报告

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1. 目标

练习如何构建决策树。认识归一化和离散化对构建决策树的影响。

2. Data

1) Bank-all.arff 是银行的所有数据。当我们不拆分数据的时候，我们可以用 10-crossvalidation 来测试分类器的准确性。数据的最后一个属性是类标签。

2) Bank-train.arff is used for constructing the model.

   Bank-test.arff is used for testing the model.

   The last attribute is the class label.

3）**weather-nominal.arff**

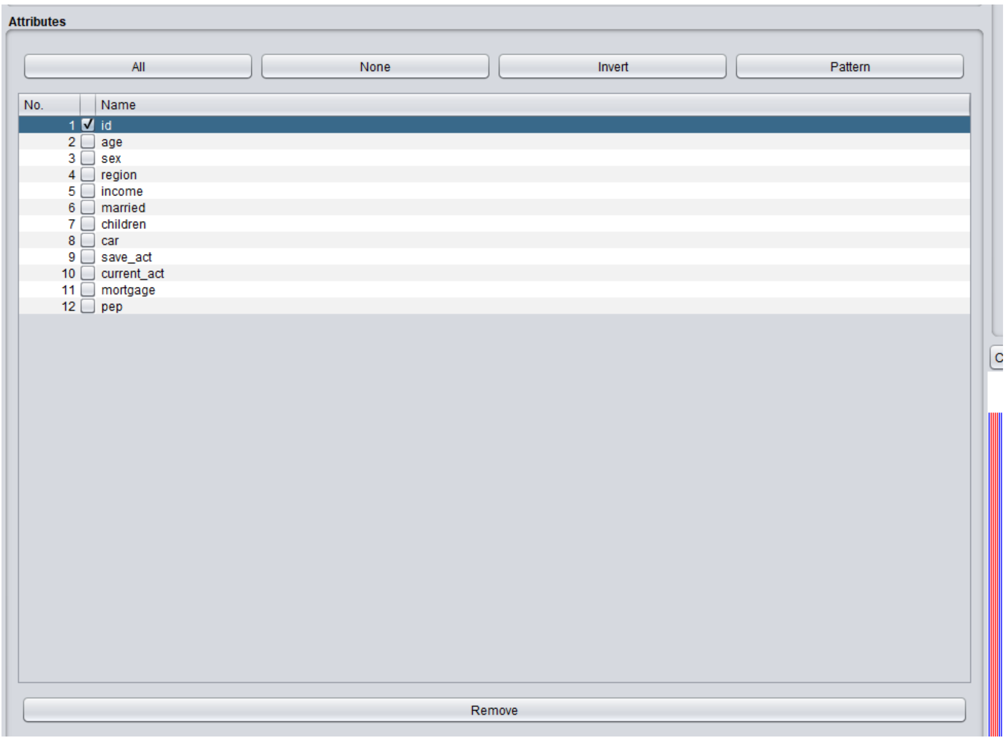
3. Contents

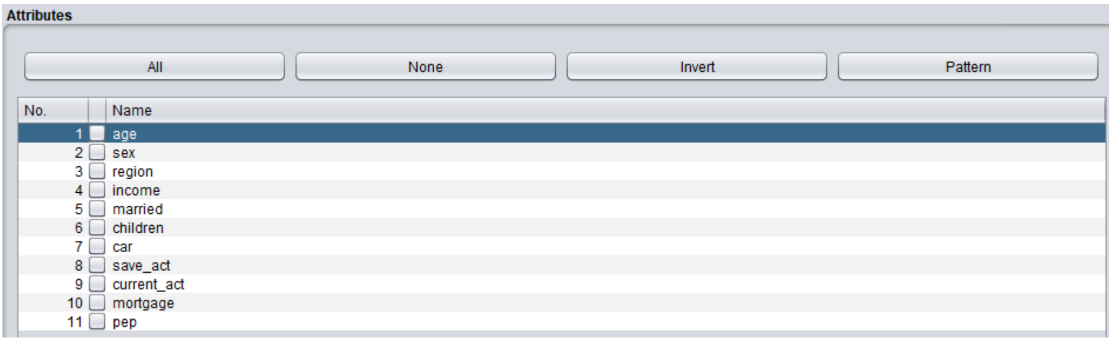
两个实验：

1. Bank-all.arff

1) 预处理，删除无用属性，保存到新的数据文件。

   导入 weka，id 这一属性对于我们分类是无用属性，因此 remove，保存到新的文件 Bank-all-1.arff。

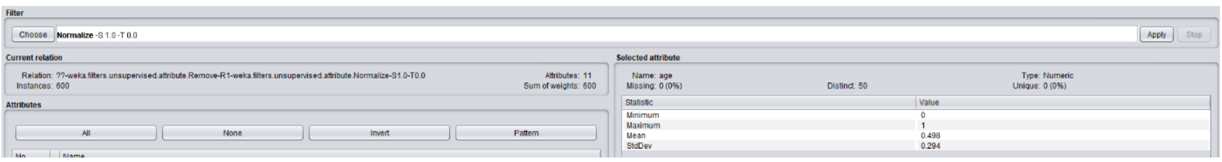


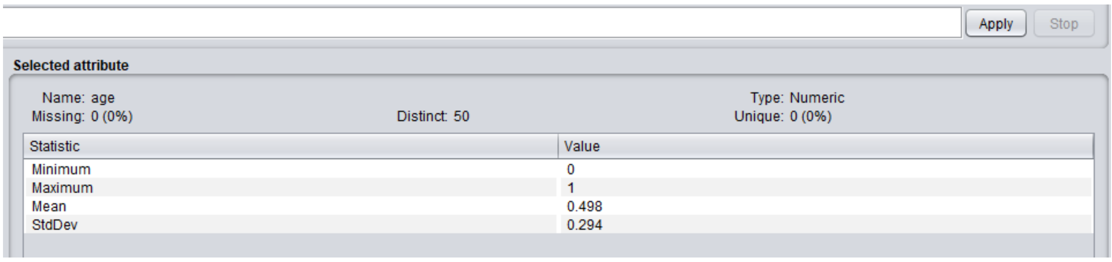


