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Heart Attack Analysis and Prediction

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Introduction

One of the main causes of the rising death rate is heart disease. One of the most significant areas to benefit from extensive information & analytics is healthcare. To forecast and treat the high death rate from heart attacks, medical data extraction is becoming increasingly important. Every day, terabytes of data are generated. To prevent making bad therapeutic judgments that have unfavourable effects, quality services are required. The cost of clinical testing can be reduced by the hospitals using suitable decision support systems. Hospital information systems are now used by hospitals to manage patient data. The vast volume of data produced by the healthcare sector is not efficiently utilized. To cut costs and anticipate heart disease, a novel strategy is required. To determine which data mining techniques are efficient and accurate, this paper will review several research projects on heart attack finding and categorization using various data mining techniques.

By using several data mining techniques like correlation matrix, KMeans clustering, Decision Tree classifier and Naive Bayes, we came up with a fast, efficient and fairly accurate model to predict if someone is at risk of a heart attack.

Methodology

The dataset we've chosen to go ahead with contains the data of 303 patients and has a wide range of attributes which can help us analyze the data and make appropriate predictions. The attributes are as follows.

- Age : Age of the patient
- Sex : Sex of the patient
- exang: exercise induced angina (1 = yes; 0 = no)
- ca: number of major vessels (0-3)
- cp : Chest Pain type chest pain type
  - Value 1: typical angina
  - Value 2: atypical angina
  - Value 3: non-anginal pain
  - Value 4: asymptomatic
- trtbps : resting blood pressure (in mm Hg)
- chol : cholestoral in mg/dl fetched via BMI sensor
- fbs : (fasting blood sugar > 120 mg/dl) (1 = true; 0 = false)
- rest_ecg : resting electrocardiographic results
  - Value 0: normal
  - Value 1: having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV)
  - Value 2: showing probable or definite left ventricular hypertrophy by Estes' criteria
- thalach : maximum heart rate achieved
- target : 0= less chance of heart attack 1= more chance of heart attack

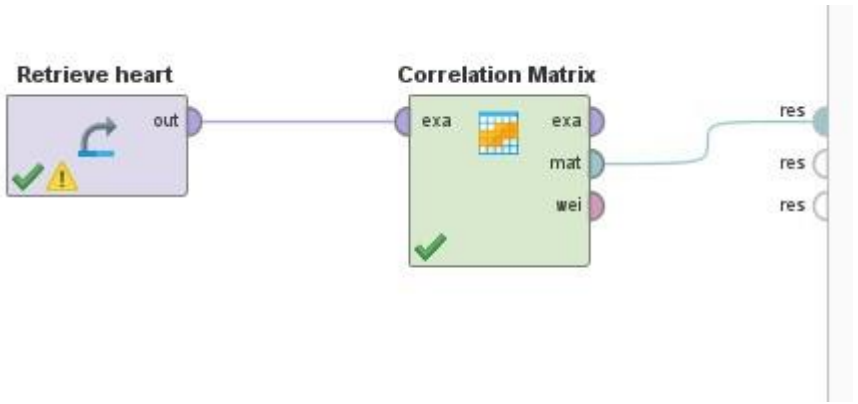
The data set mentioned can be found in Kaggle at:
https://www.kaggle.com/datasets/rashikrahmanpritom/heart-attack-analysis-prediction-dataset
The data set has both continuous and non continuous attributes. They are as follows:

```
NonContinuousColumns:'sex','exng','caa','cp','fbs','restecg','slp','
thall'
Continuous Columns: ["age","trtbps","chol","thalachh","oldpeak"]
```

