# Bayesian Network

## All features Without Discretization

Correctly Classified Instances 50 81.9672 %

Incorrectly Classified Instances 11 18.0328 %

Kappa statistic 0.6402

Mean absolute error 0.0795

Root mean squared error 0.2271

Relative absolute error 39.4596 %

Root relative squared error 71.8029 %

Total Number of Instances 61

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.781 0.138 0.862 0.781 0.820 0.643 0.906 0.867 <50

0.862 0.219 0.781 0.862 0.820 0.643 0.909 0.923 >50\_1

**0.820 0.176 0.824 0.820 0.820 0.643 0.907 0.894**

=== Confusion Matrix ===

a b c d e <-- classified as

25 7 0 0 0 | a = <50

4 25 0 0 0 | b = >50\_1

## All features With Discretization

=== Summary ===

Correctly Classified Instances 53 86.8852 %

Incorrectly Classified Instances 8 13.1148 %

Kappa statistic 0.7371

Mean absolute error 0.0719

Root mean squared error 0.2091

Relative absolute error 35.6744 %

Root relative squared error 66.1034 %

Total Number of Instances 61

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.875 0.138 0.875 0.875 0.875 0.737 0.927 0.907 <50

0.862 0.125 0.862 0.862 0.862 0.737 0.926 0.941 >50\_1

**0.869 0.132 0.869 0.869 0.869 0.737 0.926 0.923**

=== Confusion Matrix ===

a b c d e <-- classified as

28 4 0 0 0 | a = <50

4 25 0 0 0 | b = >50\_1

## Reduced feature

=== Run information ===

Evaluator: weka.attributeSelection.WrapperSubsetEval -B weka.classifiers.bayes.BayesNet -F 5 -T 0.01 -R 1 -E DEFAULT -- -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5

Search: weka.attributeSelection.GreedyStepwise -T -1.7976931348623157E308 -N -1 -num-slots 1

Relation: cleveland-14-heart-disease

Instances: 303

Attributes: 14

age

sex

cp

trestbps

chol

fbs

restecg

thalach

exang

oldpeak

slope

ca

thal

num

Evaluation mode: 10-fold cross-validation

=== Attribute selection 10 fold cross-validation (stratified), seed: 1 ===

number of folds (%) attribute

1( 10 %) 1 age

1( 10 %) 2 sex

8( 80 %) 3 cp

0( 0 %) 4 trestbps

0( 0 %) 5 chol

0( 0 %) 6 fbs

0( 0 %) 7 restecg

0( 0 %) 8 thalach

1( 10 %) 9 exang

1( 10 %) 10 oldpeak

1( 10 %) 11 slope

3( 30 %) 12 ca

5( 50 %) 13 thal

# Bayesian Network with Selected attributes: 1,2,3,9,10,11,12,13 : 8

age

sex

cp

exang

oldpeak

slope

ca

thal

## Without Discretization

=== Summary ===

Correctly Classified Instances 52 85.2459 %

Incorrectly Classified Instances 9 14.7541 %

Kappa statistic 0.7037

Mean absolute error 0.0722

Root mean squared error 0.2043

Relative absolute error 35.8545 %

Root relative squared error 64.6121 %

Total Number of Instances 61

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.875 0.172 0.848 0.875 0.862 0.704 0.913 0.865 <50

0.828 0.125 0.857 0.828 0.842 0.704 0.912 0.933 >50\_1

**0.852 0.150 0.853 0.852 0.852 0.704 0.912 0.898**

=== Confusion Matrix ===

a b c d e <-- classified as

28 4 0 0 0 | a = <50

5 24 0 0 0 | b = >50\_1

## With Discretization

=== Summary ===

Correctly Classified Instances 54 88.5246 %

Incorrectly Classified Instances 7 11.4754 %

Kappa statistic 0.7688

Mean absolute error 0.067

Root mean squared error 0.1946

Relative absolute error 33.2512 %

Root relative squared error 61.5368 %

Total Number of Instances 61

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.938 0.172 0.857 0.938 0.896 0.773 0.920 0.859 <50