2) 选择两种方法对数据进行规范化，保存到新的数据文件中。并列出规范化的结果。

min-max 标准化：

点击该页中，Filter 下方的 Choose，在 unsupervised 文件夹下找到 Normalize。

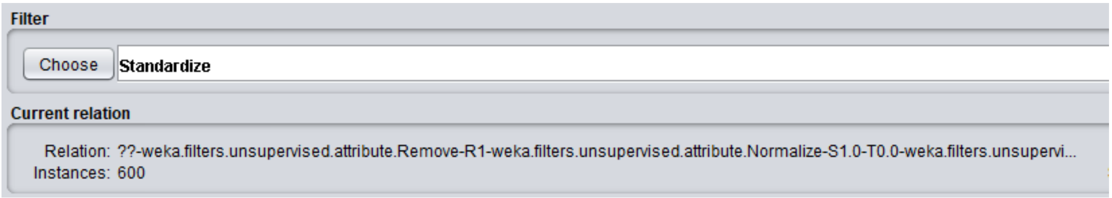


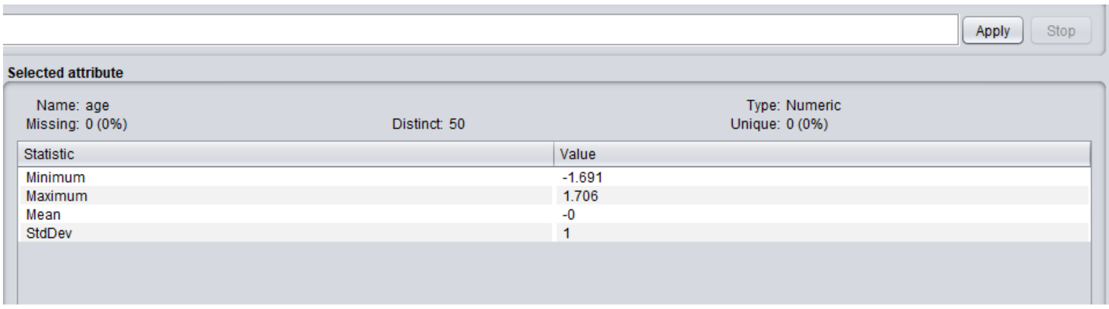


点击 Apply 归一，并 save 保存为新的文件 bank-all-2.1.arff

z-score 标准化：

点击该页中，Filter 下方的 Choose，在 unsupervised 文件夹下找到 Standardize。点击 Apply 归一，并 save 保存为新的文件 bank-all-2.2.arff。

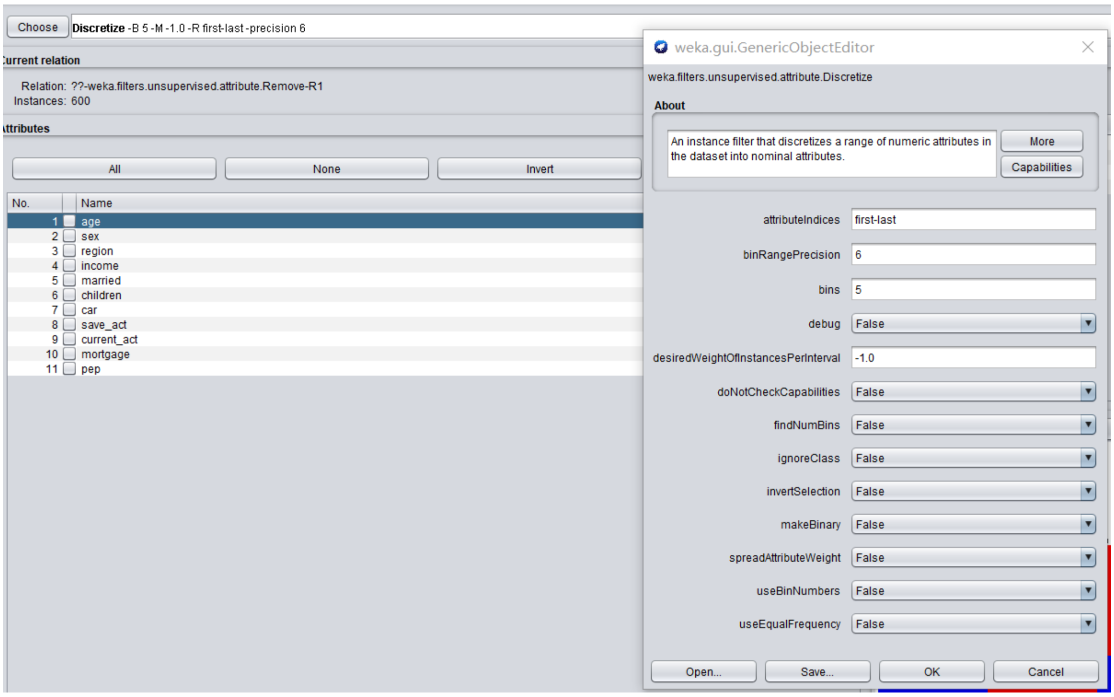


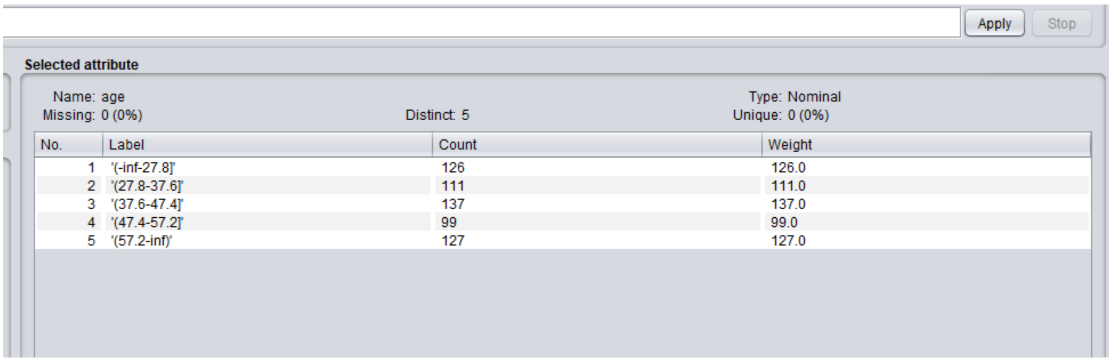


3) 选择两种方法对数据进行离散，保存到新的数据文件中。并列出离散化的结果。

等宽离散化

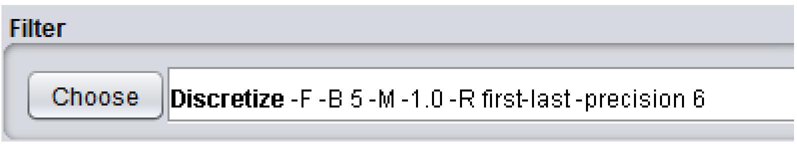
点击该页中，Filter 下方的 Choose，在 unsupervised 文件夹下找到 Discretize，并修改参数。点击 Apply 离散，并 save 保存为新的文件 bank-all-3.1.arff。