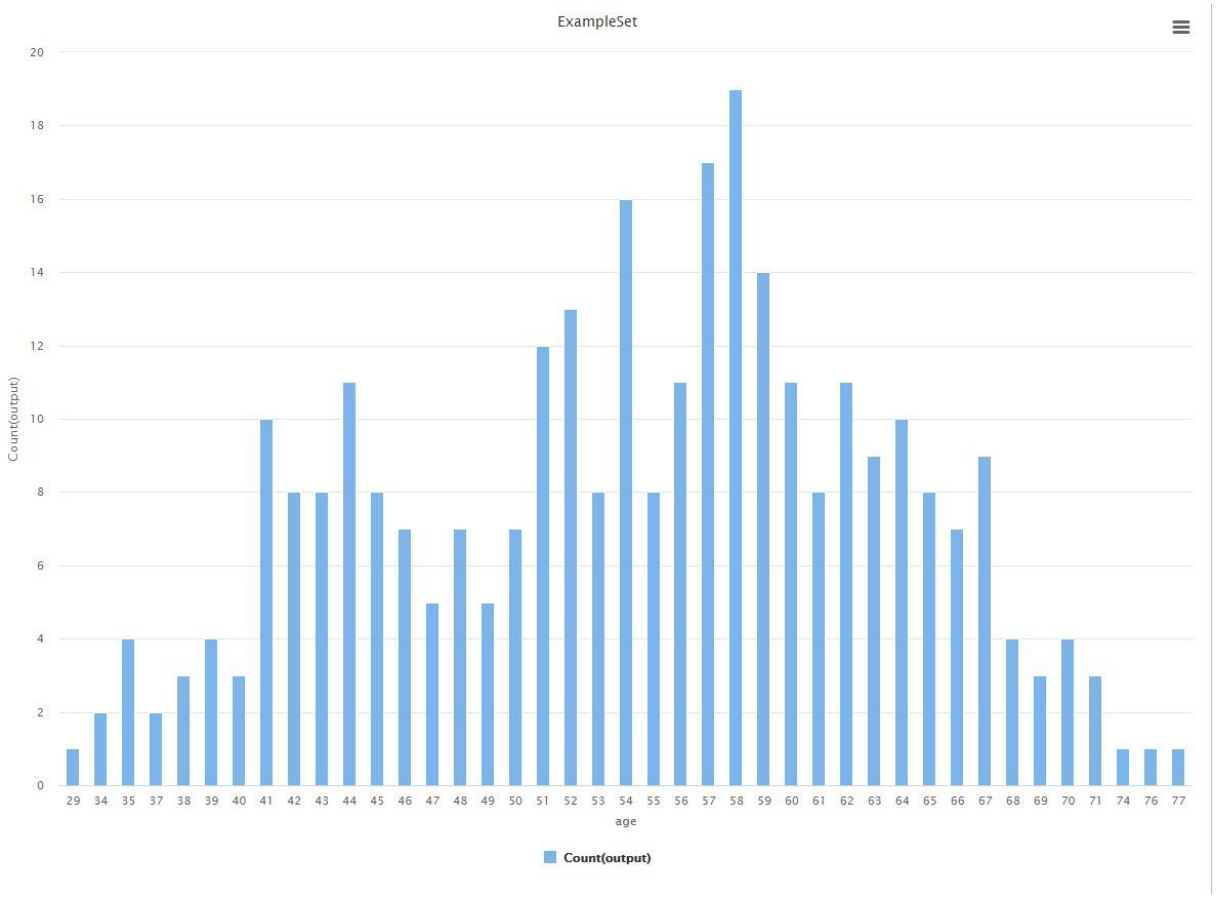
Data Preprocessing

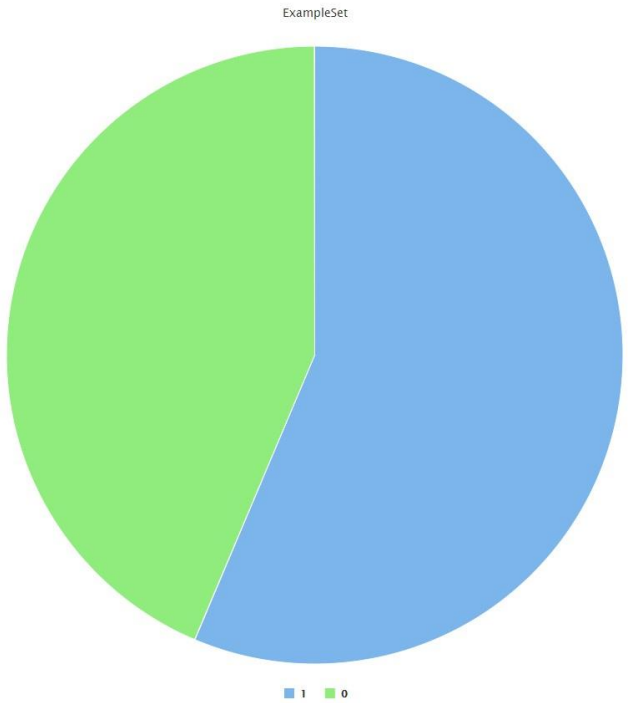
- There are no NULL values in the data, so there is no need to replace anything with the mean value
- The Outliers in the data are very less. (Checked using Rapid Miner)
- There is no linear correlation between continuous variables. (Checked by using Rapid Miner Correlation Matrix)

Attribut...	age	sex	cp	trtbps	chol	fbs	restecg	thalachh	exng	oldpeak	slp	caa	thall	output
age	1	0.098	-0.069	0.279	0.214	0.121	-0.116	-0.399	0.097	0.210	-0.169	0.276	0.068	-0.225
sex	0.098	1	0.049	0.057	0.198	-0.045	0.058	0.044	-0.142	-0.096	0.031	-0.118	-0.210	0.281
cp	-0.069	0.049	1	0.048	-0.077	0.094	0.044	0.296	-0.394	-0.149	0.120	-0.181	-0.162	0.434
trtbps	0.279	0.057	0.048	1	0.123	0.178	-0.114	-0.047	0.068	0.193	-0.121	0.101	0.062	-0.145
chol	0.214	0.198	-0.077	0.123	1	0.013	-0.151	-0.010	0.067	0.054	-0.004	0.071	0.099	-0.085
fbs	0.121	-0.045	0.094	0.178	0.013	1	-0.084	-0.009	0.026	0.006	-0.060	0.138	-0.032	-0.028
restecg	-0.116	0.058	0.044	-0.114	-0.151	-0.084	1	0.044	-0.071	-0.059	0.093	-0.072	-0.012	0.137
thalachh	-0.399	0.044	0.296	-0.047	-0.010	-0.009	0.044	1	-0.379	-0.344	0.387	-0.213	-0.096	0.422
exng	0.097	-0.142	-0.394	0.068	0.067	0.026	-0.071	-0.379	1	0.288	-0.258	0.116	0.207	-0.437
oldpeak	0.210	-0.096	-0.149	0.193	0.054	0.006	-0.059	-0.344	0.288	1	-0.578	0.223	0.210	-0.431
slp	-0.169	0.031	0.120	-0.121	-0.004	-0.060	0.093	0.387	-0.258	-0.578	1	-0.080	-0.105	0.346
caa	0.276	-0.118	-0.181	0.101	0.071	0.138	-0.072	-0.213	0.116	0.223	-0.080	1	0.152	-0.392
thall	0.068	-0.210	-0.162	0.062	0.099	-0.032	-0.012	-0.096	0.207	0.210	-0.105	0.152	1	-0.344
