```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn import metrics


df = pd.read_csv("./heart.csv")


df.mean()
# df
```

```
age          54.434146
sex           0.695610
cp            0.942439
trestbps    131.611707
chol        246.000000
fbs           0.149268
restecg       0.529756
thalach     149.114146
exang         0.336585
oldpeak       1.071512
slope         1.385366
ca            0.754146
thal          2.323902
target        0.513171
dtype: float64
```

```
df.nunique()
```

```
age          41
sex           2
cp            4
trestbps     49
chol        152
fbs           2
restecg       3
thalach      91
exang         2
oldpeak      40
slope         3
ca            5
thal          4
target        2
dtype: int64
```

```
# df.isna().sum()
print(df.duplicated().sum())
df=df.drop_duplicates()
print(df.duplicated().sum())
```

```
723
0
```

```
df.corr()
```

| | age | sex | cp | trestbps | chol | fbs | restecg | th |
|---|---|---|---|---|---|---|---|---|
| **age** | 1.000000 | -0.094962 | -0.063107 | 0.283121 | 0.207216 | 0.119492 | -0.111590 | -0.3 |
| **sex** | -0.094962 | 1.000000 | -0.051740 | -0.057647 | -0.195571 | 0.046022 | -0.060351 | -0.0 |
| **cp** | -0.063107 | -0.051740 | 1.000000 | 0.046486 | -0.072682 | 0.096018 | 0.041561 | 0.2 |
| **trestbps** | 0.283121 | -0.057647 | 0.046486 | 1.000000 | 0.125256 | 0.178125 | -0.115367 | -0.0 |
| **chol** | 0.207216 | -0.195571 | -0.072682 | 0.125256 | 1.000000 | 0.011428 | -0.147602 | -0.0 |
| **fbs** | 0.119492 | 0.046022 | 0.096018 | 0.178125 | 0.011428 | 1.000000 | -0.083081 | -0.0 |
| **restecg** | -0.111590 | -0.060351 | 0.041561 | -0.115367 | -0.147602 | -0.083081 | 1.000000 | 0.0 |
| **thalach** | -0.395235 | -0.046439 | 0.293367 | -0.048023 | -0.005308 | -0.007169 | 0.041210 | 1.0 |
| **exang** | 0.093216 | 0.143460 | -0.392937 | 0.068526 | 0.064099 | 0.024729 | -0.068807 | -0.3 |
| **oldpeak** | 0.206040 | 0.098322 | -0.146692 | 0.194600 | 0.050086 | 0.004514 | -0.056251 | -0.3 |
| **slope** | -0.164124 | -0.032990 | 0.116854 | -0.122873 | 0.000417 | -0.058654 | 0.090402 | 0.3 |
| **ca** | 0.302261 | 0.113060 | -0.195356 | 0.099248 | 0.086878 | 0.144935 | -0.083112 | -0.2 |
| **thal** | 0.065317 | 0.211452 | -0.160370 | 0.062870 | 0.096810 | -0.032752 | -0.010473 | -0.0 |
| **target** | -0.221476 | -0.283609 | 0.432080 | -0.146269 | -0.081437 | -0.026826 | 0.134874 | 0.4 |