0.828 0.063 0.923 0.828 0.873 0.773 0.920 0.943 >50\_1

**0.885 0.120 0.888 0.885 0.885 0.773 0.920 0.899**

=== Confusion Matrix ===

a b c d e <-- classified as

30 2 0 0 0 | a = <50

5 24 0 0 0 | b = >50\_1

0 0 0 0 0 | c = >50\_2

## Voting Ensemble made from Bayesian network and Decision tree on Maximum probability combination

=== Summary ===

Correctly Classified Instances 53 86.8852 %

Incorrectly Classified Instances 8 13.1148 %

Kappa statistic 0.7362

Mean absolute error 0.1047

Root mean squared error 0.215

Relative absolute error 51.9852 %

Root relative squared error 67.984 %

Total Number of Instances 61

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.906 0.172 0.853 0.906 0.879 0.738 0.910 0.868 <50

0.828 0.094 0.889 0.828 0.857 0.738 0.909 0.927 >50\_1

**0.869 0.135 0.870 0.869 0.868 0.738 0.910 0.896**

=== Confusion Matrix ===

a b c d e <-- classified as

29 3 0 0 0 | a = <50

5 24 0 0 0 | b = >50\_1

# Voting Classifier consisting of SimpleLogistic ,.MultilayerPerceptron and Bayesian Network

=== Summary ===

Correctly Classified Instances 53 86.8852 %

Incorrectly Classified Instances 8 13.1148 %

Kappa statistic 0.7371

Mean absolute error 0.0525

Root mean squared error 0.229

Relative absolute error 26.0377 %

Root relative squared error 72.4239 %

Total Number of Instances 61

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.875 0.138 0.875 0.875 0.875 0.737 0.869 0.831 <50

0.862 0.125 0.862 0.862 0.862 0.737 0.869 0.809 >50\_1

**0.869 0.132 0.869 0.869 0.869 0.737 0.869 0.821**

=== Confusion Matrix ===

a b c d e <-- classified as

28 4 0 0 0 | a = <50

4 25 0 0 0 | b = >50\_1

0 0 0 0 0 | c = >50\_2

0 0 0 0 0 | d = >50\_3

0 0 0 0 0 | e = >50\_4

## STACKING ENSEMBLE (BAYSEAN NETWORK AND DECISION TREE WITH LOGISTIC REGRESSION AS META MODEL)

=== Summary ===

Correctly Classified Instances 54 88.5246 %

Incorrectly Classified Instances 7 11.4754 %

Kappa statistic 0.7688

Mean absolute error 0.0941

Root mean squared error 0.2089

Relative absolute error 46.712 %

Root relative squared error 66.0635 %

Total Number of Instances 61

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.938 0.172 0.857 0.938 0.896 0.773 0.890 0.809 <50

0.828 0.063 0.923 0.828 0.873 0.773 0.890 0.923 >50\_1

**0.885 0.120 0.888 0.885 0.885 0.773 0.890 0.863**

=== Confusion Matrix ===

a b c d e <-- classified as

30 2 0 0 0 | a = <50

5 24 0 0 0 | b = >50\_1

0 0 0 0 0 | c = >50\_2

0 0 0 0 0 | d = >50\_3

0 0 0 0 0 | e = >50\_4

Discretized Features: **Age, trestbp, chol, thalch, old peak**

## Selected attributes: 1,2,3,9,10,11,12,13 : 8

age

sex

cp

exang

oldpeak

slope

ca

thal

## VOTING: Naïve Bayes, Bayesian Network, Decision Trees

=== Summary ===

Correctly Classified Instances 53 86.8852 %

Incorrectly Classified Instances 8 13.1148 %

Kappa statistic 0.7354

Mean absolute error 0.0772

Root mean squared error 0.2013

Relative absolute error 38.3243 %

Root relative squared error 63.6369 %

Total Number of Instances 61

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.938 0.207 0.833 0.938 0.882 0.742 0.915 0.890 <50