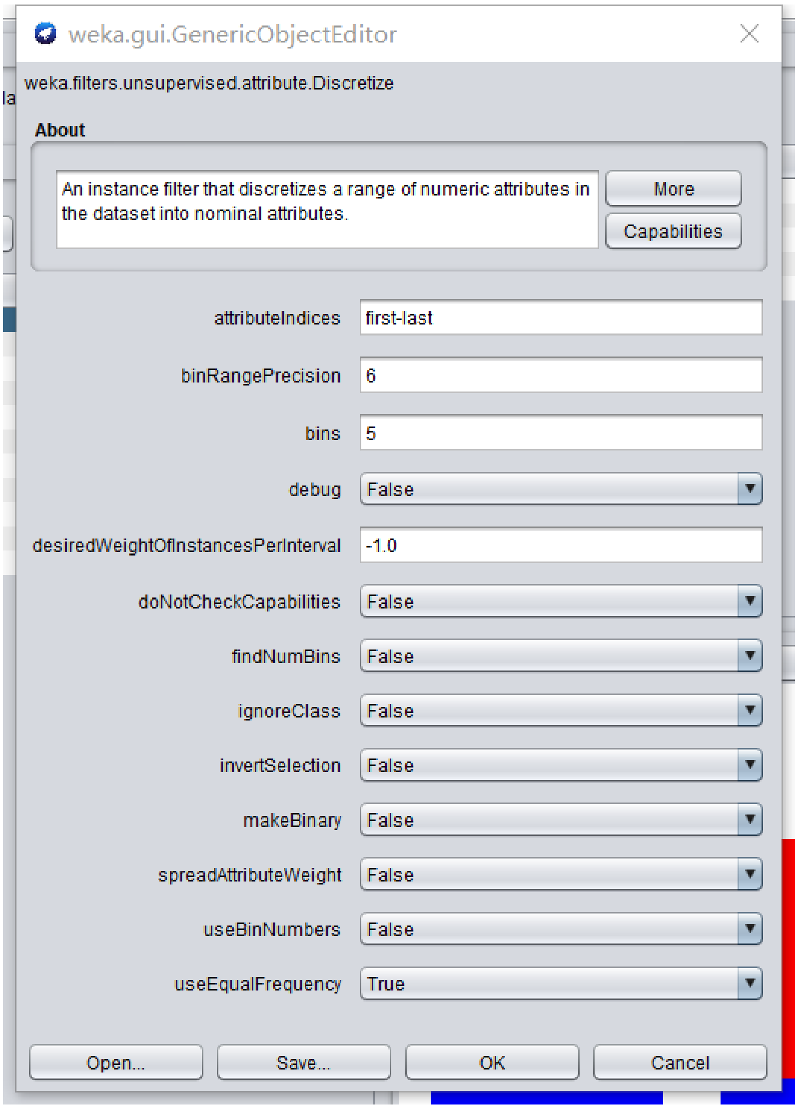


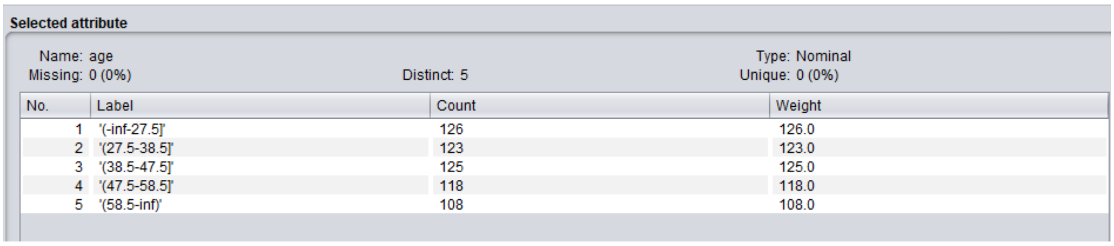


等频离散化

点击该页中，Filter 下方的 Choose，在 unsupervised 文件夹下找到 Discretize，并修改参数。点击 Apply 离散，并 save 保存为新的文件 bank-all-3.2.arff。





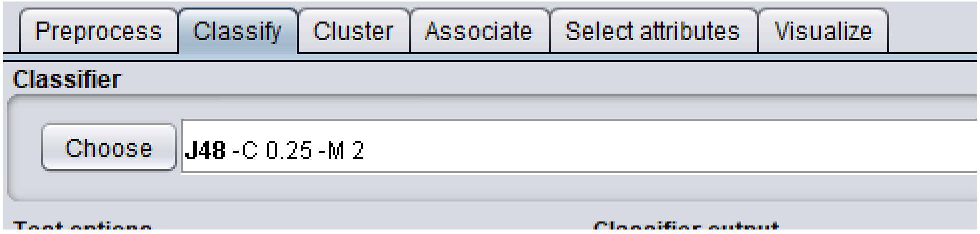

Selected attribute

Name: age
Missing: 0 (0%)
Distinct: 5
Type: Nominal
Unique: 0 (0%)

No.	Label	Count	Weight
1	'(-inf-27.5]'	126	126.0
2	'(27.5-38.5]'	123	123.0
3	'(38.5-47.5]'	125	125.0
4	'(47.5-58.5]'	118	118.0
5	'(58.5-inf)'	108	108.0

4) 利用银行原始数据，用 J48 构建决策树。选择 10-crossvalidation。比较 J48 与 binary split 或 multiple split 的结果。分析 "minNumObj "参数的影响（选择 minNumObj=2 或 1）。