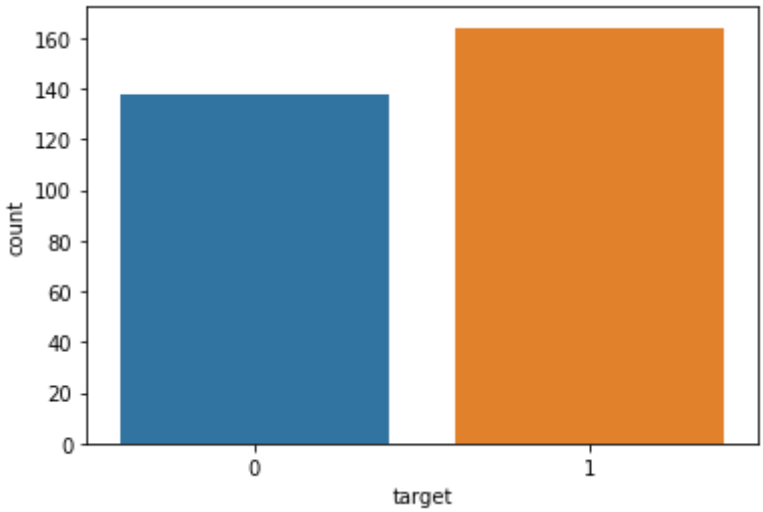
```
# columns_to_standerdize=["age","trestbps","chol","thalach","oldpeak"]
# for column in columns_to_standerdize:
    # df[column] = (df.loc[column]-df[column].mean()) / df[column].std()
# df=(df-df.mean())/df.std()
for i in df.columns:
    if(i!='target'):
        df[i]=(df[i]-df[i].mean())/df[i].std()


df.head()
```

# Data Analysis

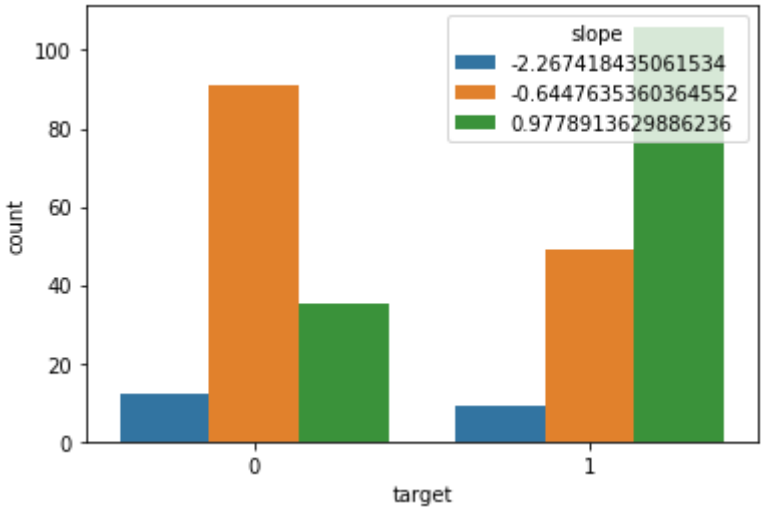
```
sns.countplot(x="target",data=df)
# more people have heart disease
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f1ee934bcd0>
```



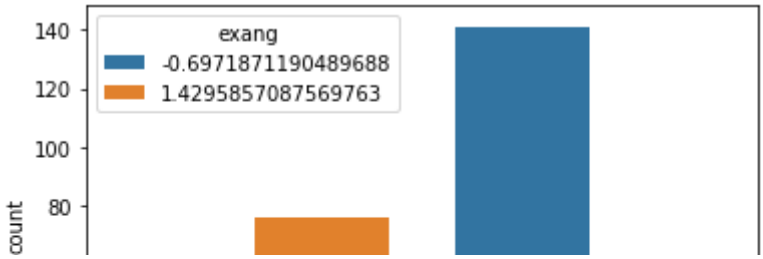

```
sns.countplot(x="target",hue="slope",data=df)
#slope=2 are more likely to have a heart disease
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f1ee92e3e50>
```