0.793 0.063 0.920 0.793 0.852 0.742 0.915 0.936 >50\_1

**0.869 0.138 0.875 0.869 0.868 0.742 0.915 0.912**

=== Confusion Matrix ===

a b c d e <-- classified as

30 2 0 0 0 | a = <50

6 23 0 0 0 | b = >50\_1

0 0 0 0 0 | c = >50\_2

0 0 0 0 0 | d = >50\_3

1. 0 0 0 0 | e = >50\_4

# === .WrapperSubsetEval ===

Evaluator: weka.attributeSelection.WrapperSubsetEval -B weka.classifiers.bayes.BayesNet -F 10 -T 0.01 -R 1 -E AUPRC -- -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5

Search: weka.attributeSelection.BestFirst -D 2 -N 5

Relation: hungarian-14-heart-disease

Instances: 294

Attributes: 14

age

sex

chest\_pain

trestbps

chol

fbs

restecg

thalach

exang

oldpeak

slope

ca

thal

num

Evaluation mode: evaluate on all training data

=== Attribute Selection on all input data ===

Search Method:

Best first.

Start set: no attributes

Search direction: bi-directional

Stale search after 5 node expansions

Total number of subsets evaluated: 168

Merit of best subset found: 0.921

Attribute Subset Evaluator (supervised, Class (nominal): 14 num):

Wrapper Subset Evaluator

Learning scheme: weka.classifiers.bayes.BayesNet

Scheme options: -D -Q weka.classifiers.bayes.net.search.local.K2 -- -P 1 -S BAYES -E weka.classifiers.bayes.net.estimate.SimpleEstimator -- -A 0.5

Subset evaluation: area under the precision-recall curve

Number of folds for accuracy estimation: 10

Selected attributes: 2,3,6,7,9,10,11,13 : 8

sex

chest\_pain

fbs

restecg

exang

oldpeak

slope

thal

# Experiments Result

Tester: weka.experiment.PairedCorrectedTTester -G 1 -D 4,5,6 -R 2 -S 0.05 -result-matrix "weka.experiment.ResultMatrixPlainText -mean-prec 2 -stddev-prec 2 -col-name-width 0 -row-name-width 25 -mean-width 2 -stddev-width 2 -sig-width 1 -count-width 5 -print-col-names -print-row-names -enum-col-names"

Analysing: Percent\_correct

Datasets: 7

Resultsets: 3

Confidence: 0.05 (two tailed)

Sorted by: -

Date: 8/16/21, 7:27 PM

## Undiscretized Dataset

### Accuracy Measure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attribute** | **11 Attributes** | **5 attributes** |
|  | Bayesian Network | 83.36 | 83.36 | **84.42** |
|  | Random Forest | 82.11 | **82.36** | 76.52 \* |
|  | Multilayer Perceptron | 79.66 | **81.50** | 80.19 |
|  | Naïve Bayes | 83.29 | 83.55 | **85.02** |
|  | Simple Logistic | 83.25 | 84.02 | **84.16** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 82.91 | **83.96** | 83.43 |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 84.41 | **84.67** | 83.49 |

### Kappa\_ Statistics

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attribute** | **11 Attributes** | **5 attributes** |
|  | Bayesian Network | 0.66 | 0.66 | **0.69** |
|  | Random Forest | **0.64** | **0.64** | 0.52 \* |
|  | Multilayer Perceptron | 0.59 | **0.63** | 0.60 |
|  | Naïve Bayes | 0.66 | 0.67 | **0.70** |
|  | Simple Logistic | 0.66 | **0.68** | **0.68** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.65 | **0.67** | 0.66 |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.68 | **0.69** | 0.67 |

### Precision

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attribute** | **11 Attributes** | **5 attributes** |
|  | Bayesian Network | 0.84 | 0.84 | **0.86** |
|  | Random Forest | 0.82 | **0.83** | 0.78 |
|  | Multilayer Perceptron | **0.81** | **0.83** | 0.81 |
|  | Naïve Bayes | 0.84 | 0.84 | **0.85** |
|  | Simple Logistic | 0.83 | **0.84** | **0.84** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.83 | **0.84** | **0.84** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.85 | **0.85** | 0.84 |

