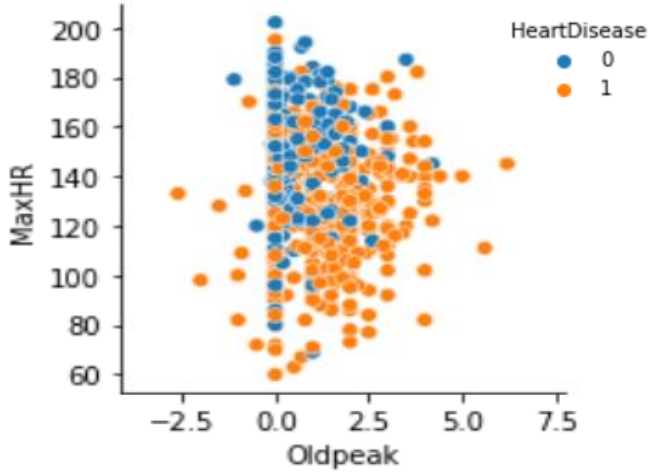
**After filtering row becomes 902 before 918**

# Data Preparation and Feature Engineering

## Exploratory Data Analysis (EDA) Insights

Numerical Data



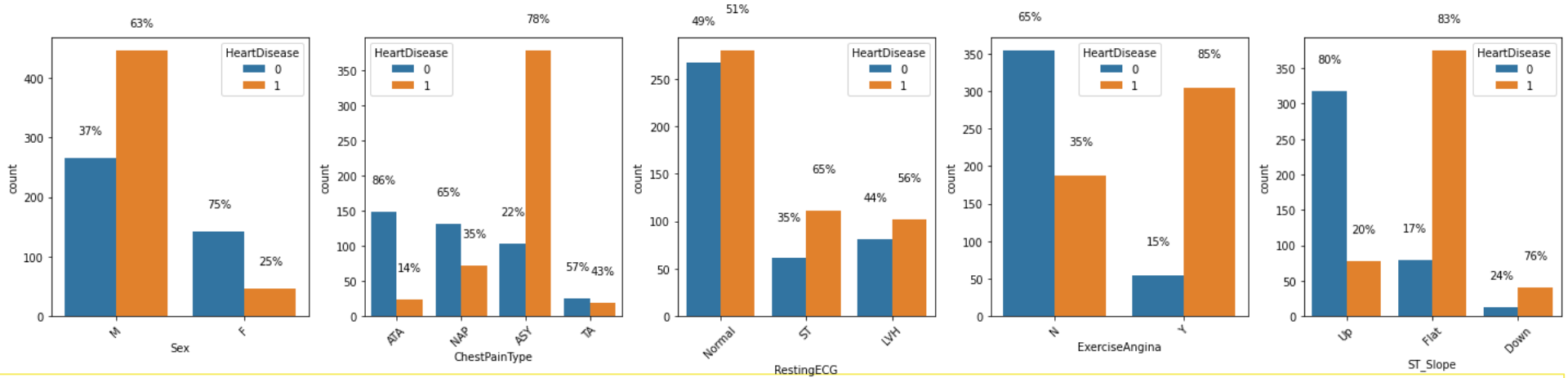




- There is no redundant feature(s)
- Oldpeak has highest correlation to heart disease (41%)
- Meanwhile MaxHR has high correlation to heart disease, but in negative way (-40%)
- The higher Oldpeak and the lower MaxHR tend have heart disease and heart failure

# Data Preparation and Feature Engineering

## Exploratory Data Analysis (EDA) Insights

Categorical Data




- The highest category that risky have heart disease:
  - Sex : Male
  - ChestPainType : ASY (Asymptomatic)
  - RestingECG : Normal
  - ExcerciseAngina : Yes
  - ST_Slope : Flat
- Those condition needs to be proven by further check other aspects (ex. Lifestyle)

# Data Preparation and Feature Engineering

## Feature Engineering

## Label Encoding

| | | |
|---|---|---|
| Sex | M | F |
| ExerciseAngina | N | Y |

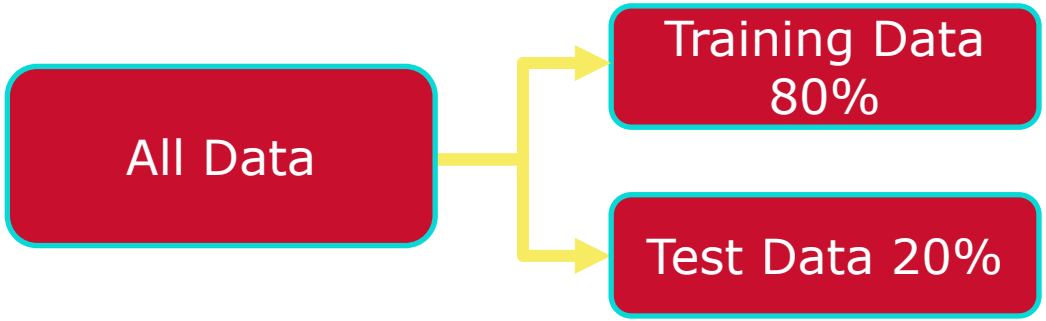
| | | |
|---|---|---|
| Sex | 0 | 1 |
| ExerciseAngina | 0 | 1 |

