APPENDIX 1

SAMPLE OUTPUTS

Results file obtained by running the ‘Continuous Ant Miner unordered rule set algorithm on the ‘Dermatology’ dataset. The aim is to determine the type of Eryhemato-Squamous Disease. It has 366 instances, 34 attributes and 6 classes.

Class Distribution

<table>
<thead>
<tr>
<th>Class code</th>
<th>Class</th>
<th>Number of instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>psoriasis</td>
<td>112</td>
</tr>
<tr>
<td>2</td>
<td>seboreic dermatitis</td>
<td>61</td>
</tr>
<tr>
<td>3</td>
<td>lichen planus</td>
<td>72</td>
</tr>
<tr>
<td>4</td>
<td>pityriasis rosea</td>
<td>49</td>
</tr>
<tr>
<td>5</td>
<td>cronic dermatitis</td>
<td>52</td>
</tr>
<tr>
<td>6</td>
<td>pityriasis rubra pilaris</td>
<td>20</td>
</tr>
</tbody>
</table>

Parameter settings

No Ants per Iteration: 1
Max no iterations: 1000
Min no instances covered by rule: 10
Max no instances left uncovered: 5
Max no rules allowed to converge: 5
Transition rule: random proportional selection

Number of Instances : 366
Number of Attributes : 34
Number of Classes : 6

Attribute Information:

@relation dermatology
@attribute erythema \{0,1,2,3\}
@attribute scaling \{0,1,2,3\}
@attribute definite-borders \{0,1,2,3\}
@attribute itching \{0,1,2,3\}
@attribute koebner-phenomenon \{0,1,2,3\}
@attribute polygonal-papules \{0,1,2,3\}
@attribute follicular-papules \{0,1,2,3\}
@attribute oral-mucosal-involvement \{0,1,2,3\}
@attribute knee-and-elbow-involvement \{0,1,2,3\}
@attribute scalp-involvement \{0,1,2,3\}
@attribute family-history \{0,1\}
@attribute melanin incontinence \{0,1,2,3\}
@attribute eosinophils in the infiltrate \{0,1,2,3\}
@attribute PNL infiltrate \{0,1,2,3\}
@attribute fibrosis of the papillary dermis \{0,1,2,3\}
@attribute exocytosis \{0,1,2,3\}
@attribute acanthosis \{0,1,2,3\}
@attribute hyperkeratosis \{0,1,2,3\}
@attribute parakeratosis \{0,1,2,3\}
@attribute clubbing of the rete ridges \{0,1,2,3\}
@attribute elongation of the rete ridges \{0,1,2,3\}
@attribute thinning of the suprapapillary epidermis {0,1,2,3}
@attribute spongiform pustule {0,1,2,3}
@attribute munro microabcess {0,1,2,3}
@attribute focal hypergranulosis {0,1,2,3}
@attribute disappearance of the granular layer {0,1,2,3}
@attribute vacuolisation and damage of basal layer {0,1,2,3}
@attribute spongiosis {0,1,2,3}
@attribute saw-tooth-appearance-of-retes {0,1,2,3}
@attribute follicular-horn-plug {0,1,2,3}
@attribute perifollicular-parakeratosis {0,1,2,3}
@attribute inflammatory-mononuclear-infiltrate {0,1,2,3}
@attribute band-like-infiltrate {0,1,2,3}
@attribute Age numeric
@attribute class {1,2,3,4,5,6}

Output

Fold :0

IF Ploygonal-papules = 1 AND Melanin-incontinence = 1 AND Fibrosis-papillary-dermis = 1 AND Spongiosis = 0 AND Perifollicular-parakeratosis = 1 THEN Eryhemato-Squamous = 1
No. of instances covered: 125

IF Koebner-phenomenon = 1 AND Disappearance-granular-layer = 1 AND Perifollicular-parakeratosis=1 THEN Eryhemato-Squamous= 5
No. of instances covered: 150