### Recall

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attribute** | **11 Attributes** | **5 attributes** |
|  | Bayesian Network | 0.86 | 0.86 | 0.86 |
|  | Random Forest | **0.86** | **0.86** | 0.80 |
|  | Multilayer Perceptron | 0.82 | 0.83 | **0.84** |
|  | Naïve Bayes | 0.87 | 0.88 | **0.89** |
|  | Simple Logistic | 0.87 | **0.89** | **0.89** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.86 | **0.87** | **0.87** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | **0.88** | **0.88** | 0.87 |

### F\_Measure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attribute** | **11 Attributes** | **5 attributes** |
|  | Bayesian Network | 0.85 | 0.85 | **0.86** |
|  | Random Forest | **0.84** | **0.84** | 0.79 \* |
|  | Multilayer Perceptron | 0.81 | **0.83** | 0.82 |
|  | Naïve Bayes | 0.85 | 0.85 | **0.87** |
|  | Simple Logistic | 0.85 | **0.86** | **0.86** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.85 | **0.86** | 0.85 |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | **0.86** | **0.86** | 0.85 |

### Area Under Curve

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attribute** | **11 Attributes** | **5 attributes** |
|  | Bayesian Network | **0.91** | **0.91** | 0.90 |
|  | Random Forest | **0.90** | **0.90** | 0.85 \* |
|  | Multilayer Perceptron | 0.87 | **0.89** | 0.87 |
|  | Naïve Bayes | **0.91** | **0.91** | 0.90 |
|  | Simple Logistic | **0.91** | **0.91** | 0.90 |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | **0.90** | **0.90** | 0.89 |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.91 | **0.92** | 0.90 |

### Training Time

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attribute** | **11 Attributes** | **5 attributes** |
|  | Bayesian Network | **0.00** | **0.00** | **0.00** |
|  | Random Forest | **0.04** | 0.06 | **0.04** |
|  | Multilayer Perceptron | 0.94 | 0.83 \* | **0.36 \*** |
|  | Naïve Bayes | **0.00** | **0.00** | **0.00** |
|  | Simple Logistic | 0.07 | 0.08 | **0.05 \*** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 10.16 | 9.26 \* | **4.23 \*** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 1.08 | 1.06 | **0.51 \*** |

(1) 'cleveland dataset attribute selection with Information Gain Attribute Evaluation & Gain-Ratio Attribute Evaluation with Ranker Search Method

1. age numeric
2. sex {female,male}
3. cp {typ\_angina,asympt,non\_anginal,atyp\_angina}
4. fbs {t,f}
5. restecg {left\_vent\_hyper,normal,st\_t\_wave\_abnormality}
6. thalach numeric
7. exang {no,yes}
8. oldpeak numeric
9. slope {up,flat,down}
10. ca numeric
11. thal {fixed\_defect,normal,reversable\_defect}
12. num {<50,>50\_1,>50\_2,>50\_3,>50\_4}

(2) 'cleveland dataset WrapperSubsetEval With GreedyStepwise Search & Best-First Search On Bayesian Network

1. sex {female,male}
2. cp {typ\_angina,asympt,non\_anginal,atyp\_angina}
3. thalach numeric
4. ca numeric
5. thal {fixed\_defect,normal,reversable\_defect}
6. num {<50,>50\_1,>50\_2,>50\_3,>50\_4}

(3) cleveland-14-heart-disease with Full Dataset

1. 'age' real
2. 'sex' { female, male}
3. 'cp' { typ\_angina, asympt, non\_anginal, atyp\_angina}
4. 'trestbps' real
5. 'chol' real
6. 'fbs' { t, f}
7. 'restecg' { left\_vent\_hyper, normal, st\_t\_wave\_abnormality}
8. 'thalach' real
9. 'exang' { no, yes}
10. 'oldpeak' real
11. 'slope' { up, flat, down}
12. 'ca' real
13. 'thal' { fixed\_defect, normal, reversable\_defect}
14. 'num' { '<50', '>50\_1', '>50\_2', '>50\_3', '>50\_4'}