output	-0.225	0.281	0.434	-0.145	-0.085	-0.028	0.137	0.422	-0.437	-0.431	0.346	-0.392	-0.344	1



By general sense we might think that older people might have higher chances for heart attack but on seeing the data it says otherwise. Most heart attacks happened in the middle aged people.





Male vs Female Positve Outcome, again almost equal results. (some bias because there were more male records in the dataset

Adding the csv data to a dataframe using Pandas.

```
df1 = df

df1 = pd.get_dummies(df1, columns = cat_cols,
drop_first = True) X = df1.drop(['output'],axis=1) y =
df1[['output']] scaler = RobustScaler() X[con_cols] =
scaler.fit_transform(X[con_cols]) print("The first 5
rows of X are") X.head()
```

We have chosen to go ahead with 3 algorithms because they are quite intuitive and different from one another

1) Decision Tree

We'll also be using a popular and accurate classifier to predict classes for our dataset. For the above-mentioned, we are using the Decision Trees. It is a supervised learning algo used for classification of tuples.
The algorithm focuses on reducing the entropy of the entire dataset by splitting labelled attributes into their classes, starting from the attribute which has the highest entropy and going to the attribute which has the highest entropy in the reduced dataset. Thus, we calculate the entropy/information gain of each attribute to decide the root node and then split the data according to their unique labels, and then proceed to split the reduced data further based on the remaining attributes.
For performing the above, we use a custom decision tree code written from scratch in python .