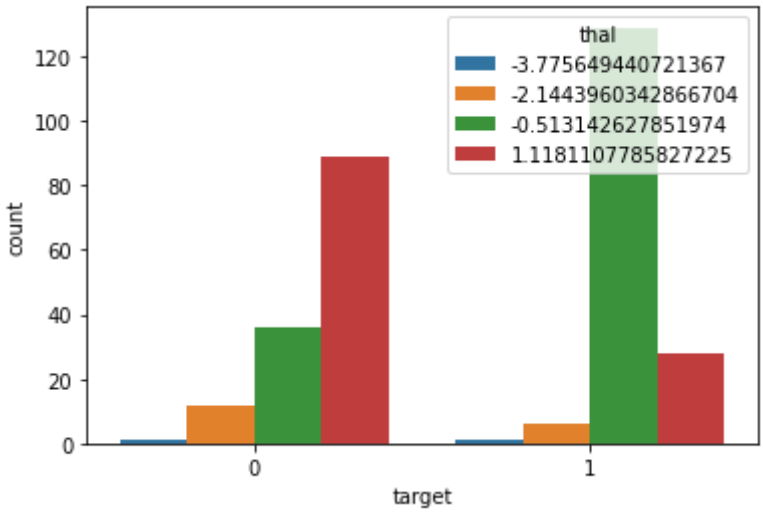

```
sns.countplot(x="target",hue="exang",data=df)
#exang=0 are more likely to have a heart disease
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f1ee8dba310>
```



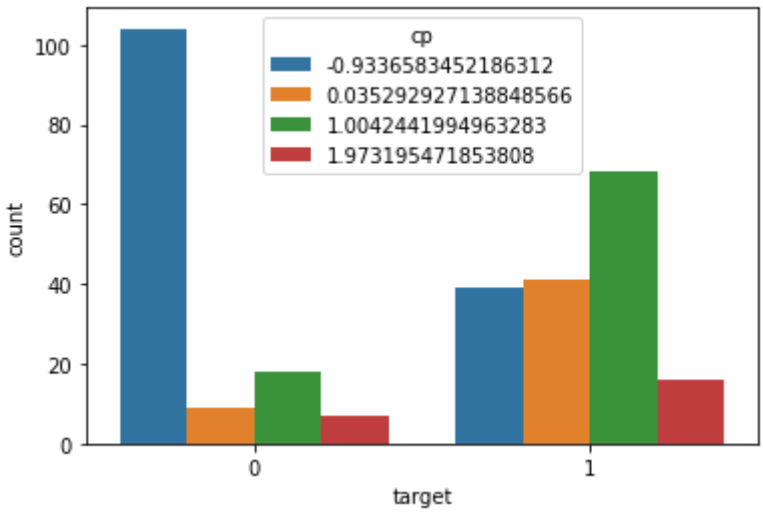

```
sns.countplot(x="target",hue="thal",data=df)
#thal=2 are more likely to have a heart disease
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f1ee8d5eb50>
```




```
sns.countplot(x="target",hue="cp",data=df)
#cp=2 are more likely to have a heart disease
#cp=0 are more likely to not have a heart disease
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f1ee8ccedd0>
```




## Spliting the data for Testing and Training

```
def split_data(X,Y):
    np.random.seed(0)
```

```
    mask = np.random.rand(X.shape[0])<=0.80
    X_train = X[mask]
    X_test =  X[~mask]
    Y_train = Y[mask]
    Y_test = Y[~mask]

    return X_train,X_test,Y_train,Y_test
```

# Logistic Regression

```
def sigmoid(x):
    return 1/(1 + np.exp(-x))

def find_accuracy(Ypred,Y):
    train_accuracy=0
    for i in range(len(Ypred)):
        if(Ypred[i]==Y[i]):
            train_accuracy+=1
    train_accuracy/=len(Ypred)
    return train_accuracy

def f1_score(Ypred,Y):
    tp=0
    fn=0
    fp=0
    for i in range(len(Ypred)):
        if(Ypred[i]==Y[i]):
            if(Ypred[i]==1): tp+=1
        else:
            if(Ypred[i]==1 and Y[i]==0): fp+=1
            if(Ypred[i]==0 and Y[i]==1): fn+=1
    recall=tp/(tp+fn)
    pression=tp/(tp+fp)
    f1=(2*recall*pression)/(recall+pression)
    return f1
```