打开原始数据，在 classify 界面中，点击 choose 里的 tree 文件夹，选择 J48，并根据要求调整参数



multiple split minNumObj=2

```
|   |   save_act = YES: NO (119.0/12.0)
children = 1
|   income <= 15538.8
|   |   age <= 41: NO (22.0/2.0)
|   |   age > 41: YES (2.0)
|   income > 15538.8: YES (111.0/5.0)
children = 2
|   income <= 30189.4: NO (83.0/9.0)
|   income > 30189.4: YES (51.0/5.0)
children = 3
|   income <= 44288.3: NO (60.0/5.0)
|   income > 44288.3: YES (8.0)

Number of Leaves  :     15

Size of the tree :      27


Time taken to build model: 0.02 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances         546               91      %
Incorrectly Classified Instances        54                9      %
Kappa statistic                          0.8178
Mean absolute error                      0.1559
Root mean squared error                  0.2903
Relative absolute error                 31.4168 %
Root relative squared error             58.2815 %
Total Number of Instances              600

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.872    0.058    0.926      0.872    0.898      0.819    0.893     0.862     YES
                 0.942    0.128    0.898      0.942    0.919      0.819    0.893     0.869     NO
Weighted Avg.    0.910    0.096    0.911      0.910    0.910      0.819    0.893     0.866

=== Confusion Matrix ===

   a   b   <-- classified as
 239  35 |   a = YES
  19 307 |   b = NO
```

multiple split minNumObj=1

```
=== Classifier model (full training set) ===

J48 pruned tree
------------------
: NO (600.0/274.0)

Number of Leaves  :     1

Size of the tree :      1


Time taken to build model: 0 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances         326               54.3333 %
Incorrectly Classified Instances       274               45.6667 %
Kappa statistic                          0
Mean absolute error                      0.4963
Root mean squared error                  0.4981
Relative absolute error                 99.9972 %
Root relative squared error            100      %
Total Number of Instances              600

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.000    0.000    ?          0.000    ?          ?        0.492     0.453     YES
                 1.000    1.000    0.543      1.000    0.704      ?        0.492     0.539     NO
Weighted Avg.    0.543    0.543    ?          0.543    ?          ?        0.492     0.500

=== Confusion Matrix ===

   a   b   <-- classified as
   0 274 |   a = YES
   0 326 |   b = NO
```

Binary split minNumObj=1

```
=== Summary ===

Correctly Classified Instances         525               87.5    %
Incorrectly Classified Instances        75               12.5    %
Kappa statistic                          0.747
Mean absolute error                      0.1806
Root mean squared error                  0.3431
Relative absolute error                 36.3861 %
Root relative squared error             68.8846 %
Total Number of Instances              600

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.836    0.092    0.884      0.836    0.859      0.748    0.848     0.779     YES
                 0.908    0.164    0.868      0.908    0.888      0.748    0.848     0.832     NO
Weighted Avg.    0.875    0.131    0.875      0.875    0.875      0.748    0.848     0.808

=== Confusion Matrix ===

   a   b   <-- classified as
 229  45 |   a = YES
  30 296 |   b = NO
```

Binary split minNumObj=2

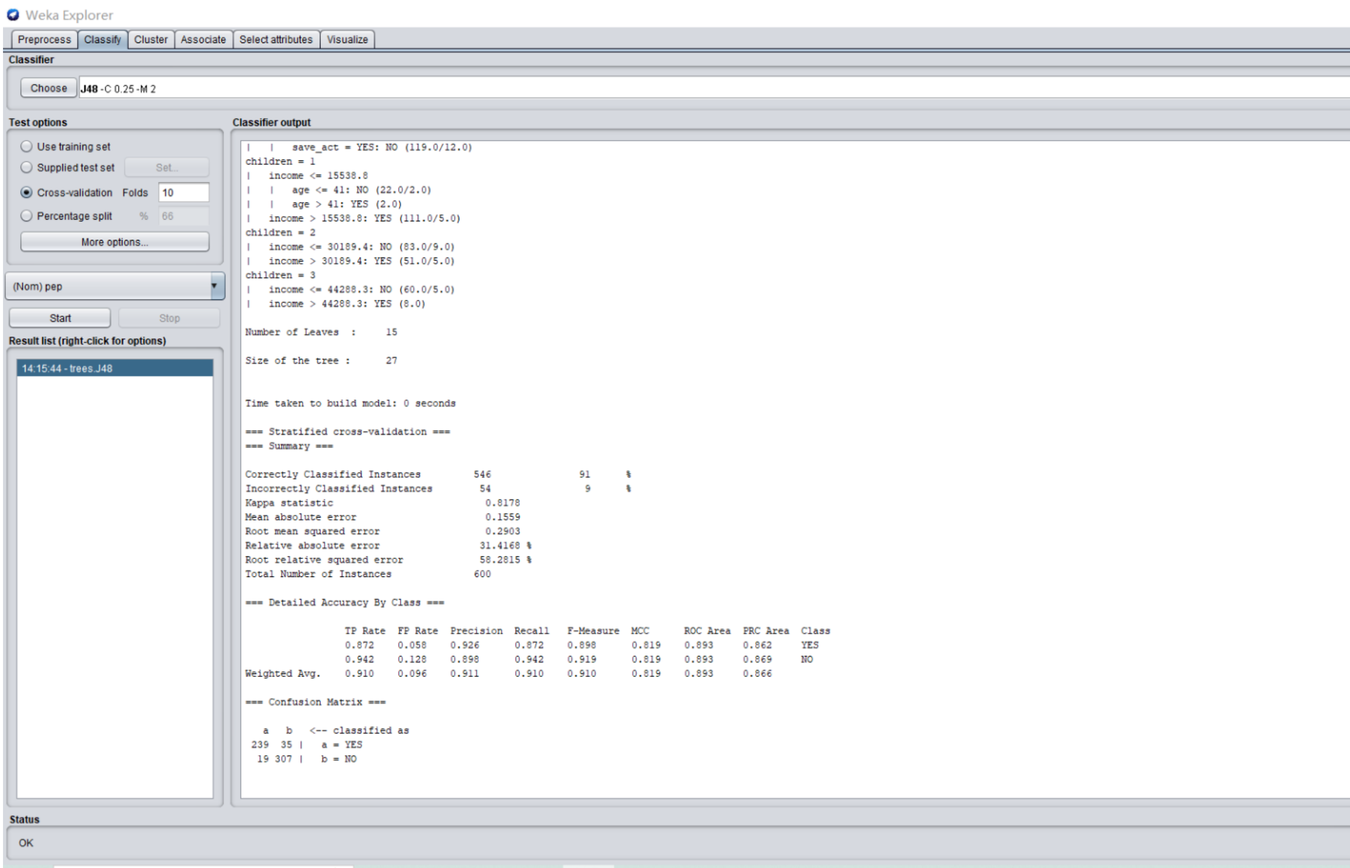
```
=== Summary ===

Correctly Classified Instances         523               87.1667 %
Incorrectly Classified Instances        77               12.8333 %
Kappa statistic                          0.7401
Mean absolute error                      0.1856
Root mean squared error                  0.3451
Relative absolute error                 37.3999 %
Root relative squared error             69.2717 %
Total Number of Instances              600

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.828    0.092    0.883      0.828    0.855      0.741    0.848     0.794     YES
                 0.908    0.172    0.863      0.908    0.885      0.741    0.848     0.818     NO
Weighted Avg.    0.872    0.135    0.872      0.872    0.871      0.741    0.848     0.807

=== Confusion Matrix ===

   a   b   <-- classified as
 227  47 |   a = YES
  30 296 |   b = NO
```