The above attributes are used to construct the decision tree using the below code. (After importing all the necessary libraries and retrieving the dataset, the following snippet fetches us the decision tree) The code is as follows:

```
from sklearn import tree dt =

DecisionTreeClassifier(random_state = 42)

dt.fit(X_train, y_train)

y_pred = dt.predict(X_test)
text_representation = tree.export_text(dt)
print(text_representation)
```

```
print("The test accuracy score of Decision Tree is ",
accuracy_score(y_test, y_pred))
```

After observing the output, we can classify any new tuple based on their class in other attributes. This is how we implement decision tree on our dataset and classify them in different classes. After appropriate tree pruning we get the following tree

2) Random Forest Algorithm

It is the most potent and well-known algorithm in ML. It is a part of supervised computer learning.It is applied to classification and regression issues. The steps in the random forest method are as follows:

• Information is gathered
• Decision trees are built using various samples
• It uses the decision tree average.
Although it can handle datasets with categorical variables, it is slower than a single decision tree. ignores values that are missing.

Utilising Random Forest offers the primary benefit of having higher accuracy and lower volatility than using a single model. Choice matrix is used. Based on the parameters in the dataset, data pre-processing is completed. The quantity of trees directly affects the accuracy of the outcome, thus if there are more trees, the accuracy will be higher. Using this classifier, the model is now being trained. We obtain a predicted outcome from each tree as well as an independently computed amount of entropy. The most voted prediction result is selected.

```
rf = RandomForestClassifier() rf.fit(X_train,
y_train) y_pred = dt.predict(X_test) print("The test
accuracy score of Random Forest is ",
accuracy_score(y_test, y_pred))
```

Now we find the attribute weight of random forest using decision tree criterion:

Gain Ratio **Accuracy** **Information Gain**

attribute	weight
trtbps	0.131
caa	0.067
exng	0.051
sex	0.094
cp	0.135
oldpeak	0.046
thalachh	0.074
slp	0.045
fbs	0.042
age	0.207
thall	0.042
restecg	0.066

attribute	weight
trtbps	0.182
caa	0.033
exng	0.031
sex	0.062
cp	0.112
oldpeak	0.071
thalachh	0.103
slp	0.033
fbs	0.023
age	0.292
thall	0.021
restecg	0.036

attribute	weight
trtbps	0.182
caa	0.034
exng	0.028
sex	0.061
cp	0.118
oldpeak	0.065
thalachh	0.111
slp	0.029
fbs	0.016
age	0.300
thall	0.020
restecg	0.036

3) Support Vector Machine (SVM)

Support Vector Machine is very well known precision and supervised learning technique. It is used mostly for MLClassification issues.
In order to quickly classify following data points, the SVM method aims to define the optimum decision boundary or line that may split n-dimensional spaces into groups. This ideal decision boundary is referred to as a "hyperplane".
Advantages:

- Support vector machines' benefits include:
- efficient in high-dimensional environments.
- Especially useful in situations where the number of dimensions exceeds the number of samples.
- It is also computationally efficient since it only uses a portion of the training points (known as support vectors) in the decision function.
- Different Parameters may be given for the decision function, making it flexible.