## One Hot Encoding

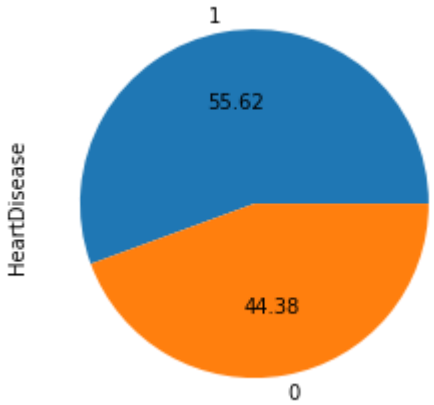
| | | | | |
|---|---|---|---|---|
| ChestPainType | ChestPainType_ASY | FChestPainType_ATA | ChestPainType_NAP | ChestPainType_TA |
| RestingECG | RestingECG_LVH | RestingECG_Normal | RestingECG_ST | |
| ST_Slope | ST_Slope_Down | ST_Slope_Flat | ST_Slope_Up | |

# Modelling and Evaluation

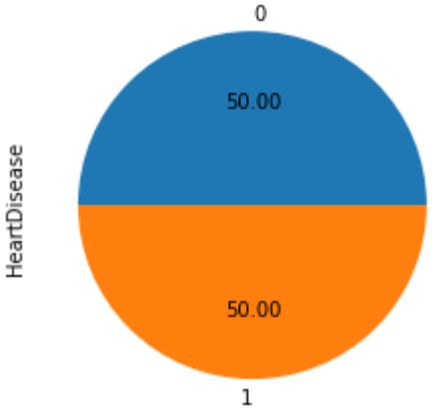
## Data Split




## Imbalance Data Training




**Oversampling Use SMOTE**



# Modelling and Evaluation

## Model Training with Hyper Parameter Tuning and Evaluation

### Logistic Regression

```
logreg = LogisticRegression(random_state=42)
```

```
# Hyperparameter Tuning
parameters = {
    'penalty': ('l2','none'),
    'C': (1,2,5),
    'fit_intercept': [0],
    'solver': ('newton-cg', 'sag', 'lbfgs'),
    'max_iter': (2,9)
}

# note: I use recall
logreg_gridcv = GridSearchCV(logreg, parameters, cv=5, scoring='recall')
logreg_gridcv.fit(x_train, y_train)
```

| | |
|---|---|
| Recall | 91% |
| F-1 Score | 85% |
| Precision | 88% |

### Random Forest

```
RF = RandomForestClassifier(random_state=42)
```

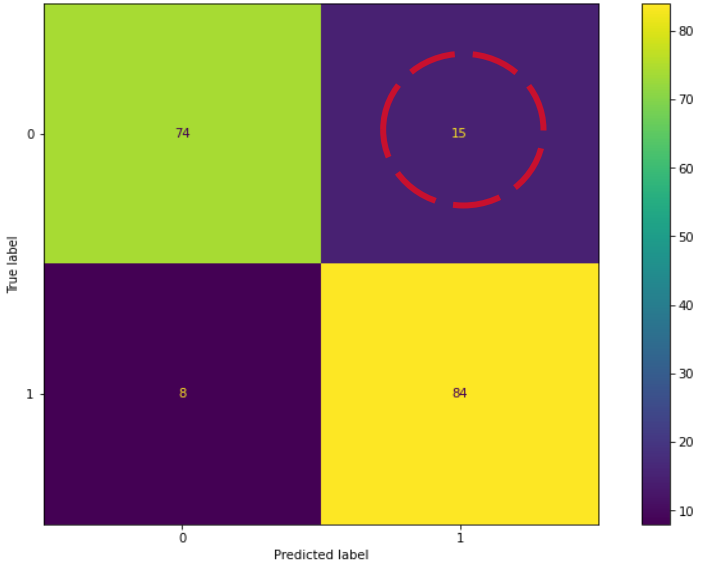
```
# Hyperparameter Tuning
parameters = {
    'max_depth': (1,3,5,7),
    'min_samples_split':(2, 5, 10),
    'min_samples_leaf': (1, 2, 4)
}

# note: I use recall
RF_gridcv = GridSearchCV(RF, parameters, cv=5, scoring='recall')
RF_gridcv.fit(x_train, y_train)
```

