The Hong Kong Polytechnic University
Department of Computing

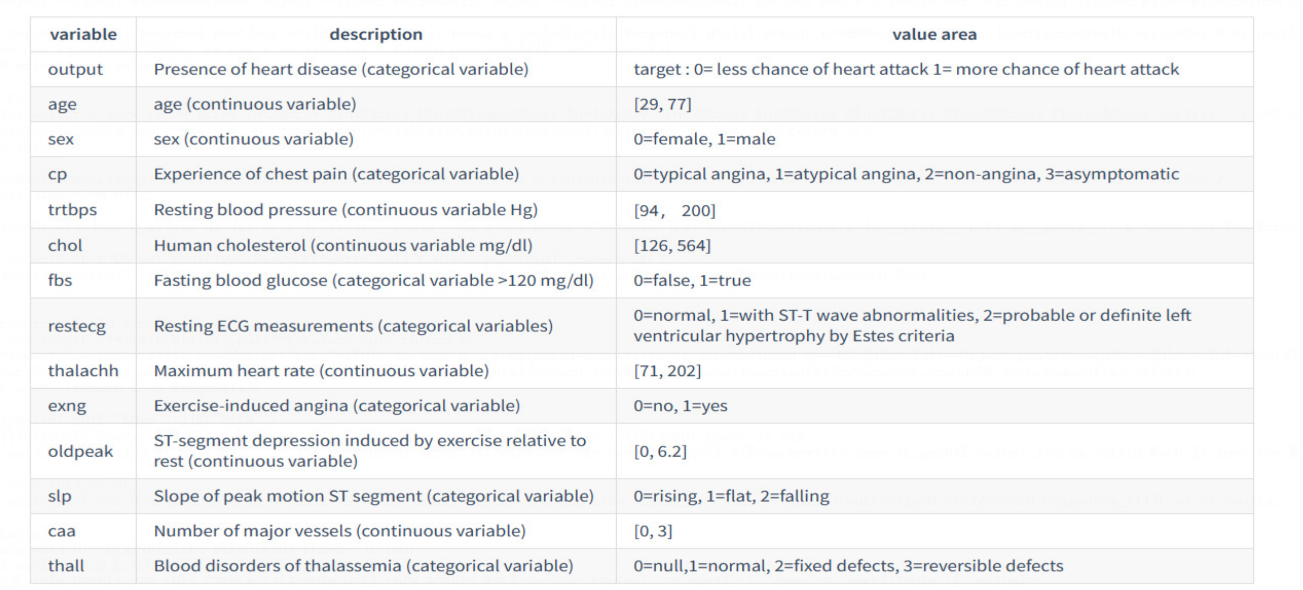
Student :		**ID :**	
Course :	COMP4433 – Data Mining and Data ware housing	**Date :**	12/18/2023
Subject :	Individual project - Heart Attack Analysis and Prediction		
Remarks :			
Grade :			