Before Tuning

```
from sklearn import tree dt =

DecisionTreeClassifier(random_state = 42)

dt.fit(X_train, y_train)

y_pred = dt.predict(X_test)
text_representation = tree.export_text(dt)
print(text_representation)

print("The test accuracy score of Decision Tree is ",
accuracy_score(y_test, y_pred))
```

Accuracy: 86.89%

After Tuning
Takes some hit on computational costs

```
svm = SVC()

parameters = {"C":np.arange(1,10,1),'gamma':[0.00001,0.00005,

0.0001,0.0005,0.001,0.005,0.01,0.05,0.1,0.5,1,5]} searcher =

GridSearchCV(svm, parameters)

searcher.fit(X_train, y_train) print("The best params
are :", searcher.best_params_) print("The best score
is   :", searcher.best_score_)

y_pred = searcher.predict(X_test) print("The test accuracy score of SVM
after hyper-parameter tuning is ", accuracy_score(y_test, y_pred))
```

Accuracy: 90.166%

Results and Discussions

The best accuracies obtained are as follows:

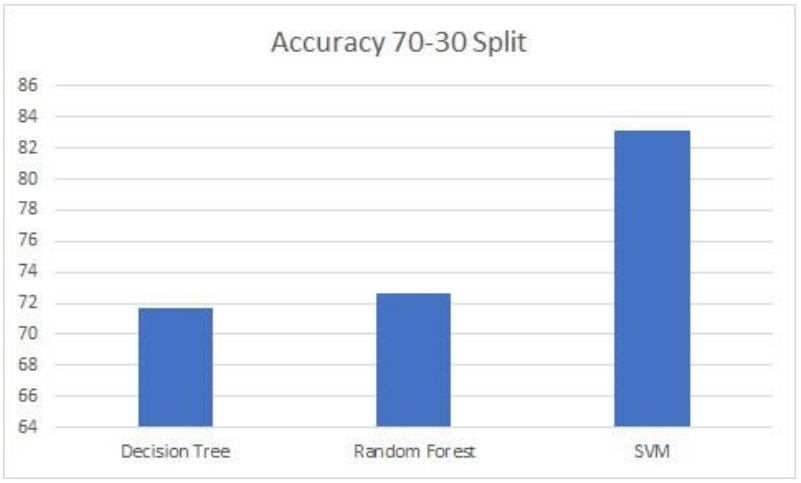
1) Support vector machine algorithm is 90.166%.

2) Decision tree algorithm is 78.8666%.

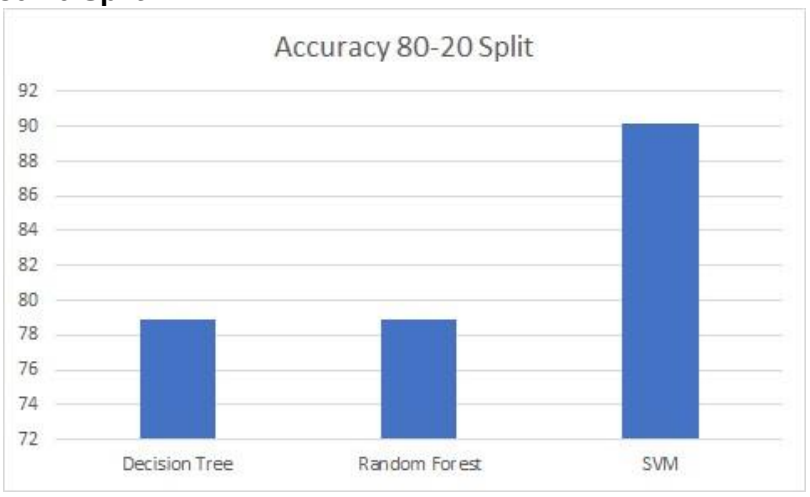
3) Random Forest tree algorithm is 78.877%.