| | |
|---|---|
| Recall | 93% |
| F-1 Score | 80% |
| Precision | 86% |

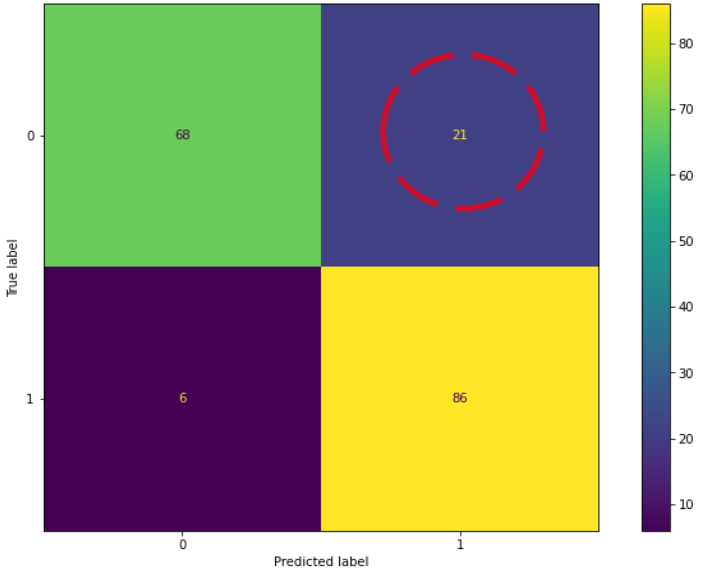
# Modelling and Evaluation

## The Best Algorithm

### Logistic Regression




### Random Forest

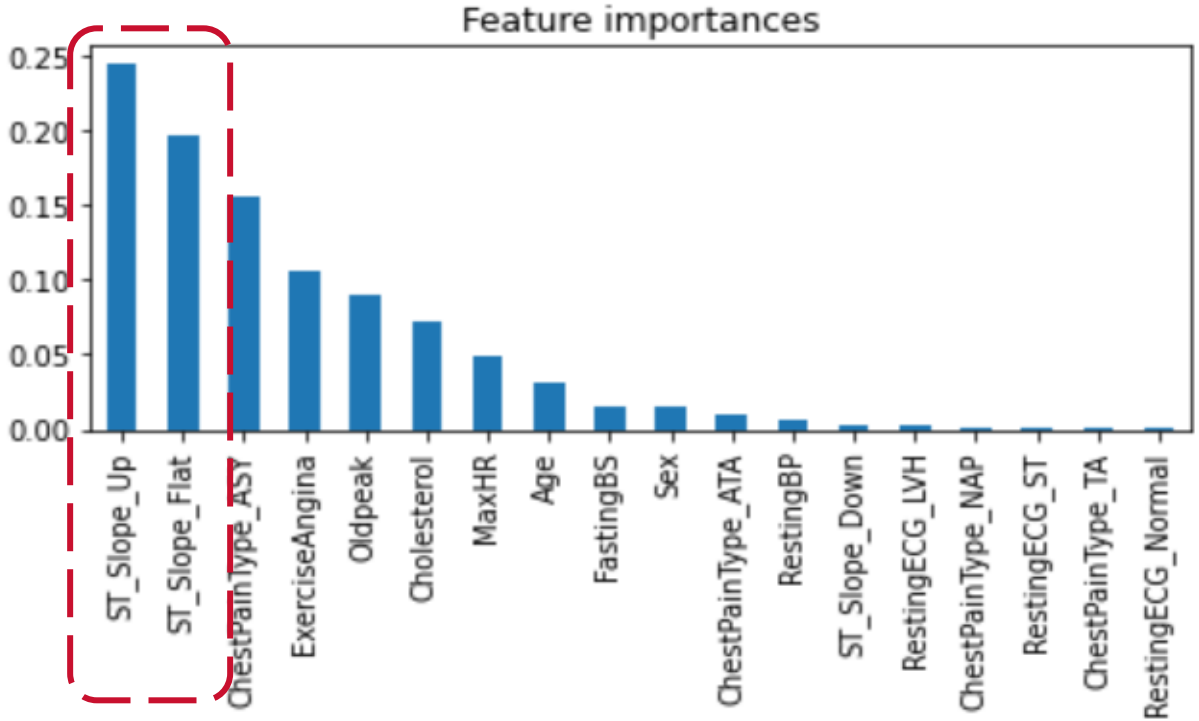



**False positive in these confusion metric:**
**Model predicts people have heart disease, but they don't**

Logistic Regression is suitable algorithm to predict the tendetion of heart failure

# Modelling and Evaluation

## Feature Importance




**The slope of the peak exercise ST segment become the highest factor that cause heart failure**

# Conclusion and Recommendation

- All features in the dataset are used to analysing (no redundant features)
- Individual ST_Slope become the highest factor that can cause heart failure.
- Best algorithm to use is logistic regression

Adding more features about lifestyle. Example:

- Smoker status
- Daily food


# THANK YOU

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