Individual Project

Table of Contents

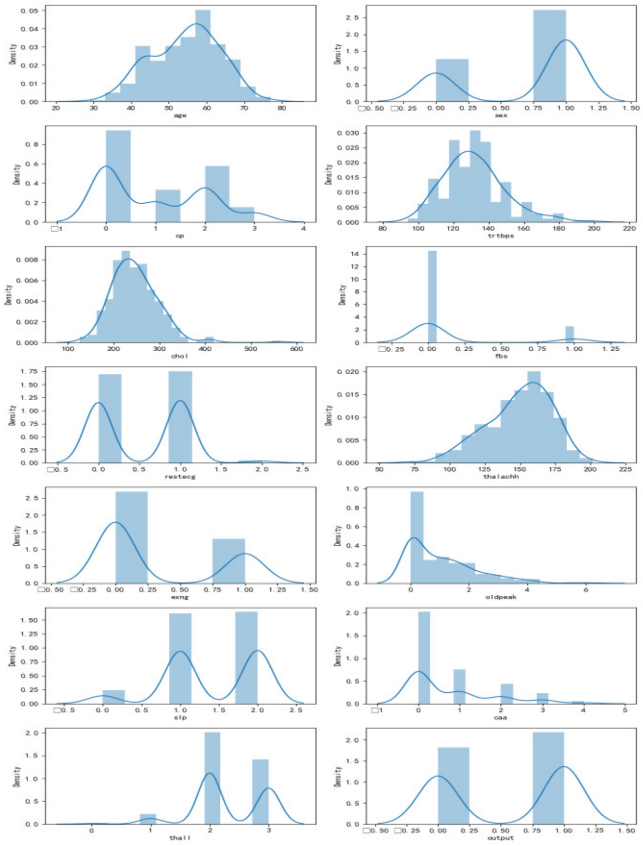
1 Dataset exploration

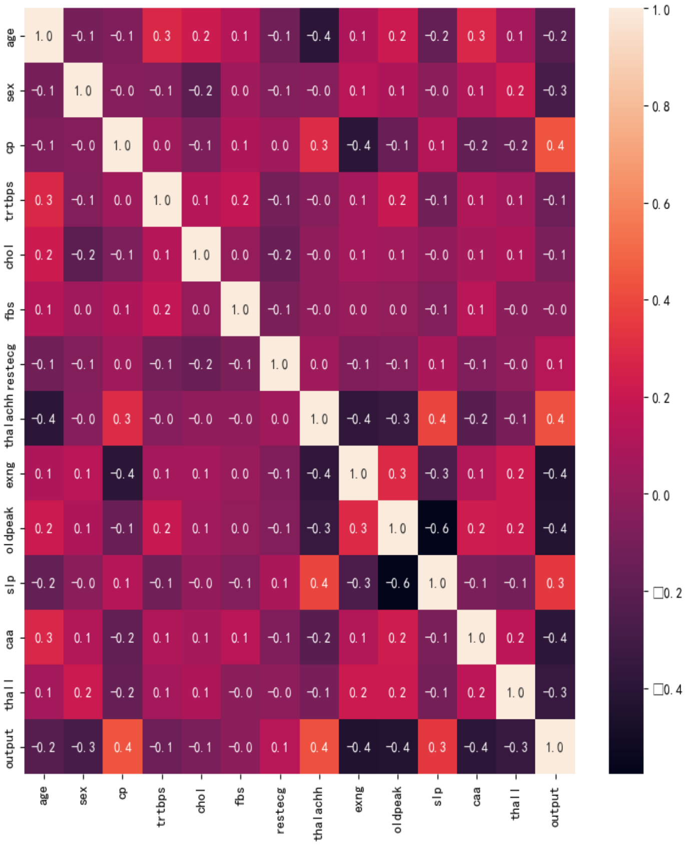
Data introduction: This data comes from kaggle, contains 14 dimensions, 303 samples, the specific variables are described in the following table.

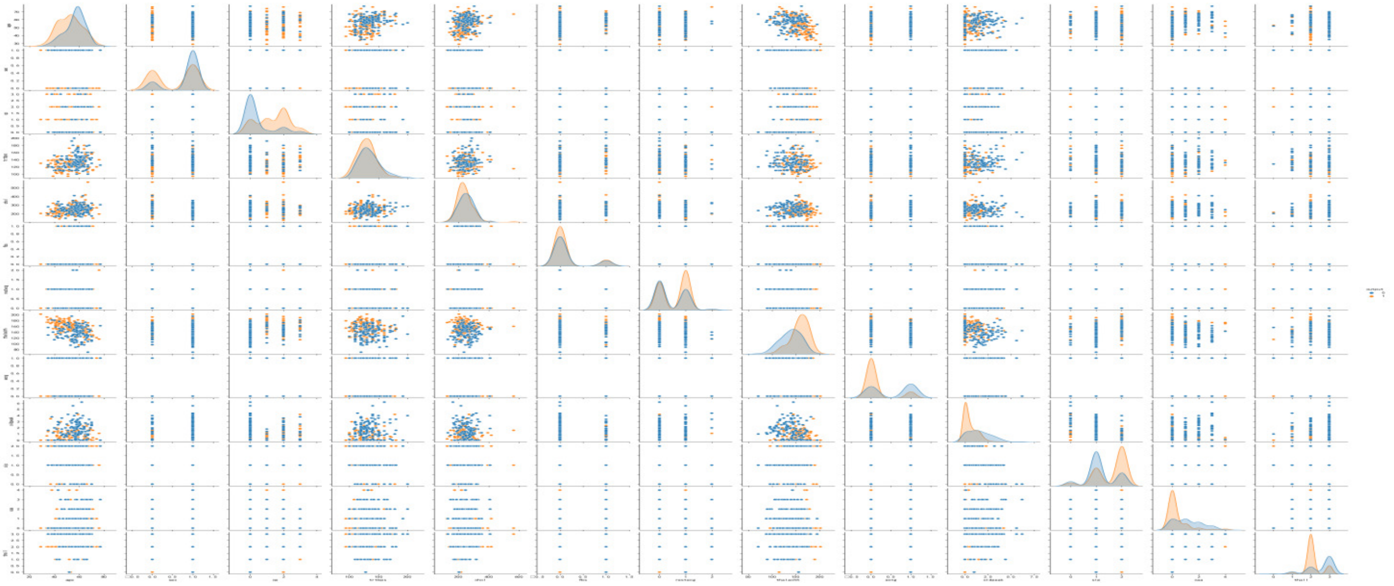


variable	description	value area
output	Presence of heart disease (categorical variable)	target : 0= less chance of heart attack 1= more chance of heart attack
age	age (continuous variable)	[29, 77]
sex	sex (continuous variable)	0=female, 1=male
cp	Experience of chest pain (categorical variable)	0=typical angina, 1=atypical angina, 2=non-angina, 3=asymptomatic
trtbps	Resting blood pressure (continuous variable Hg)	[94， 200]
chol	Human cholesterol (continuous variable mg/dl)	[126, 564]
fbs	Fasting blood glucose (categorical variable >120 mg/dl)	0=false, 1=true
restecg	Resting ECG measurements (categorical variables)	0=normal, 1=with ST-T wave abnormalities, 2=probable or definite left ventricular hypertrophy by Estes criteria
thalachh	Maximum heart rate (continuous variable)	[71, 202]
exng	Exercise-induced angina (categorical variable)	0=no, 1=yes
oldpeak	ST-segment depression induced by exercise relative to rest (continuous variable)	[0, 6.2]
slp	Slope of peak motion ST segment (categorical variable)	0=rising, 1=flat, 2=falling
caa	Number of major vessels (continuous variable)	[0, 3]
thall	Blood disorders of thalassemia (categorical variable)	0=null,1=normal, 2=fixed defects, 3=reversible defects