Accuracies obtained with different Training - Testing Splits

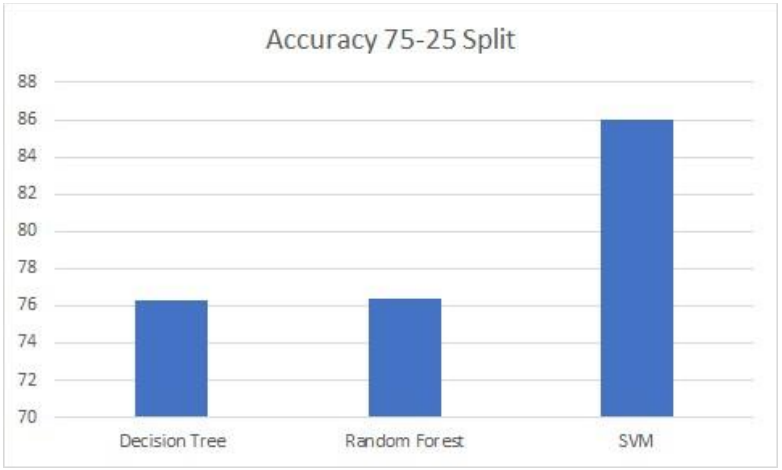
70-30 Split



80-20 Split

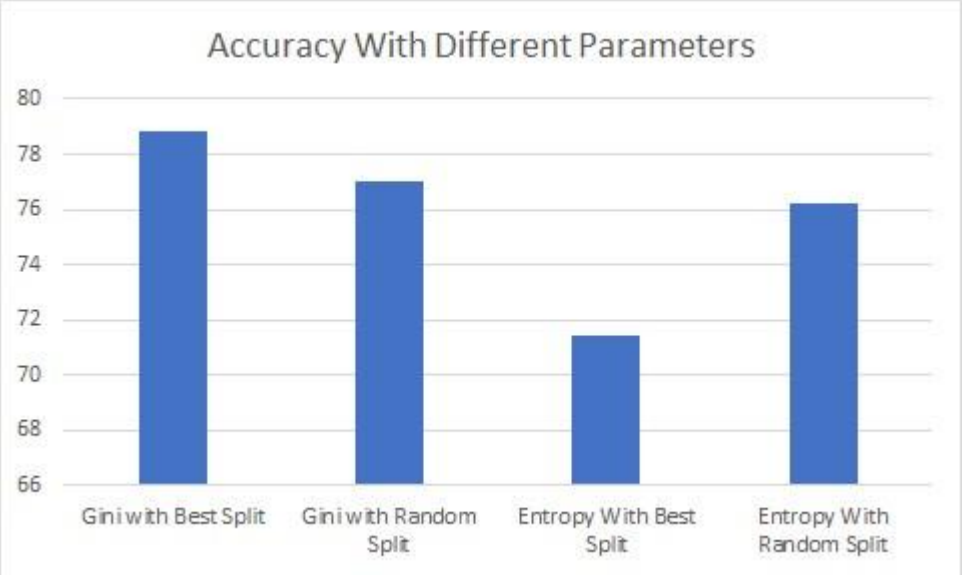


75-25 Split



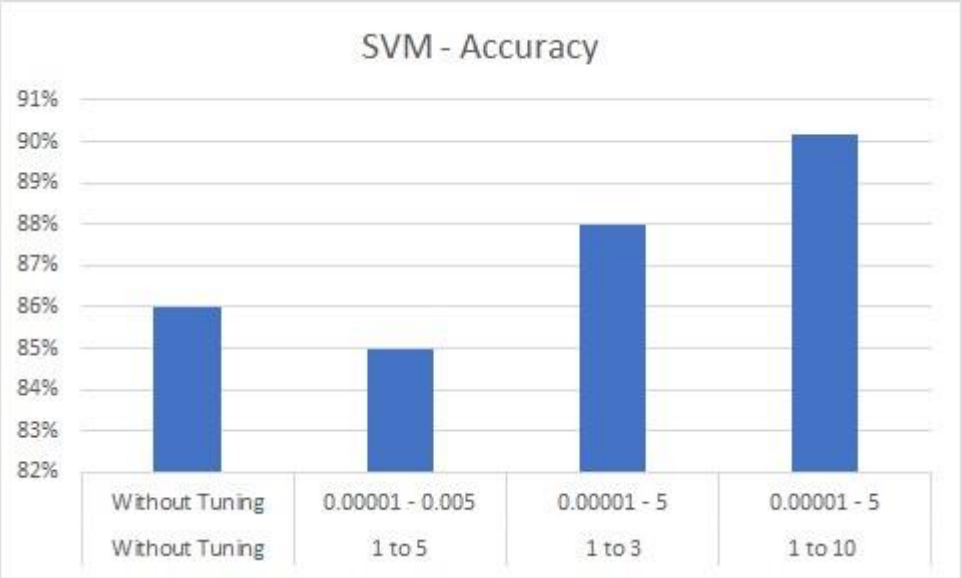
Accuracies Obtained with Multiple Parameter Combinations (Decision Tree and Random Forest)