对于原始数据,Binary split 准确率比 multiple split 的偏低， minNumObj 的选择也有影响，minNumObj=2 准确率较高

5) 利用规范化数据用 J48 构建决策树。选择 10-crossvalidation。比较 J48 与 binary split 或 multiple split 的结果。分析 "minNumObj "参数的影响（选择 minNumObj=2 或 1）。

选择归一化数据，并重复以上步骤

multiple split minNumObj=2



multiple split minNumObj=1

```
Time taken to build model: 0 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances         546               91      %
Incorrectly Classified Instances        54                9      %
Kappa statistic                          0.8178
Mean absolute error                      0.1559
Root mean squared error                  0.2903
Relative absolute error                 31.4168 %
Root relative squared error             58.2815 %
Total Number of Instances              600

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.872    0.058    0.926      0.872    0.898      0.819    0.893     0.862     YES
                 0.942    0.128    0.898      0.942    0.919      0.819    0.893     0.869     NO
Weighted Avg.    0.910    0.096    0.911      0.910    0.910      0.819    0.893     0.866

=== Confusion Matrix ===

   a   b   <-- classified as
 239  35 |   a = YES
  19 307 |   b = NO
```

Binary split minNumObj=1

```
=== Summary ===

Correctly Classified Instances         526               87.6667 %
Incorrectly Classified Instances        74               12.3333 %
Kappa statistic                          0.7504
Mean absolute error                      0.1787
Root mean squared error                  0.3396
Relative absolute error                 36.0083 %
Root relative squared error             68.1725 %
Total Number of Instances              600

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.839    0.092    0.885      0.839    0.861      0.751    0.856     0.792     YES
                 0.908    0.161    0.871      0.908    0.889      0.751    0.856     0.839     NO
Weighted Avg.    0.877    0.129    0.877      0.877    0.876      0.751    0.856     0.818

=== Confusion Matrix ===

   a   b   <-- classified as
 230  44 |   a = YES
  30 296 |   b = NO
```

Binary split minNumObj=2

```
=== Summary ===

Correctly Classified Instances         523               87.1667 %
Incorrectly Classified Instances        77               12.8333 %
Kappa statistic                          0.7401
Mean absolute error                      0.1856
Root mean squared error                  0.3451
Relative absolute error                 37.3999 %
Root relative squared error             69.2717 %
Total Number of Instances              600

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.828    0.092    0.883      0.828    0.855      0.741    0.848     0.794     YES
                 0.908    0.172    0.863      0.908    0.885      0.741    0.848     0.818     NO
Weighted Avg.    0.872    0.135    0.872      0.872    0.871      0.741    0.848     0.807

=== Confusion Matrix ===

   a   b   <-- classified as
 227  47 |   a = YES
  30 296 |   b = NO
```

对于归一化数据，Binary split 准确率比 multiple split 的偏低，但 minNumObj 的选择几乎无影响

6) 利用离散化数据，用 ID3 构建决策树，展示结果。

首先，在 weka 的 Tools->package manager 里找到下述包进行安装

simpleEducationalLearningSchemes

```
=== Summary ===

Correctly Classified Instances         459               76.5    %
Incorrectly Classified Instances       116               19.3333 %
Kappa statistic                          0.5931
Mean absolute error                      0.1974
Root mean squared error                  0.4418
Relative absolute error                 41.5496 %
Root relative squared error             90.705  %
UnClassified Instances                  25                4.1667 %
Total Number of Instances              600

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.784    0.190    0.772      0.784    0.778      0.593    0.784     0.701     YES
                 0.810    0.216    0.821      0.810    0.815      0.593    0.797     0.765     NO
Weighted Avg.    0.798    0.204    0.799      0.798    0.798      0.593    0.791     0.736

=== Confusion Matrix ===

   a   b   <-- classified as
 203  56 |   a = YES
  60 256 |   b = NO
```

7) 对比 J48 和 ID3 的结果。

本实验 J48 的分类效果要好于 ID3，应采用 J48 来进行，可能由于 J48 的属性可以是连续值，ID3 的属性必须是离散值，而该实验的数据并不均是离散的。

2．用规范化数据和离散化数据生成训练（400 个对象）和测试（200 个对象）文件。使用训练数据来训练模型，使用测试数据来测试模型。

1) 对于规范化数据，比较 J48 中 binary split 或 multiple split 的结果。分析 "minNumObj "参数的影响（选择 minNumObj=2 或 1）。

multiple split minNumObj=2

```
=== Summary ===

Correctly Classified Instances         177               88.5    %
Incorrectly Classified Instances        23               11.5    %
Kappa statistic                          0.7681
Mean absolute error                      0.1685
Root mean squared error                  0.3248
Total Number of Instances              200

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.821    0.057    0.929      0.821    0.872      0.773    0.886     0.878     YES
                 0.943    0.179    0.853      0.943    0.896      0.773    0.886     0.856     NO
Weighted Avg.    0.885    0.121    0.889      0.885    0.884      0.773    0.886     0.866

=== Confusion Matrix ===

  a  b   <-- classified as
 78 17 |  a = YES
  6 99 |  b = NO
```

multiple split minNumObj=1

```
=== Summary ===

Correctly Classified Instances         175               87.5    %
Incorrectly Classified Instances        25               12.5    %
Kappa statistic                          0.7482
Mean absolute error                      0.1688
Root mean squared error                  0.3368
Total Number of Instances              200

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Clas
                 0.821    0.076    0.907      0.821    0.862      0.751    0.883     0.846     YES
                 0.924    0.179    0.851      0.924    0.886      0.751    0.883     0.871     NO
Weighted Avg.    0.875    0.130    0.878      0.875    0.874      0.751    0.883     0.859

=== Confusion Matrix ===

  a  b   <-- classified as
 78 17 |  a = YES
  8 97 |  b = NO
```