IF THEN Eryhemato-Squamous = 4
No. of instances covered: 8
Fold :1

IF Melanin-incontinence = 1 AND Fibrosis-papillary-dermis = 1 AND Spongiosis = 1 AND Saw-tooth-appearance-retes = 1 AND Perifollicular-parakeratosis = 1 THEN Eryhemato-Squamous = 1
No. of instances covered: 144

IF Ploygonal-papules = 1 AND Scalp-involvement = 1 AND Melanin-incontinence = 1 AND Follicular-horn-plug = 1 THEN Eryhemato-Squamous=4
No of instances covered: 100

IF THEN Eryhemato-Squamous=6
No of instances covered: 10

Fold :2

IF PNL-infiltrate = 1 AND Fibrosis-papillary-dermis = 1 AND Clubbing-rete-ridges = 1 THEN Eryhemato-Squamous=2
No.of instances covered: 139

IF PNL-infiltrate = 1 AND Perifollicular-parakeratosis = 1
THEN Eryhemato-Squamous=3
No. of instances covered: 70

IF Ploygonal-papules = 1 AND Oral-mucus = 0 AND PNL-infiltrate = 1 AND Perifollicular-parakeratosis = 0 THEN Eryhemato-Squamous= 5
No. of instances covered: 100
IF THEN Eryhemato-Squamous= 4

No. of instances covered: 8

Fold: 3

IF Fibrosis-papillary-dermis=1 AND Focal-hypergranulosi s =1 AND Spongiosis =1 AND Saw-tooth-appearance-retes=1 AND Perifollicular-parakeratosis=1 THEN Eryhemato-Squamous =1

No. of instances covered: 149

IF Oral-mucus =0 AND PNL-infiltrate =1 AND Vacou lisation-basal-layer =0 THEN Eryhemato-Squamous=3

No. of instances covered: 130

IF THEN Eryhemato-Squamous=4

No. of instances covered: 7

Fold: 4

IF Knee-Elbow-involvement =1 AND Fibrosis-papillary-dermis =0 AND Focal-hypergranulosis =0 AND Disappearance-granular-layer=1 AND Saw-tooth-appearance-retes =1 THEN Eryhemato-Squamous=2

No. of instances covered: 151

IF Band-like-infiltrate= 4 THEN Eryhemato-Squamous=3

No. of instances covered: 109

IF PNL-infiltrate=1 AND Fibrosis-papillary-dermis=1 THEN Eryhemato-Squamous=6

No. of instances covered: 60
IF THEN Eryhemato-Squamous=5
No. of instances covered: 9

Fold:5

IF Fibrosis-papillary-dermis=1 AND Focal-hypergranulosis=1 AND Spongiosis=1 AND Saw-tooth-appearance-retes=1 AND age>45 THEN Eryhemato-Squamous-Type=1
No. of instances covered: 145

IF Oral-mucus=1 AND Melanin-incontinence=1 AND PNL-infiltrate=1 THEN Eryhemato-Squamous=5
No. of instances covered: 112

IF Fibrosis-papillary-dermis=1 AND Vacuolisation-basal-layer=1 THEN Eryhemato-Squamous=6
No. of instances covered: 72

IF THEN Eryhemato-Squamous=2
No. of instances covered: 1

Fold:6

IF Follicular-papules=1 AND PNL-infiltrate=1 AND Fibrosis-papillary-dermis=1 AND age <50 THEN Eryhemato-Squamous=3
No. of instances covered: 116

IF Ploygonal-papules=0 AND Scalp-involvment=1 AND Melanin-incontinence=0 AND PNL-infiltrate=1 AND Fibrosis-papillary-dermis=0 AND Elongation-rete-ridges=1 AND Follicular-horn-plug=0
THEN Eryhemato-Squamous= 4
No. of instances covered: 138

IF Oral-mucus=0 AND PNL-infiltrate=0 AND Perifollicular-parakeratosis=0 THEN Eryhemato-Squamous=5
No. of instances covered: 47