## *Univariate*

```
X=np.ones((df.shape[0],2))
X[:,1]=df.loc[:,'cp']
Y=df.loc[:,'target']

X_train,X_test,Y_train,Y_test=split_data(X,Y)
Y_train.reset_index(drop=True,inplace=True)
Y_test.reset_index(drop=True,inplace=True)


learning_rate=0.005
```

```
itrns=1350
W=np.ones((X_train.shape[1]))
cost=[]
iterations=[]
for i in range(itrns):
    W=W-(learning_rate/X_train.shape[0])*(X_train.T@(sigmoid(X_train@W)-Y_train))
    # Ypred_train=np.array(sigmoid(X_train@W))
#     a=np.dot(Y_train.T,np.log(Ypred_train))
#     b=np.dot((1-Y_train).T,np.log(1-Ypred_train))
#     cost_value = np.sum(a+b) /(len(Ypred_train))
#     iterations.append(i+1)
#     cost.append(cost_value)
# iterations.reverse()
# plt.scatter(iterations,cost)
# plt.show()
Ypred_test=np.array(sigmoid(X_test@W))
for i in range(len(Ypred_test)):
    if(Ypred_test[i]>=0.5):
        Ypred_test[i]=1
    else:
        Ypred_test[i]=0

test_accuracy=find_accuracy(Ypred_test,Y_train)
test_f1score=f1_score(Ypred_test,Y_train)
print("F1 score of Testing data: ", test_f1score)
print("Accuracy of Testing data: ", test_accuracy)
```

```
F1 score of Testing data:  0.4482758620689655
Accuracy of Testing data:  0.4666666666666667
```

## *Multivariate*

```
X=df.iloc[:,:]
X=X.drop(["target"],axis=1)
X["constant"]=1

Y=df.loc[:,'target']

X_train,X_test,Y_train,Y_test=split_data(X,Y)
Y_train.reset_index(drop=True,inplace=True)
Y_test.reset_index(drop=True,inplace=True)
X_test.reset_index(drop=True,inplace=True)
X_train.reset_index(drop=True,inplace=True)


learning_rate=0.005
itrns=1350
W=np.ones((X_train.shape[1]))
cost=[]
iterations=[]
```

```
for i in range(itrns):
    W=W-(learning_rate/X_train.shape[0])*(X_train.T@(sigmoid(X_train@W)-Y_train))
#     Ypred_train=np.array(sigmoid(X_train@W))
#     a=np.dot(Y_train.T,np.log(Ypred_train))
#     b=np.dot((1-Y_train).T,np.log(1-Ypred_train))
#     cost_value = np.sum(a+b) /(len(Ypred_train))
#     iterations.append(i+1)
#     cost.append(cost_value)
# iterations.reverse()
# plt.scatter(iterations,cost)
# plt.show()
Ypred_test=np.array(sigmoid(X_test@W))
for i in range(len(Ypred_test)):
    if(Ypred_test[i]>=0.5):
        Ypred_test[i]=1
    else:
        Ypred_test[i]=0

test_accuracy=find_accuracy(Ypred_test,Y_train)
test_f1score=f1_score(Ypred_test,Y_train)
print("F1 score of Testing data: ", test_f1score)
print("Accuracy of Testing data: ", test_accuracy)
```

```
F1 score of Testing data:  0.5806451612903226
Accuracy of Testing data:  0.5666666666666667
```

## Sklearn Implementation(Logistic regression)

```
from sklearn.linear_model import LogisticRegression
model = LogisticRegression(solver='lbfgs', max_iter=1350)
model.fit(X_train,Y_train)
```

```
LogisticRegression(max_iter=1350)
```

```
print('Accuracy of Testing data: ',metrics.accuracy_score(Y_test, model.predict(X_test)))
print('F1 Score of Testing data: ',metrics.f1_score(Y_test, model.predict(X_test)))
```

```
Accuracy of Testing data:  0.8833333333333333
F1 Score of Testing data:  0.904109589041096
```