Binary split minNumObj=1

```
=== Summary ===

Correctly Classified Instances         173               86.5    %
Incorrectly Classified Instances        27               13.5    %
Kappa statistic                          0.7281
Mean absolute error                      0.1736
Root mean squared error                  0.3527
Relative absolute error                 34.9003 %
Root relative squared error             70.5275 %
Total Number of Instances              200

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.811    0.086    0.895      0.811    0.851      0.731    0.869     0.814     YES
                 0.914    0.189    0.842      0.914    0.877      0.731    0.869     0.857     NO
Weighted Avg.    0.865    0.140    0.867      0.865    0.864      0.731    0.869     0.837

=== Confusion Matrix ===

  a  b   <-- classified as
 77 18 |  a = YES
  9 96 |  b = NO
```

Binary split minNumObj=2

```
=== Summary ===

Correctly Classified Instances         177               88.5    %
Incorrectly Classified Instances        23               11.5    %
Kappa statistic                          0.7681
Mean absolute error                      0.1693
Root mean squared error                  0.3246
Relative absolute error                 34.0386 %
Root relative squared error             64.9126 %
Total Number of Instances              200

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Clas
                 0.821    0.057    0.929      0.821    0.872      0.773    0.887     0.874     YES
                 0.943    0.179    0.853      0.943    0.896      0.773    0.887     0.861     NO
Weighted Avg.    0.885    0.121    0.889      0.885    0.884      0.773    0.887     0.867

=== Confusion Matrix ===

  a  b   <-- classified as
 78 17 |  a = YES
  6 99 |  b = NO
```

该实验，binary split 和 mutiple split 的结果相近，minNumObj=2 时的结果略好于 minNumObj=1 时的结果。

2) 对于离散数据，给出 1）中的结果，并分析规范化数据与离散数据效果上的差别。

选择相同的离散化标准，对测试集和训练集，而后用测试集对模型进行训练。

```
=== Summary ===

Correctly Classified Instances         157               78.5    %
Incorrectly Classified Instances        39               19.5    %
Kappa statistic                          0.5995
Mean absolute error                      0.199
Root mean squared error                  0.4432
UnClassified Instances                   4                2      %
Total Number of Instances              200

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.753    0.155    0.814      0.753    0.782      0.601    0.795     0.730     YES
                 0.845    0.247    0.791      0.845    0.817      0.601    0.796     0.748     NO
Weighted Avg.    0.801    0.204    0.802      0.801    0.800      0.601    0.795     0.739

=== Confusion Matrix ===

  a  b   <-- classified as
 70 23 |  a = YES
 16 87 |  b = NO
```