Distribution of features, feature correlation heatmap and feature pairplot

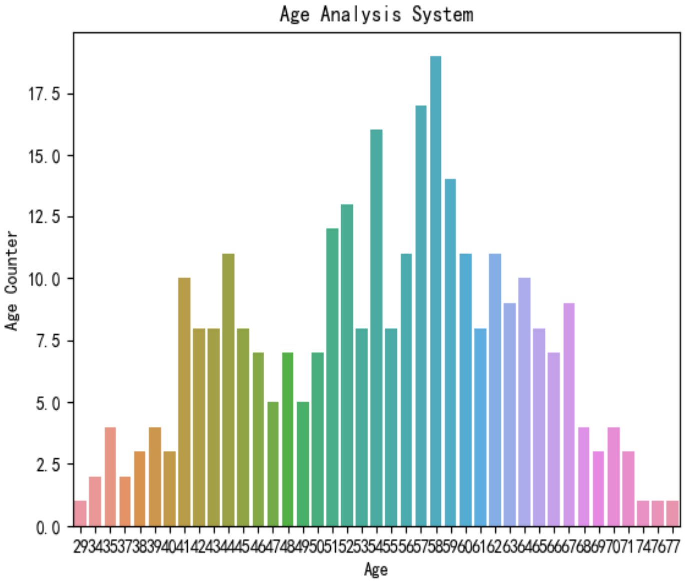


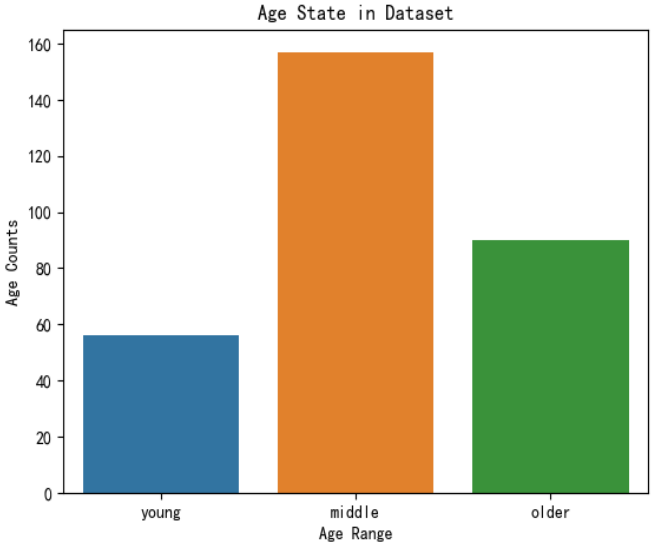


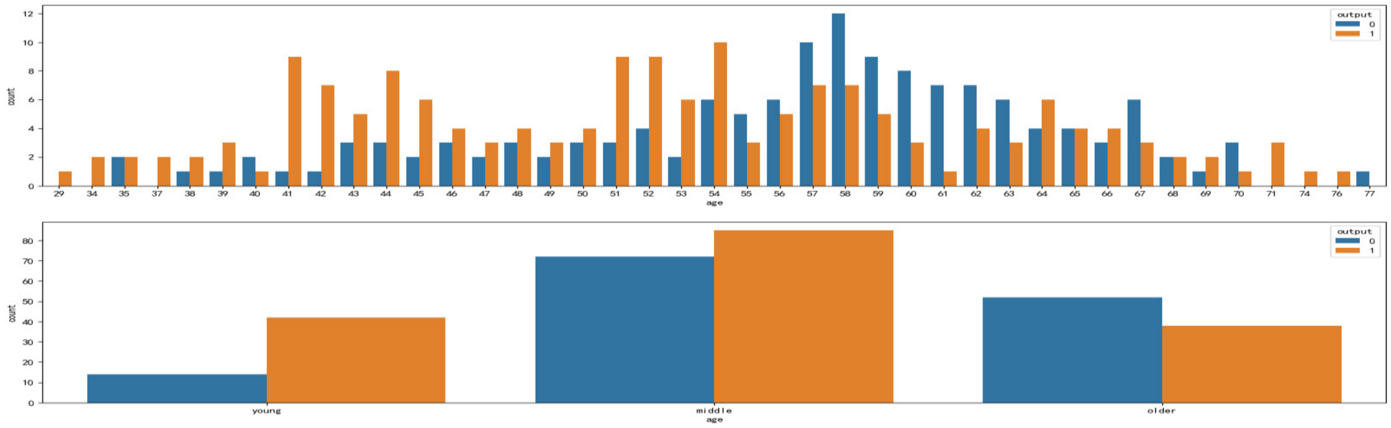


Analysis: In the feature distribution bar chart, we can find feature age, trtbps, chol, thalachh follow a normal distribution. In the correlation heatmap figure, we can know the feature cp, thalachh, exng, oldpeak, thall, caa, thall has highest correlation with feature output. In the pairplot figure, we can find the distributions of features age, cp, tahlachh, oldpeak, caa with respect to the two values of output are more differentiated. These features are more discriminatory for outputs.