Decision Tree With Parameters	Accuracy
Gini with Best Split	78.86
Gini with Random Split	77
Entropy With Best Split	71.433
Entropy With Random Split	76.23



Accuracies Obtained with Multiple Parameter Combinations (SVM Hyper Tuning)

C range	Gamma Ranges	Accuracy
Without Tuning	Without Tuning	86%
1 to 5	0.00001 - 0.005	85%
1 to 3	0.00001 - 5	88%
1 to 10	0.00001 - 5	90.16%



Confusion Matrix Obtained

Decision Tree (Best Case)

25	**4**
9	**23**

Random Forest (Default)

25	**4**
9	**23**

SVM (Linear Kernel) (No Tuning)

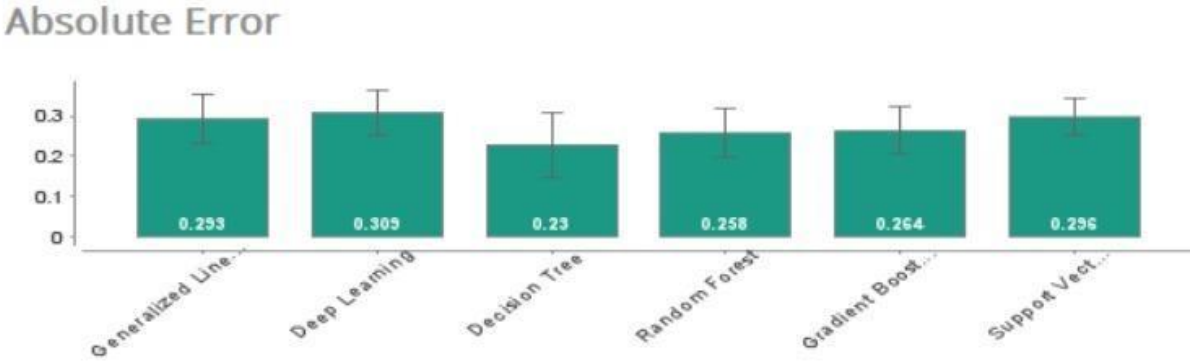
26	**3**
5	**27**

SVM (RBF Kernel) Hyper Parameter Tuning

27	**2**
7	**25**

On comparing all the three models we can easily say that SVM is far more accurate than the remaining models

Comparision with other algorithms with Rapid Miner AutoModel



Our hyper tuned SVM Model gave a better accuracy then Rapid Miner AutoModel

Conclusion

These learning methods divide the provided information into various categories and, if an unknown sample is provided as input, forecasts the risk of heart disease. Medical students can use the system as a training tool. Additionally, it will be beneficial for doctors. We have created a generalised system, so in the future we may use it to analyse various datasets by just changing the name of the dataset file provided for the training module.

References

1)https://www.kaggle.com/datasets/rashikrahmanpritom/heart-attack-analysis-prediction-dataset : kaggle dataset link

2) Heart Attack Probability Analysis Using Machine Learning

A. A. Shanbhag, C. Shetty, A. Ananth, A. S. Shetty, K. Kavanashree Nayak and B. R. Rakshitha, "Heart Attack Probability Analysis Using Machine Learning

3) Cluster Based Association Rule Mining For Heart Attack Prediction

Akhil, Jabbar & Dr, P. & Deekshatulu, B.L.. (2011). Cluster based Association rule mining for Heart Attack Prediction. 32. 196-201.

Remaining References are presented in Literature Survey.