# Discretized Dataset With Cross Validation

### Accuracy Measure

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 83.70 | **85.28** | 83.90 | 84.96 | 84.88 |
|  | Random Forest | 80.00 | 80.85 | 81.25 | 79.33 | **82.31** |
|  | Multilayer Perceptron | 81.38 | **83.03** | 82.30 | 82.26 | 80.61 |
|  | Naïve Bayes | 83.57 | **85.08** | 83.83 | 85.02 | **85.08** |
|  | Simple Logistic | 83.03 | 84.15 | 83.29 | 82.96 | **84.82** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 83.31 | 84.55 | 83.23 | 83.96 | **84.62** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 83.70 | **85.00** | 84.42 | 83.90 | 84.16 |

### Kappa\_ Statistics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.67 | **0.70** | 0.67 | **0.70** | 0.69 |
|  | Random Forest | 0.59 | 0.61 | 0.62 | 0.58 | **0.64** |
|  | Multilayer Perceptron | 0.62 | **0.66** | 0.64 | 0.64 | 0.61 |
|  | Naïve Bayes | 0.67 | **0.70** | 0.67 | **0.70** | **0.70** |
|  | Simple Logistic | 0.66 | 0.68 | 0.66 | 0.65 | **0.69** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.66 | **0.69** | 0.66 | 0.68 | **0.69** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.67 | **0.70** | 0.68 | 0.67 | 0.68 |

### Precision

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.85 | **0.86** | 0.85 | **0.86** | 0.85 |
|  | Random Forest | 0.80 | **0.82** | 0.81 | 0.79 | 0.82 |
|  | Multilayer Perceptron | 0.82 | **0.85** | 0.84 | 0.83 | 0.81 |
|  | Naïve Bayes | 0.85 | **0.86** | 0.85 | **0.86** | 0.85 |
|  | Simple Logistic | 0.83 | **0.85** | 0.83 | 0.83 | 0.84 |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.84 | **0.85** | 0.84 | **0.85** | **0.85** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.84 | **0.86** | 0.85 | 0.84 | 0.84 |

### Recall

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.87 | 0.88 | 0.86 | 0.88 | **0.89** |
|  | Random Forest | 0.85 | 0.85 | **0.87** | 0.85 | **0.87** |
|  | Multilayer Perceptron | 0.84 | 0.84 | 0.84 | **0.85** | **0.85** |
|  | Naïve Bayes | 0.86 | 0.87 | 0.86 | 0.87 | **0.89** |
|  | Simple Logistic | 0.87 | 0.87 | 0.87 | 0.87 | **0.89** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.86 | 0.88 | 0.86 | 0.86 | **0.89** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.87 | **0.88** | **0.88** | **0.88** | **0.88** |

### F\_measure

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.85 | **0.87** | 0.85 | **0.87** | **0.87** |
|  | Random Forest | 0.82 | 0.83 | 0.83 | 0.82 | **0.84** |
|  | Multilayer Perceptron | 0.83 | **0.84** | **0.84** | **0.84** | 0.83 |
|  | Naïve Bayes | 0.85 | 0.86 | 0.85 | 0.86 | **0.87** |
|  | Simple Logistic | 0.85 | 0.86 | 0.85 | 0.85 | **0.87** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.85 | **0.86** | 0.85 | 0.85 | **0.86** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.85 | **0.86** | **0.86** | **0.86** | **0.86** |

### Area Under Curve

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.91 | **0.92** | **0.92** | 0.91 | 0.89 |
|  | Random Forest | 0.88 | **0.89** | **0.89** | 0.88 | 0.87 |
|  | Multilayer Perceptron | 0.90 | **0.91** | 0.89 | 0.90 | 0.87 |
|  | Naïve Bayes | 0.91 | **0.92** | **0.92** | 0.91 | 0.89 |
|  | Simple Logistic | 0.89 | 0.90 | 0.89 | 0.89 | 0.88 |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.91 | **0.92** | 0.91 | 0.91 | 0.89 |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.91 | **0.92** | 0.91 | 0.91 | 0.89 |