Exploration on age features

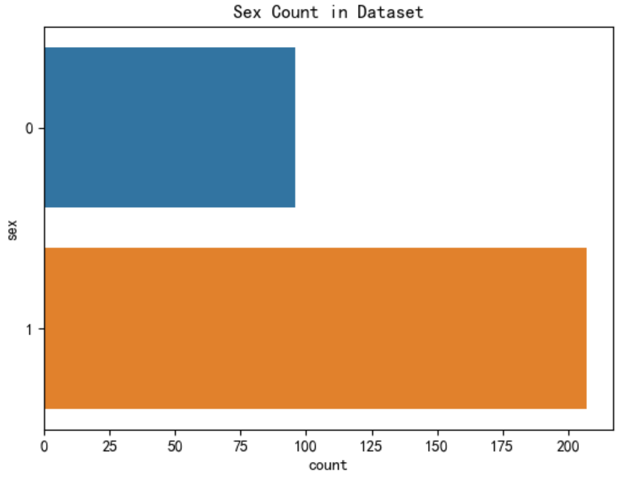


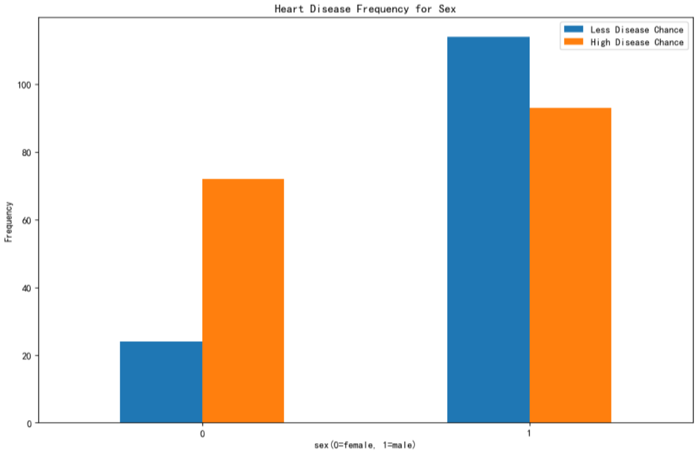


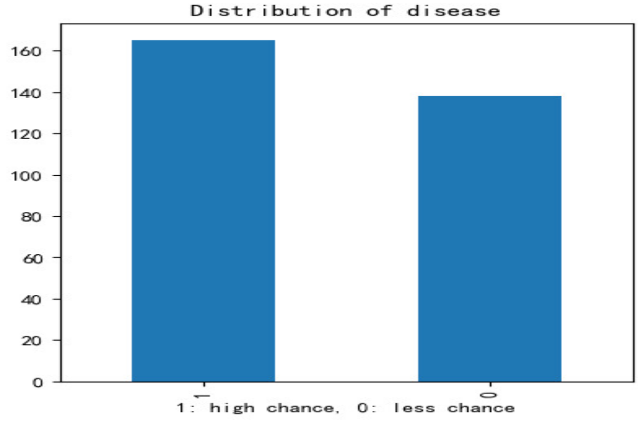


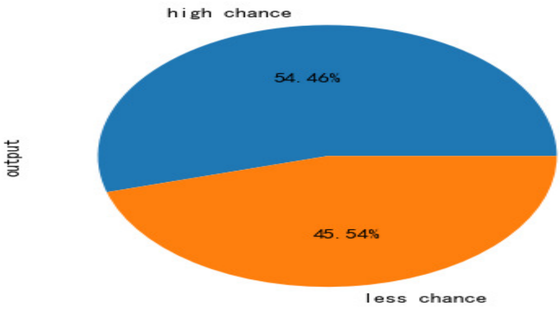
Analysis: The above figure shows us the age distribution of the different datasets, we can see that the number of people and the percentage of illnesses are not the same for different ages, in order to better represent the groups, we discretize the ages, [0,45) for young people, [45,60) for middle-aged people, and [60,100) for elderly people. We can also observe that the proportion of probability of disease varies in different groups.
The young people and middle people have more chance to have a heart attack than the old people.