离散数据的准确率比规范化数据的较低，minNumObj 选择影响不大

给出算法中得到的混淆矩阵及计算的准确率、错误率、精确率和召回率。对计算结果进行截图，并用一些可视化的结果来展示你的结果。

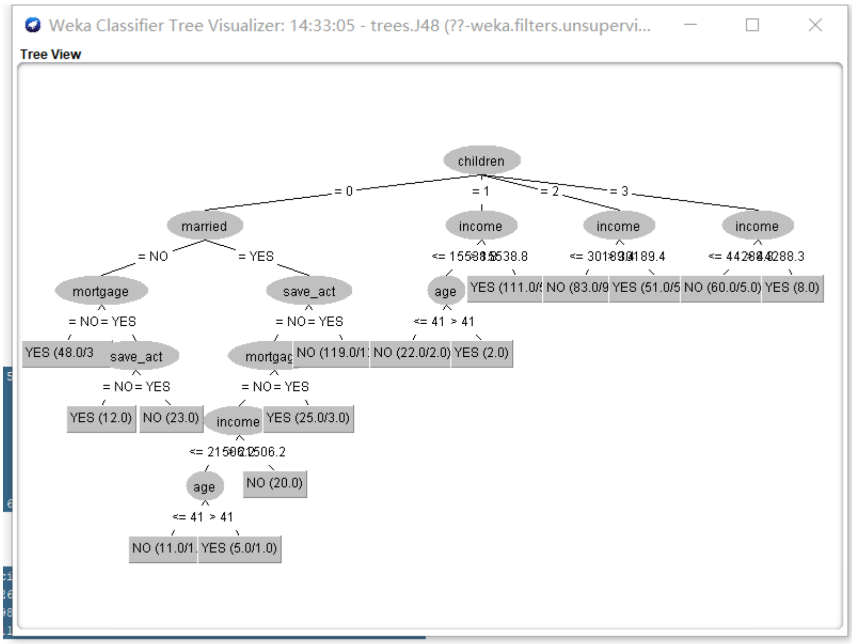
J48：

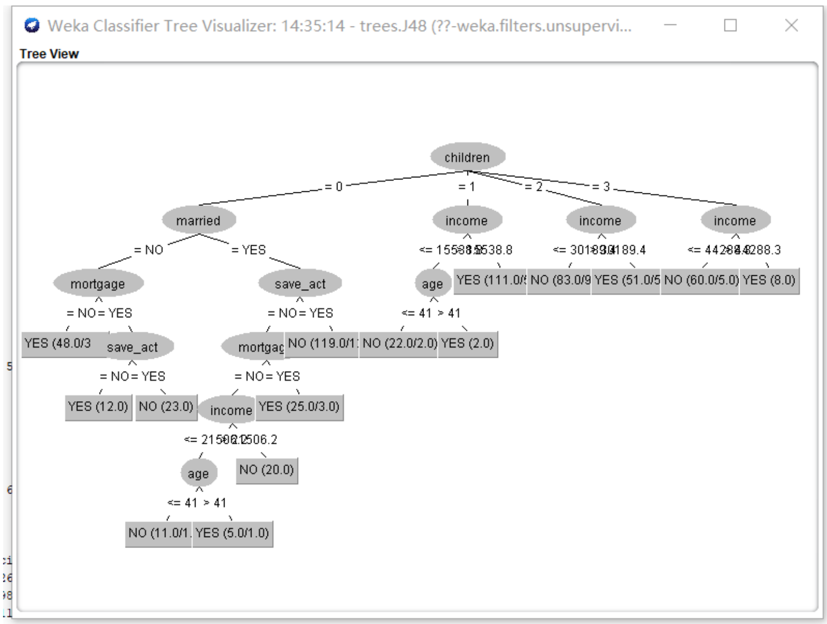
混淆矩阵：

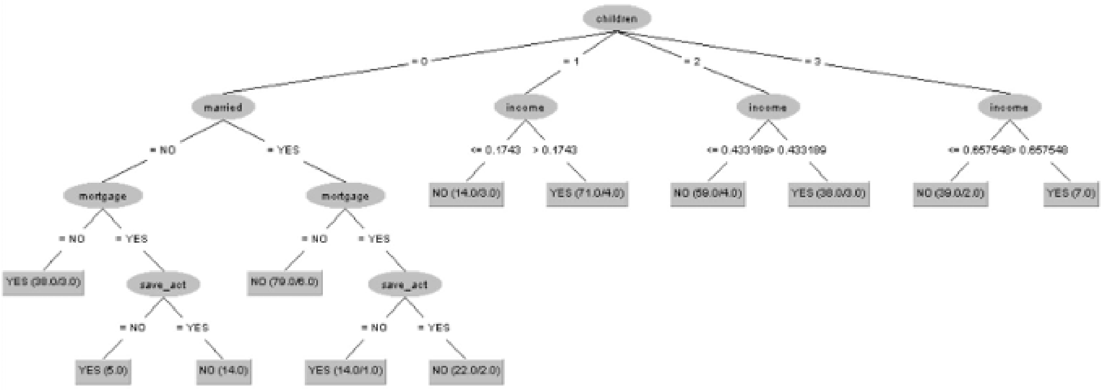
```
=== Confusion Matrix ===

  a  b   <-- classified as
 78 17 |  a = YES
  6 99 |  b = NO
```

（面板中，右键单击相应的输出，然后选择 Visualize tree）

可视化：







准确率=(78+99)/200=88.5%
错误率=1-88.5%=11.5%
精确率=78/(78+6)=92.9%
召回率=78/(78+17)=82.1%

ID3:
混淆矩阵:

```
=== Confusion Matrix ===

  a  b   <-- classified as
 70 23 |  a = YES
 16 87 |  b = NO
```