IF THEN Eryhemato-Squamous=6
No. of instances covered: 26

Fold: 7

IF Koebner-phenomenon=1 AND Melanin-incontinence=1 AND Fibrosis-papillary-dermis=1 AND Disappearance-granular-layer=0 AND Perifollicular-parakeratosis=1 THEN Eryhemato-Squamous= 2
No. of instances covered: 130

IF Band-like-infiltrate=4 THEN Eryhemato-Squamous= 3
No. of instances covered: 149

IF THEN Eryhemato-Squamous= 4
No. of instances covered: 20

Fold: 8

IF Fibrosis-papillary-dermis=1 AND Focal-hypergranulosis=1
Spongiosis=1 AND Saw-tooth-appearance-retes= 0 AND Perifollicular-parakeratosis= 1 THEN Eryhemato-Squamous= 1
No. of instances covered: 145
IF Band-like-infiltrate=4 THEN Eryhemato-Squamous= 3
No. of instances covered: 100

IF Koebner-phenomenon=1 AND PNL-infiltrate=1 AND Disappearance-granular-layer=1 AND Perifollicular-parakeratosis=1 THEN
Eryhemato-Squamous= 5
No. of instances covered: 46

IF THEN Eryhemato-Squamous=2
No. of instances covered: 34

Fold: 9:

IF Melanin-incontinence =1 AND Fibrosis-papillary-dermis =1 AND Spongiosis =1 AND Saw-tooth-appearance-retes =1 AND Perifollicular-parakeratosis =1 THEN Eryhemato-Squamous= 1
No. of instances covered: 154

IF Ploygonal-papules =2 AND Scalp-involvment=3 AND Melanin-incontinence=2 AND Follicular-horn-plug=1 THEN Eryhemato-Squamous= 4
No. of instances covered: 100

IF Follicular-papules =2 AND PNL-infiltrate = 1 AND Elongation-rete-ridges = 1 THEN Eryhemato-Squamous= 3
No. of instances covered: 80

IF THEN Eryhemato-Squamous= 6
No. of instances covered: 25
Average Accuracy : 96.15±2.90
Overall Average Rules : 3.5
Overall Average Rule Length : 2.25

Results file obtained by running the ‘Hybrid algorithm’ on the ‘Heart-c’ dataset. The aim is to determine the type of Eryhemato-Squamous Disease. It has 303 instances, 14 attributes (mixed).

DataSet successfully loaded: C:\Program Files\ project \dataset \heart-c- mix.arff

Number of Nominal and Binary Attributes: 7
Number of Continuous Attributes: 6
Number of Records: 298

Outputting settings and raw predictions to: C:\Program Files\ project \dataset \rawoutput.txt

Starting Experiment: heart-c- mix.arff
@relation cleveland-14-heart-disease
@attribute 'age' real
@attribute 'sex' { female, male}
@attribute 'cp' { typ_angina, asympt, non_anginal, atyp_angina}
@attribute 'trestbps' real
@attribute 'chol' real
@attribute 'fbs' { t, f}
@attribute 'restecg' { left_vent_hyper, normal, st_t_wave_abnormality }
@attribute 'thalach' real
@attribute 'exang' { no, yes}
@attribute 'oldpeak' real
@attribute 'slope' { up, flat, down}
@attribute 'ca' real
@attribute 'thal' { fixed_defect, normal, reversible_defect}

Fold: 0

Rule 0: IF thal = normal AND trestbps <= 168.4798553559175 AND thalach >= 111.06293772829093 AND oldpeak <= 3.156854865735439 AND ca <= 2.0913533981901065 THEN <50

Rule 1: IF thalach >= 91.83597647371136 AND oldpeak <= 2.467923698685322 AND ca <= 0.4222258590856041 THEN <50

Rule 2: IF exang = no AND trestbps <= 178.27125582440337 AND thalach >= 132.7246420164332 AND oldpeak <= 2.479861785840013 THEN <50

Rule 3: IF cp = asympt AND trestbps >= 106.57618560190011 AND thalach <= 181.16273381938464 THEN >50_1

Rule 4: IF cp = asympt AND trestbps >= 109.72922827269333 AND thalach <= 177.53329191346106 THEN >50_1