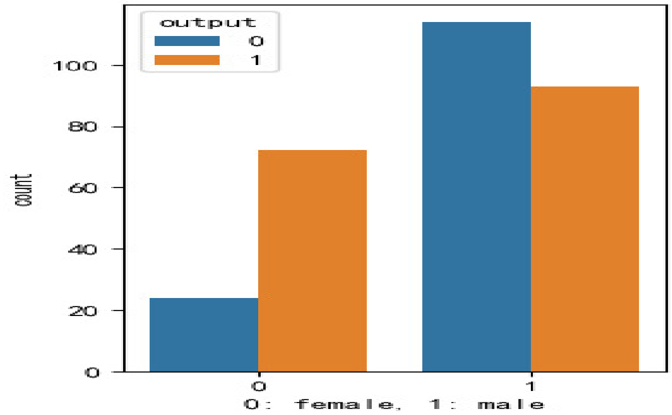
Exploration on sex features

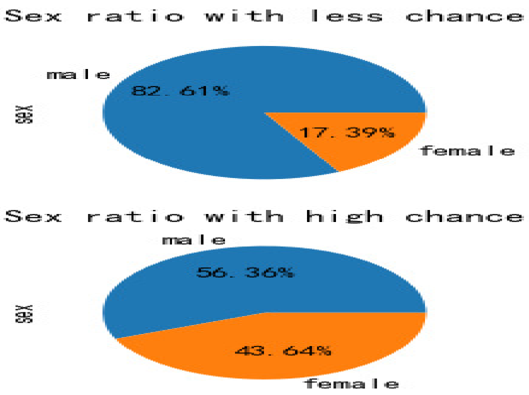












Analysis: According the above figure, we can find the there is no gender balance in the given data set and also can discover the male ratio is bigger than female under the condition of less chance of heart disease but roughly eauql under the condition of high chance of heart disease

2 Feature processing

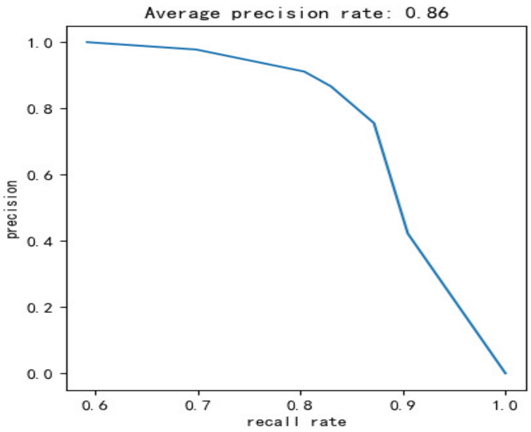
Step 1:Convert
Converts discrete data, from ordinary 0,1,2, to real strings. The rules are as follow.
Age: 0-45 young, 45-60 middle, 60-100 older
Sex: 0 female, 1male
Cp: 0 typical, 1 atypical, 2 non-anginal, 3 asymptomatic
Fbs: 0 false, 1 true
Exng: 0 no,1 yes
Slp: 0 rising, 1flat, 2 falling
Thall: 0 null, 1 normal, 2 fixed, 3 reversed
Restecg: 0 normal, 1 ST-T-abnormal, 2 Left-ventricular-hypertrophy
Caa: 0 zero, 1 one, 2 two, 3 three

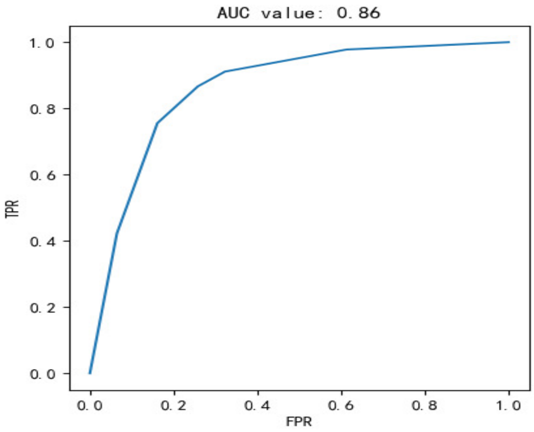
Step 2:
One-hot encoding

Step 3:
z-score normalization

3 Predict

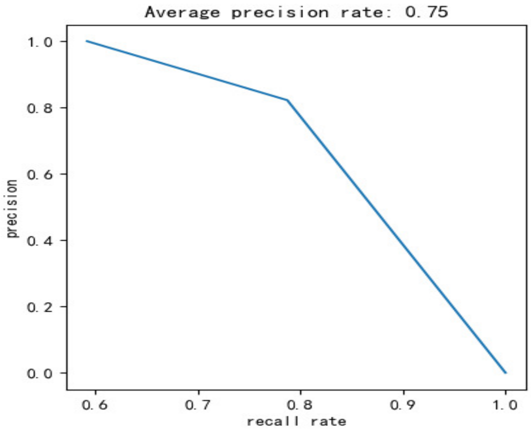
Clustering-based Approaches:
KNN:
accuracy: 0.8481420765027323
precision: 0.8297872340425532
recall: 0.8666666666666667
F1 score: 0.8478260869565217