### Training Time

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
|  | Random Forest | 0.04 | 0.04 | 0.04 | 0.04 | 0.02 \* |
|  | Multilayer Perceptron | 8.82 | 3.17 \* | 36.56 | 6.45 \* | 0.86 \* |
|  | Naïve Bayes | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
|  | Simple Logistic | 0.18 | 0.13 \* | 0.15 \* | 0.15 \* | 0.07 \* |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 80.53 | 29.49 \* | 114.17 | 61.52 \* | 7.69 \* |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 8.16 | 3.00 \* | 6.83 \* | 6.17 \* | 0.91 \* |

## Discretized Dataset With 80:20

### Accuracy Measure

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 84.03 | **86.16** | 84.19 | 85.51 | 85.51 |
|  | Random Forest | **81.55** | 80.73 | 80.07 | 79.91 | 81.21 |
|  | Multilayer Perceptron | 80.24 | 81.55 | **82.04** | 81.73 | 80.07 |
|  | Naïve Bayes | 84.36 | **85.67** | 83.86 | 85.50 | **85.67** |
|  | Simple Logistic | 82.21 | **85.83** | 83.04 | 83.86 | 85.51 v |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 83.86 | **85.01** | 82.38 | 84.85 | 84.85 |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 84.51 | **85.51** | 84.18 | 84.36 | 84.68 |

### Kappa\_ Statistics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.68 | **0.72** | 0.68 | 0.71 | 0.71 |
|  | Random Forest | **0.62** | 0.61 | 0.59 | 0.59 | **0.62** |
|  | Multilayer Perceptron | 0.60 | 0.63 | **0.64** | 0.63 | 0.60 |
|  | Naïve Bayes | 0.68 | **0.71** | 0.67 | **0.71** | **0.71** |
|  | Simple Logistic | 0.64 | **0.71** | 0.66 | 0.67 | **0.71 v** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.67 | **0.69** | 0.64 | **0.69** | **0.69** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.69 | **0.71** | 0.68 | 0.68 | 0.69 |

### Precision

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.83 | 0.84 | 0.84 | **0.85** | 0.84 |
|  | Random Forest | 0.79 | **0.81** | 0.78 | 0.78 | **0.81** |
|  | Multilayer Perceptron | 0.80 | **0.82** | **0.82** | 0.81 | 0.81 |
|  | Naïve Bayes | 0.83 | 0.84 | 0.83 | **0.85** | 0.84 |
|  | Simple Logistic | 0.84 | **0.85** | 0.83 | 0.84 | 0.84 |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.83 | **0.84** | 0.81 | **0.84** | **0.84** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.83 | **0.84** | 0.82 | 0.83 | **0.84** |

### Recall

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.89 | **0.92** | 0.88 | 0.90 | 0.91 |
|  | Random Forest | **0.90** | 0.85 | 0.88 | 0.89 | 0.86 |
|  | Multilayer Perceptron | 0.85 | 0.85 | **0.87** | **0.87** | 0.83 |
|  | Naïve Bayes | 0.89 | **0.91** | 0.88 | 0.89 | **0.91** |
|  | Simple Logistic | 0.84 | 0.89 | 0.87 | 0.87 | **0.91 v** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.89 | **0.91** | 0.88 | 0.89 | 0.90 |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.90 | **0.91** | 0.91 | **0.91** | 0.89 |

### F\_measure

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.86 | **0.88** | 0.86 | 0.87 | 0.87 |
|  | Random Forest | 0.84 | 0.83 | 0.83 | 0.83 | 0.83 |
|  | Multilayer Perceptron | 0.82 | 0.83 | **0.84** | **0.84** | 0.82 |
|  | Naïve Bayes | 0.86 | **0.87** | 0.86 | **0.87** | **0.87** |
|  | Simple Logistic | 0.84 | **0.87** | 0.85 | 0.86 | **0.87 v** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.86 | **0.87** | 0.84 | 0.86 | **0.87** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.86 | **0.87** | 0.86 | 0.86 | 0.86 |