Rule 5: IF sex = male AND thalach <= 168.6815442271605 THEN >50_1

Rule 6: IF THEN >50_1
Confusion Matrix

<table>
<thead>
<tr>
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<th>&lt;50</th>
<th>&gt;50_1</th>
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<tr>
<td>&gt;50_1</td>
<td>9</td>
<td>6</td>
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</tbody>
</table>

**Fold: 1**

Rule 0: IF thal = normal AND trestbps <= 167.7743919368724 AND thalach >= 108.31266600150842 AND oldpeak <= 3.5521879070507647 AND ca <= 1.8166695203758645 THEN <50

Rule 1: IF cp = asympt AND trestbps >= 104.23878062913883 AND thalach <= 177.0106315596641 THEN >50_1

Rule 2: IF exang = no AND trestbps <= 178.27125582440337 AND thalach >= 132.7246420164332 AND oldpeak <= 2.47986178584013 THEN <50

Rule 3: IF cp = asympt AND age <= 70.32879071978309 AND trestbps >= 107.4888079716948 AND thalach <= 175.78771111092465 THEN >50_1

Rule 4: IF sex = male AND age >= 44.18657967234368 AND trestbps >= 95.46840753865479 AND thalach <= 176.31302789257313 THEN >50_1

Rule 5: IF sex = male AND age >= 44.06131849281444 AND trestbps >= 99.31710539969964 AND thalach <= 174.34657042605673 THEN >50_1

Rule 6: IF THEN >50_1
Confusion Matrix

<table>
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<tr>
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<tr>
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<td>4</td>
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Fold: 2

Rule 0 : IF  thal = normal  AND thalach >= 110.45963770271001 AND oldpeak <= 2.752867951483059 AND ca <= 2.400094422406193 THEN <50

Rule 1 : IF  chol <= 314.4660140926551 AND thalach >= 88.22313553800025 AND oldpeak <= 5.382304898713404 AND ca <= 0.7071765415484652 THEN <50

Rule 2 : IF  exang = no AND trestbps <= 178.27125582440337 AND thalach >= 132.7246420164332 AND oldpeak <= 2.47986178540013 THEN <50

Rule 3 : IF  thalach >= 109.41351501035683 AND oldpeak <= 3.0834417920129287 ca <= 0.7724689010012897 THEN <50

Rule 4 : IF  cp = asympt AND chol >= 160.90835311537174 AND chol <= 353.8406291622336 AND thalach <= 181.82394767991175 THEN >50_1

Rule 5 : IF  sex = male AND age >= 44.583130118477 AND trestbps >= 105.29526763154742 AND chol >= 135.43852075185467 AND thalach <= 174.85686900882723 THEN >50_1

Rule 6 : IF THEN >50_1
Confusion Matrix

<table>
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<tr>
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<th>&gt;50_1</th>
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**Fold: 3**

Rule 0: IF thal = normal AND trestbps <= 160.16298129271001 AND thalach >= 112.41800784231224 AND oldpeak <= 2.473745950579219 AND ca <= 2.8807788259485165 THEN <50

Rule 1: IF thalach >= 84.28650888205506 AND oldpeak <= 3.0233542053694222 AND ca <= 0.09454017910109382 THEN <50

Rule 2: IF exang = no AND trestbps <= 178.27125582440337 AND thalach >= 132.7246420164332 AND oldpeak <= 2.479861785840013 THEN <50

Rule 3: IF cp = asympt AND trestbps >= 107.5280507048431 AND thalach <= 177.0855807957433 THEN >50_1

Rule 4: IF cp = asympt AND chol >= 160.90835311537174 AND chol <= 353.8406291622336 AND thalach <= 181.82394767991175 THEN >50_1

Rule 5: IF sex = male AND age >= 44.653525198164424 AND trestbps >= 107.51014669317424 AND thalach <= 174.77881277657215 THEN >50_1

Rule 6: IF sex = male AND age >= 44.73476541783919 AND trestbps >= 94.82337281455604 AND thalach <= 174.80077281272133 THEN >50_1