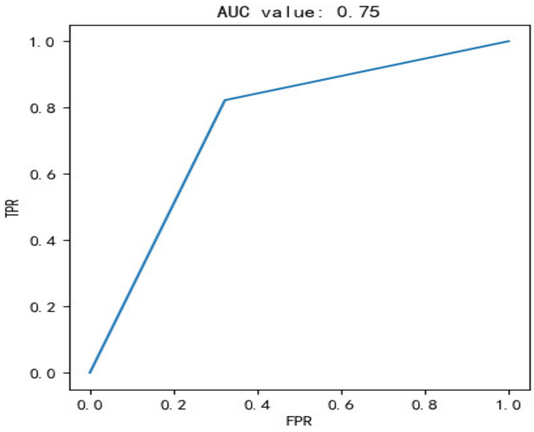




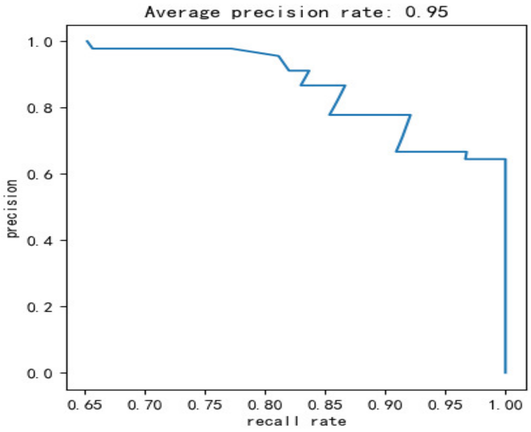
Classification-based

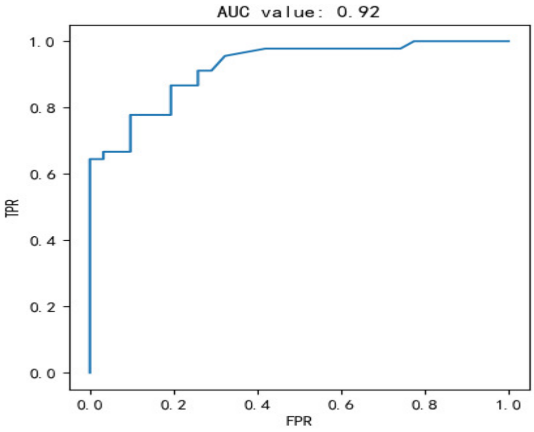
Decision Tree(Only set max_depth=10):
accuracy: 0.7189617486338797
precision: 0.7872340425531915
recall: 0.8222222222222222
F1 score: 0.8043478260869565





Random forest(only set n_estimators=100):
accuracy: 0.8283060109289616
precision: 0.8636363636363636
recall: 0.8444444444444444
F1 score: 0.853932584269663





Analysis: From the above results, we can find that among the classification methods, the knn performance of the clustering method is better than the decision tree, but not as good as the random deep forest of the integration method. In the above results, we can also find that knn has the smoothest curve.

4 Association Rule Mining

Further discretization:
In order to use association rule mining, we need to discretize all data. So add the follow converting rules. These rule can be found in reference.

Trtbps: [90,139] normal, and [139,200] high
Chol: <200 mg/dl low risk, [200,240] borderline high risk, >240 high risk
Tthalachh [150,200] normal, others are abnormal
Oldpeak: normal <=1, >1 abnormal

Normalization
Then use z-score normalization

ARM:
Use mlxtend package to do the apriori and association_rules. Set the min_support=0.2 and min_threshold=0.8.

Result:
There are so many rules so I only list some of them. More results can be found in folder csv file.
Less chance of heart attack

Antecedents	consequents	support	confidence	lift
frozenset({'exng_yes', 'sex_male'})	frozenset({'output_less'})	0.20462	0.805195	1.767928
frozenset({'cp_typical', 'thalachh_abnormal'})	frozenset({'output_less'})	0.244224	0.822222	1.805314
frozenset({'exng_yes', 'cp_typical'})	frozenset({'output_less'})	0.231023	0.875	1.921196

High chance of heart attack

antecedents	consequents	support	confidence	lift
frozenset({'age_middle','thall_fixed'})	frozenset({'output_more'})	0.211221	0.8	1.469091
frozenset({'exng_no','sex_female'})	frozenset({'output_more'})	0.211221	0.864865	1.588206
frozenset({'thall_fixed','sex_female'})	frozenset({'output_more'})	0.227723	0.873418	1.603913

Analysis:
In this part, I only choose two rule to do analysis.