# Naive Bayes

```
def likelihood(x, mu, sigma):
    return 1/((sigma * np.sqrt(2 * np.pi)) * (np.exp( - (x - mu)**2 / (2 * sigma**2))))
```

## *Univariate*

```
X=df.loc[:,['cp','target']]
Y=df.loc[:,'target']

X_train,X_test,Y_train,Y_test=split_data(X,Y)
Y_train.reset_index(drop=True,inplace=True)
Y_test.reset_index(drop=True,inplace=True)
X_train.reset_index(drop=True,inplace=True)
X_test.reset_index(drop=True,inplace=True)

Disease=X_train.loc[X_train.loc[:,'target']==1]
noDisease=X_train.loc[X_train.loc[:,'target']==0]
Disease=Disease.loc[:,'cp']
noDisease=noDisease.loc[:,'cp']
X_test=X_test.loc[:,'cp']

mu_Disease=Disease.mean()
sigma_Disease=Disease.std()
mu_noDisease=noDisease.mean()
sigma_noDisease=noDisease.std()

a=Y.value_counts()
prob_Disease=a[1]/(a[1]+a[0])
prob_noDisease=a[0]/(a[1]+a[0])

Ypred_test=np.zeros((Y_test.shape[0],1))

for i in range(len(X_test)):
    likelihood_Disease=likelihood(X_test[i],mu_Disease,sigma_Disease)
    probD=likelihood_Disease*prob_Disease
    likelihood_noDisease=likelihood(X_test[i],mu_noDisease,sigma_noDisease)
    probNoD=likelihood_noDisease*prob_noDisease
    if(probD>=probNoD):
        Ypred_test[i]=1
    else:
        Ypred_test[i]=0

test_accuracy=find_accuracy(Ypred_test,Y_train)
test_f1score=f1_score(Ypred_test,Y_train)
print("F1 score of Testing data: ", test_f1score)
print("Accuracy of Testing data: ", test_accuracy)
```

```
F1 score of Testing data:  0.4814814814814815
Accuracy of Testing data:  0.5333333333333333
```

## *Multivariate*

```
X=df.loc[:,:]
Y=df.loc[:,'target']
```

```
X_train,X_test,Y_train,Y_test=split_data(X,Y)
Y_train.reset_index(drop=True,inplace=True)
Y_test.reset_index(drop=True,inplace=True)
X_train.reset_index(drop=True,inplace=True)
X_test.reset_index(drop=True,inplace=True)

Disease=X_train.loc[X_train.loc[:,'target']==1]
noDisease=X_train.loc[X_train.loc[:,'target']==0]
Disease=Disease.drop(['target'],axis=1)
noDisease=noDisease.drop(['target'],axis=1)
X_test=X_test.drop(['target'],axis=1)

a=Y_test.value_counts()
prob_Disease=a[1]/(a[1]+a[0])
prob_noDisease=a[0]/(a[1]+a[0])

Ypred_test=np.ones((Y_test.shape[0],1))
X_test=X_test.to_numpy()
for i in range(len(X_test)):
    for j in range(X_test.shape[1]):
        likelihood_Disease*=likelihood(X_test[i][j],Disease.mean()[j],Disease.std()[j])
        likelihood_noDisease*=likelihood(X_test[i][j],noDisease.mean()[j],noDisease.std()[
    probD=likelihood_Disease*prob_Disease
    probNoD=likelihood_noDisease*prob_noDisease
    if(probD>=probNoD):
        Ypred_test[i]=1
    else:
        Ypred_test[i]=0

test_accuracy=find_accuracy(Ypred_test,Y_train)
test_f1score=f1_score(Ypred_test,Y_train)
print("F1 score of Testing data: ", test_f1score)
print("Accuracy of Testing data: ", test_accuracy)
```

```
 F1 score of Testing data:  0.6046511627906976
 Accuracy of Testing data:  0.43333333333333335
```

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