Rule 7: IF THEN >50_1
Confusion Matrix

<table>
<thead>
<tr>
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<th>&lt;50</th>
<th>&gt;50_1</th>
</tr>
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<tbody>
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<tr>
<td>&gt;50_1</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Fold: 4

Rule 0: IF thal = normal AND trestbps <= 163.13262829904284 AND thalach >= 108.1259859379205 AND oldpeak <= 3.5605959200504245 AND ca <= 2.184603689282199 THEN <50

Rule 1: IF thalach >= 85.87581646081675 AND oldpeak <= 2.429285305185656 AND ca <= 0.7444254630210769 THEN <50

Rule 2: IF thal = normal AND trestbps <= 165.0064401694227 AND thalach >= 111.01562072987832 AND oldpeak <= 3.5081929907732152 AND ca <= 1.6286232798233533 THEN <50

Rule 3: IF exang = no AND trestbps <= 178.34124232575127 AND thalach >= 114.17766775285092 AND oldpeak <= 2.4007258172888637 THEN <50

Rule 4: IF sex = male AND age >= 44.510627269912625 AND trestbps >= 95.75861725227075 AND thalach <= 174.26218920193094 THEN >50_1

Rule 5: IF cp = asympt AND age <= 70.32879071978309 AND trestbps >= 107.4888079716948 AND thalach <= 175.7877111092465 THEN >50_1
Rule 6 : IF THEN  >50_1

Confusion Matrix

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</table>

Fold: 5

Rule 0 : IF  thal  = normal AND age  <= 76.40452483421694 AND trestbps <= 173.90540610629827 AND chol >= 149.3453526115907 AND thalach >= 109.93627049056816 AND oldpeak <= 2.5236440273159206 THEN <50

Rule 1 : IF  thalach  >= 109.41351501035683 AND oldpeak <= 3.0834417920129287 ca <= 0.7724689010012897 THEN <50

Rule 2 : IF  thal  = normal AND thalach >= 110.45963770271001 AND oldpeak <= 2.752867951483059 AND ca <= 2.400094422406193 THEN <50

Rule 3 : IF  chol  <= 314.4660140926551 AND thalach  >= 88.22313553800025 AND oldpeak <= 5.382304898713404 AND ca <= 0.7071765415484652 THEN <50

Rule 4 : IF  cp  = asymt AND trestbps  >= 109.72922827269333 AND thalach  <= 177.53329191346106 THEN >50_1

Rule 5 : IF  sex  = male AND age  >= 44.59315866020773 AND trestbps  >= 99.20663140105107 AND thalach  <= 173.48000574324203 THEN >50_1
Rule 6: IF THEN  >50_1

Confusion Matrix

<table>
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<tr>
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<th>&gt;50_1</th>
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<tr>
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<tr>
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<td>6</td>
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</tbody>
</table>

Fold: 6

Rule 0: IF thal = normal AND trestbps <= 173.42285913556307 AND thalach >= 114.71707409116978 AND oldpeak <= 2.492083814126619 AND ca <= 2.614082626554331 THEN <50

Rule 1: IF trestbps <= 172.48226226023792 AND chol >= 175.97914120275385 AND oldpeak <= 3.5714377023319495 AND ca <= 0.7455754005891359 THEN <50

Rule 2: IF thal = normal AND trestbps <= 160.16298129271001 AND thalach >= 112.41800784231224 AND oldpeak <= 2.473745950579219 AND ca <= 2.8807788259485165 THEN <50

Rule 3: IF thalach >= 84.28650888205506 AND oldpeak <= 3.0233542053694222 AND ca <= 0.09454017910109382 THEN <50

Rule 4: IF exang = no AND trestbps <= 178.27125582440337 AND thalach >= 132.7246420164332 AND oldpeak <= 2.479861785840013 THEN <50

Rule 5: IF cp = asympt AND trestbps >= 107.52805070488431 AND thalach <= 177.0855807957433 THEN >50_1
Rule 6: IF sex = male AND age >= 44.06131849281444 AND trestbps >= 99.31710539969964 AND thalach <= 174.34657042605673 THEN >50_1