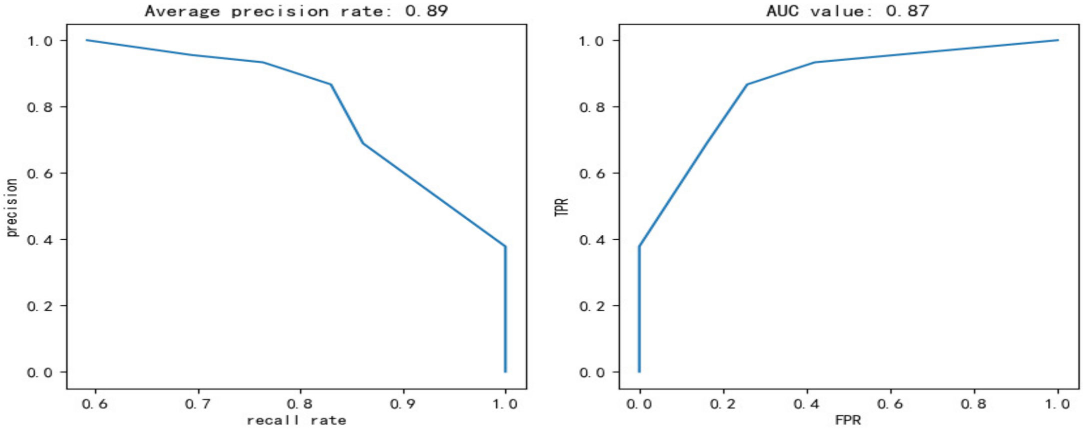
For (exng_yes,sex_male->output_less), It means a people who is male and have exercise-induced angina have less chance of less chance of heart attack that this rule has 20.5% support, 80.5% confident and 1.76 lift (>1 Positive correlation exists).

For (exng_no,sex_female->output_more), It means a people who is female and doesn't have exercise-induced angina have less chance of less chance of heart attack that this rule has 21.1% support, 86.5% confident and 1.58 lift (>1 Positive correlation exists).

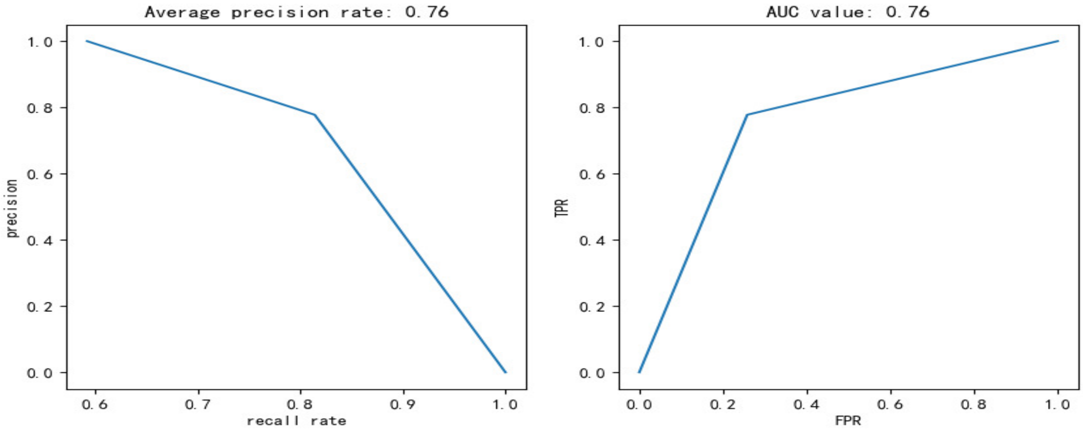
5 Improvement

I only made minor modifications i.e. categorizing on the ARM dataset. Among them, the performance of knn and decison tree has some improvement, and knn effect enhancement is more obvious. and random forest has some decrease. The results are shown below

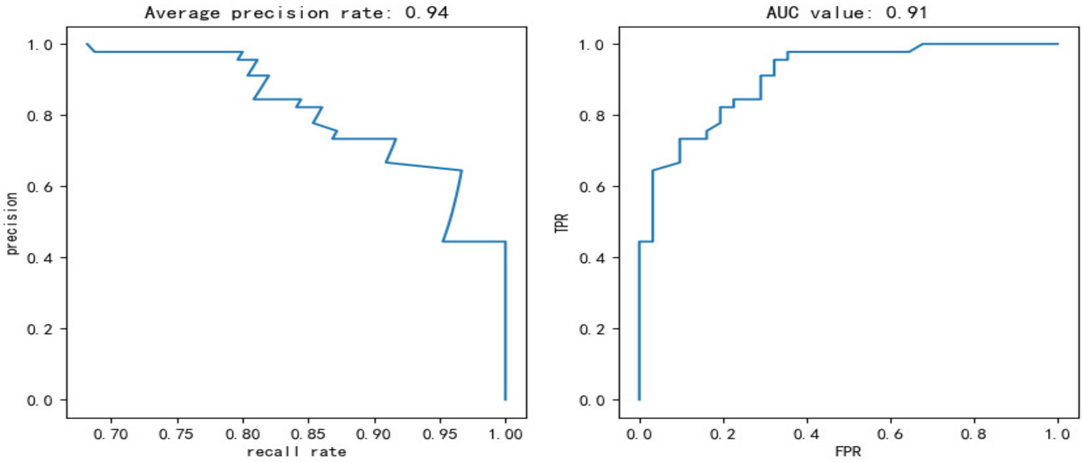
Clustering-based Approaches:
KNN:
accuracy: 0.8349726775956284
precision: 0.8297872340425532
recall: 0.8666666666666667
F1 score: 0.8478260869565217