### Area Under Curve

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.91 | **0.92** | **0.92** | **0.92** | 0.90 |
|  | Random Forest | **0.88** | **0.88** | **0.88** | **0.88** | 0.87 |
|  | Multilayer Perceptron | 0.89 | 0.89 | **0.90** | 0.88 | 0.86 |
|  | Naïve Bayes | **0.92** | **0.92** | **0.92** | **0.92** | 0.91 |
|  | Simple Logistic | 0.90 | **0.91** | 0.90 | 0.89 | 0.89 |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.91 | **0.92** | 0.91 | **0.92** | 0.90 |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | **0.92** | **0.92** | **0.92** | **0.92** | 0.89 |

### Training Time

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.01 | **0.00 \*** | **0.00** | **0.00 \*** | **0.00 \*** |
|  | Random Forest | 0.11 | 0.08 | 0.06 | 0.05 | **0.04 \*** |
|  | Multilayer Perceptron | 6.94 | 2.43 \* | 5.17 \* | 5.21 \* | **0.65 \*** |
|  | Naïve Bayes | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
|  | Simple Logistic | 0.21 | 0.11 | 0.12 | 0.11 | **0.06** |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 76.13 | 24.87 \* | 53.35 \* | 53.92 \* | **7.04 \*** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 7.34 | 2.78 \* | 5.79 \* | 5.82 \* | **0.81 \*** |

### MCC

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Model** | **13 Attributes** | **8 Attributes** | **11 attributes** | **11 attributes (IG)** | **3 Attributes** |
|  | Bayesian Network | 0.68 | **0.73** | 0.69 | 0.71 | 0.71 |
|  | Random Forest | **0.63** | 0.61 | 0.60 | 0.60 | 0.62 |
|  | Multilayer Perceptron | 0.61 | 0.63 | **0.64** | 0.63 | 0.60 |
|  | Naïve Bayes | 0.69 | **0.72** | 0.68 | 0.71 | 0.71 |
|  | Simple Logistic | 0.64 | **0.72** | 0.66 | 0.67 | 0.71 v |
|  | Stacking (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes and Simple Logistic as meta model) | 0.68 | **0.70** | 0.65 | **0.70** | **0.70** |
|  | Vote (Bayesian Network, Random Forest, Multilayer Perceptron, Naïve Bayes And Simple Logistic) | 0.69 | **0.71** | 0.69 | 0.69 | 0.69 |

**8 Attributes us Wrapper Eval**

1. age
2. sex {female,male}
3. cp {typ\_angina,asympt,non\_anginal,atyp\_angina}
4. exang {no,yes}
5. oldpeak
6. slope {up,flat,down}
7. ca
8. thal {fixed\_defect,normal,reversable\_defect}
9. num {<50,>50\_1,>50\_2,>50\_3,>50\_4}

**11 attributes Selection with Correlation Attribute Evaluation & Gain Ratio with Ranker Search Method**

1. thal {fixed\_defect,normal,reversable\_defect}
2. exang {no,yes}
3. ca
4. cp {typ\_angina,asympt,non\_anginal,atyp\_angina}
5. slope {up,flat,down}
6. sex {female,male}
7. oldpeak
8. restecg {left\_vent\_hyper,normal,st\_t\_wave\_abnormality}
9. thalach
10. age
11. chol
12. num {<50,>50\_1,>50\_2,>50\_3,>50\_4}

**11 attributes Information Gain with Ranker Search Method**

1. thal {fixed\_defect,normal,reversable\_defect}
2. cp {typ\_angina,asympt,non\_anginal,atyp\_angina}
3. ca
4. oldpeak
5. thalach
6. exang {no,yes}
7. slope {up,flat,down}
8. age
9. sex {female,male}
10. restecg {left\_vent\_hyper,normal,st\_t\_wave\_abnormality}
11. trestbps
12. num {<50,>50\_1,>50\_2,>50\_3,>50\_4}

**3 Attributes with Wrapper Subset Evaluation With Greedy Stepwise Search & Best First Search On Bayesian Network**

@attribute cp {typ\_angina,asympt,non\_anginal,atyp\_angina}

@attribute ca

@attribute thal {fixed\_defect,normal,reversable\_defect}

@attribute num {<50,>50\_1,>50\_2,>50\_3,>50\_4}