Rule 7: IF cp = asympt AND trestbps >= 107.1985016998776 AND thalach <= 177.94543902590584 THEN >50_1

Rule 8: IF THEN >50_1

Confusion Matrix

|       | <50 | >50_1
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</tr>
<tr>
<td>&gt;50_1</td>
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Fold: 7

Rule 0: IF age <= 64.2022328285756 AND chol >= 200.922690670091 AND chol <= 273.27305419927256 AND thalach >= 102.2204118835124 THEN <50

Rule 1: IF exang = no AND trestbps <= 166.11346658562803 AND thalach >= 114.25201402979359 AND oldpeak <= 2.5552378709347785 AND ca <= 1.8161097901405747 THEN <50

Rule 2: IF sex = male AND age >= 44.66571198757155 AND trestbps >= 94.33993929115866 AND trestbps <= 171.11440421548372 AND thalach <= 174.56356981367668 THEN >50_1

Rule 3: IF cp = asympt AND trestbps >= 106.71060776366346 AND thalach <= 177.38365083903986 THEN >50_1

Rule 4: IF slope = up AND age <= 74.58784742408932 AND oldpeak <= 1.825545490995543 THEN <50

Rule 5: IF THEN >50_1
Confusion Matrix

<table>
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<tr>
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<tbody>
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<td>10</td>
</tr>
<tr>
<td>&lt;50</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

**Fold: 8**

Rule 0: IF thal = normal AND trestbps <= 165.0064401694227 AND thalach >= 111.01562072987832 AND oldpeak <= 3.5081929907732152 AND ca <= 1.6268232798233533 THEN <50

Rule 1: IF exang = no AND trestbps <= 178.34124232575127 AND thalach >= 114.17766775285092 AND oldpeak <= 2.400725817288637 THEN <50

Rule 2: IF cp = asympt AND trestbps >= 107.84761342485562 AND chol <= 353.3449885207369 AND thalach <= 177.09035360610184 THEN >50_1

Rule 3: IF sex = male AND age >= 44.73476541783919 AND trestbps >= 94.82337281455604 AND thalach <= 174.80077281272133 THEN >50_1

Rule 4: IF THEN >50_1

Confusion Matrix

<table>
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<tr>
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<th>&gt;50</th>
<th>&lt;50</th>
</tr>
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<tbody>
<tr>
<td>&gt;50</td>
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<td>5</td>
</tr>
<tr>
<td>&lt;50</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

**Fold: 9**

Rule 0: IF thal = normal AND trestbps <= 165.02010060959404 AND thalach >= 112.20730068655651 AND oldpeak <= 2.4705681929019914 AND ca <= 2.3567901615445126 THEN <50
Rule 1 : IF sex = male AND age >= 44.29016789651519 AND trestbps >= 106.16131959644632 AND thalach <= 174.4812925145705 THEN >50_1

Rule 2 : IF cp = asympt AND thalach <= 177.97089130686393 THEN >50_1

Rule 3 : IF thalach >= 76.55827400996685 AND oldpeak <= 4.348682532686168 AND ca <= 0.7425751042142188 THEN <50

Rule 4 : IF THEN >50_1

Rule 5 : IF cp = asympt AND trestbps >= 106.57618560190011 AND thalach <= 181.16273381938464 THEN >50_1

Rule 6 : IF cp = asympt AND trestbps >= 109.72922827269333 AND thalach <= 177.53329191346106 THEN >50_1

Rule 7 : IF sex = male AND thalach <= 168.6815442271605 THEN >50_1

Rule 8 : IF THEN >50_1

Confusion Matrix

<table>
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<tr>
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<th>&gt;50_1</th>
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<tbody>
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<td>2</td>
</tr>
<tr>
<td>&lt;50</td>
<td>3</td>
<td>13</td>
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</tbody>
</table>

Average Accuracy: 85.46 ± 8.45

Overall Average Rules : 8

Overall Average Rule Length : 3