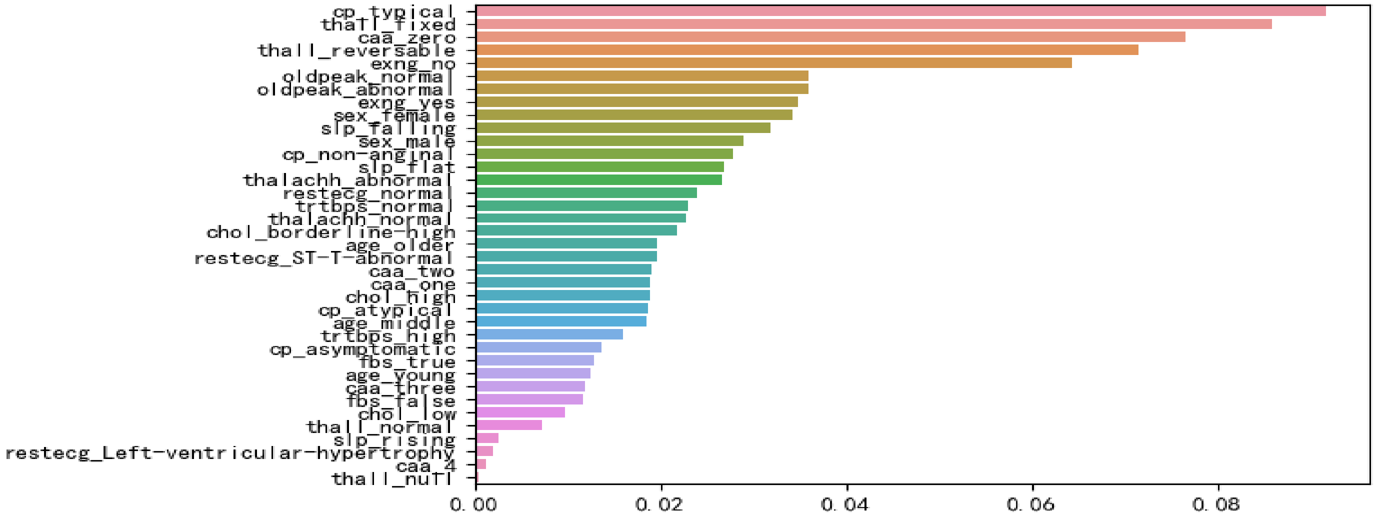
Classification-based
Decision Tree(Only set max_depth=10):
accuracy: 0.7556284153005464
precision: 0.813953488372093
recall: 0.7777777777777778
F1 score: 0.7954545454545455



Random forest(only set n_estimators=100):
accuracy: 0.8281967213114754
precision: 0.8444444444444444
recall: 0.8444444444444444
F1 score: 0.8444444444444444



Heart Disease Prediction-Characteristic Importance Analysis based on random forest



Analysis: Through this figure we can find that the three features that have the greatest importance in predicting the outcome of the random forest are cp, thall, caa. This also validates the results of feature distribution and feature correlation.

6 Evaluation

Throughout this project, I have successfully explored the power of data mining in solving a practical problem and demonstrated my understanding of various data mining techniques. I learned and developed an effective data mining solution by utilizing seaborn (sns) library to create distribution plots, heatmaps, and pairplots for data exploration.

In terms of prediction, I implemented three different algorithms - K-Nearest Neighbors (KNN), Decision Tree, and Random Forest - to predict the target variable. By employing these algorithms, I was able to make accurate predictions based on the given dataset.

Furthermore, I utilized association data mining to discover and extract rules between the features and the target variable. This helped me identify significant associations and patterns in the data, providing valuable insights into the relationships between different variables.

To further enhance the predictive power of the models, I applied discretization techniques based on association data mining. By discretizing the data, I was able to improve the performance and accuracy of the prediction methods.

Overall, this project allowed me to gain hands-on experience in data mining techniques. I learned how to effectively explore and visualize data using sns distribution plots, heatmaps, and pairplots. I successfully implemented KNN, Decision Tree, and Random Forest algorithms for prediction, and leveraged association data mining to discover valuable rules between features and the target variable. Lastly, I applied discretization techniques to further enhance the predictive performance of the models.

This project has not only deepened my understanding of data mining but also provided me with practical experience in solving real-world problems through data analysis and prediction.

7 References

Heart Attack Analysis & Prediction Dataset (kaggle.com)
Blood pressure - Wikipedia
Cholesterol - Wikipedia
Normal Heart Rate By Age: Range, Charts And More – Forbes Health
Diagnostic and prognostic value of ST segment depression limited to the recovery phase of exercise stress test - PMC (nih.gov)
Python 可视化 | Seaborn5 分钟入门(七)——pairplot - 知乎 (zhihu.com)
基于 Kaggle 心脏病数据集的数据分析和分类预测-StatisticalLearning 统计学习实验报告_kaggle 医学数据分析-CSDN 博客