上网查阅了 ID3 可视化是要修改代码，由 dot 语言进行 Graphviz 绘图的，但多次修改后仍未成功，进行如下展示:

```
children = 0
|   married = NO
|   |   mortgage = NO
|   |   |   age = '(-inf-27.8]': YES
|   |   |   age = '(27.8-37.6]'
|   |   |   |   region = INNER_CITY: YES
|   |   |   |   region = TOWN
|   |   |   |   |   sex = FEMALE: NO
|   |   |   |   |   sex = MALE
|   |   |   |   |   |   income = a: NO
|   |   |   |   |   |   income = b: YES
|   |   |   |   |   |   income = c: null
|   |   |   |   |   |   income = d: null
|   |   |   |   |   |   income = e: null
|   |   |   |   region = RURAL: YES
|   |   |   |   region = SUBURBAN: null
|   |   |   age = '(37.6-47.4]': YES
|   |   |   age = '(47.4-57.2]'
|   |   |   |   income = a: NO
|   |   |   |   income = b: YES
|   |   |   |   income = c: YES
|   |   |   |   income = d: null
|   |   |   |   income = e: null
|   |   |   age = '(57.2-inf)': YES
|   |   mortgage = YES
|   |   |   save_act = NO: YES
|   |   |   save_act = YES: NO
|   married = YES
|   |   mortgage = NO
|   |   |   income = a
|   |   |   |   sex = FEMALE: NO
|   |   |   |   sex = MALE
|   |   |   |   |   age = '(-inf-27.8]'
|   |   |   |   |   |   car = NO: NO
|   |   |   |   |   |   car = YES: YES
|   |   |   |   |   age = '(27.8-37.6]': NO
|   |   |   |   |   age = '(37.6-47.4]': YES
|   |   |   |   |   age = '(47.4-57.2]': null
|   |   |   |   |   age = '(57.2-inf)': null
|   |   |   income = b
|   |   |   |   age = '(-inf-27.8]'
|   |   |   |   |   region = INNER_CITY: YES
|   |   |   |   |   region = TOWN: NO
|   |   |   |   |   region = RURAL: NO
|   |   |   |   |   region = SUBURBAN: NO
|   |   |   |   age = '(27.8-37.6]'
|   |   |   |   |   region = INNER_CITY
|   |   |   |   |   |   sex = FEMALE: NO
|   |   |   |   |   |   sex = MALE: YES
|   |   |   |   |   region = TOWN: NO
|   |   |   |   |   region = RURAL: null
|   |   |   |   |   region = SUBURBAN: null
|   |   |   |   age = '(37.6-47.4]': NO
|   |   |   |   age = '(47.4-57.2]': NO
|   |   |   |   region = INNER_CITY
|   |   |   |   |   income = a: NO
|   |   |   |   |   income = b: NO
|   |   |   |   |   income = c
|   |   |   |   |   |   age = '(-inf-27.8]': null
|   |   |   |   |   |   age = '(27.8-37.6]': null
|   |   |   |   |   |   age = '(37.6-47.4]': YES
|   |   |   |   |   |   age = '(47.4-57.2]': null
|   |   |   |   |   |   age = '(57.2-inf)': NO
|   |   |   |   |   income = d: NO
|   |   |   |   |   income = e: null
|   |   |   |   region = TOWN: NO
|   |   |   |   region = RURAL: NO
|   |   |   |   region = SUBURBAN
|   |   |   |   |   age = '(-inf-27.8]': null
|   |   |   |   |   age = '(27.8-37.6]': NO
|   |   |   |   |   age = '(37.6-47.4]': NO
|   |   |   |   |   age = '(47.4-57.2]': null
|   |   |   |   |   age = '(57.2-inf)': YES
children = 1
|   income = a
|   |   age = '(-inf-27.8]'
|   |   |   sex = FEMALE: NO
|   |   |   sex = MALE
|   |   |   |   married = NO: NO
|   |   |   |   married = YES
|   |   |   |   |   save_act = NO: NO
|   |   |   |   |   save_act = YES: YES
|   |   age = '(27.8-37.6]'
|   |   |   region = INNER_CITY
|   |   |   |   sex = FEMALE: NO
|   |   |   |   sex = MALE
|   |   |   |   |   save_act = NO: NO
|   |   |   |   |   save_act = YES
|   |   |   |   |   |   current_act = NO: NO
|   |   |   |   |   |   current_act = YES: YES
|   |   |   region = TOWN: YES
|   |   |   region = RURAL: null
|   |   |   region = SUBURBAN: null
|   |   age = '(37.6-47.4]'
|   |   |   region = INNER_CITY: NO
|   |   |   region = TOWN: YES
|   |   |   region = RURAL: null
|   |   |   region = SUBURBAN: null
|   |   age = '(47.4-57.2]': YES
|   |   age = '(57.2-inf)': null
|   income = b
|   |   sex = FEMALE
|   |   |   region = INNER_CITY: YES
|   |   |   region = TOWN
|   |   |   |   car = NO: YES
|   |   |   |   car = YES: NO
|   |   |   region = RURAL: NO
|   |   |   region = SUBURBAN: YES
```

```
|   |   |   |   |   age = '(27.8-37.6]': NO
|   |   |   |   |   age = '(37.6-47.4]': YES
|   |   |   |   |   age = '(47.4-57.2]': null
|   |   |   |   |   age = '(57.2-inf)': null
|   |   |   income = b
|   |   |   |   age = '(-inf-27.8]'
|   |   |   |   |   region = INNER_CITY: YES
|   |   |   |   |   region = TOWN: NO
|   |   |   |   |   region = RURAL: NO
|   |   |   |   |   region = SUBURBAN: NO
|   |   |   |   age = '(27.8-37.6]'
|   |   |   |   |   region = INNER_CITY
|   |   |   |   |   |   sex = FEMALE: NO
|   |   |   |   |   |   sex = MALE: YES
|   |   |   |   |   region = TOWN: NO
|   |   |   |   |   region = RURAL: null
|   |   |   |   |   region = SUBURBAN: null
|   |   |   |   age = '(37.6-47.4]': NO
|   |   |   |   age = '(47.4-57.2]': NO
|   |   |   |   age = '(57.2-inf)'
|   |   |   |   |   sex = FEMALE: YES
|   |   |   |   |   sex = MALE: NO
|   |   |   income = c: NO
|   |   |   income = d: NO
|   |   |   income = e: NO
|   |   mortgage = YES
|   |   |   save_act = NO
|   |   |   |   region = INNER_CITY: YES
|   |   |   |   region = TOWN
|   |   |   |   |   age = '(-inf-27.8]': null
|   |   |   |   |   age = '(27.8-37.6]': NO
|   |   |   |   |   age = '(37.6-47.4]': null
|   |   |   |   |   age = '(47.4-57.2]': YES
|   |   |   |   |   age = '(57.2-inf)': null
|   |   |   |   region = RURAL: YES
|   |   |   |   region = SUBURBAN: YES
|   |   |   save_act = YES
|   |   |   |   |   |   current_act = YES: YES
|   |   |   region = TOWN: YES
|   |   |   region = RURAL: null
|   |   |   region = SUBURBAN: null
|   |   age = '(37.6-47.4]'
|   |   |   region = INNER_CITY: NO
|   |   |   region = TOWN: YES
|   |   |   region = RURAL: null
|   |   |   region = SUBURBAN: null
|   |   age = '(47.4-57.2]': YES
|   |   age = '(57.2-inf)': null
|   income = b
|   |   sex = FEMALE
|   |   |   region = INNER_CITY: YES
|   |   |   region = TOWN
|   |   |   |   car = NO: YES
|   |   |   |   car = YES: NO
|   |   |   region = RURAL: NO
|   |   |   region = SUBURBAN: YES
|   |   sex = MALE: YES
|   income = c
|   |   mortgage = NO: YES
|   |   mortgage = YES
|   |   |   age = '(-inf-27.8]': null
|   |   |   age = '(27.8-37.6]': NO
|   |   |   age = '(37.6-47.4]': YES
|   |   |   age = '(47.4-57.2]': YES
|   |   |   age = '(57.2-inf)'
|   |   |   |   sex = FEMALE: YES
|   |   |   |   sex = MALE: NO
|   income = d: YES
|   income = e: YES
children = 2
|   income = a
|   |   region = INNER_CITY
|   |   |   age = '(-inf-27.8]': NO
|   |   |   age = '(27.8-37.6]'
```

```
|    |    |    |    sex = MALE: YES
|    |    |    age = '(37.6-47.4]': null
|    |    |    age = '(47.4-57.2]': null
|    |    |    age = '(57.2-inf)': null
|    |    region = TOWN: NO
|    |    region = RURAL
|    |    |    age = '(-inf-27.8]': NO
|    |    |    age = '(27.8-37.6]': YES
|    |    |    age = '(37.6-47.4]': null
|    |    |    age = '(47.4-57.2]': null
|    |    |    age = '(57.2-inf)': null
|    |    region = SUBURBAN: YES
|    income = b
|    |    age = '(-inf-27.8]'
|    |    |    current_act = NO
|    |    |    |    sex = FEMALE: NO
|    |    |    |    sex = MALE: YES
|    |    |    current_act = YES: NO
|    |    age = '(27.8-37.6]': NO
|    |    age = '(37.6-47.4]': NO
|    |    age = '(47.4-57.2]': NO
|    |    age = '(57.2-inf)': NO
|    income = c
|    |    age = '(-inf-27.8]': null
|    |    age = '(27.8-37.6]': YES
|    |    age = '(37.6-47.4]'
|    |    |    mortgage = NO
|    |    |    |    sex = FEMALE
|    |    |    |    |    married = NO: YES
|    |    |    |    |    married = YES: NO
|    |    |    |    sex = MALE: YES
|    |    |    mortgage = YES: NO
|    |    age = '(47.4-57.2]'
|    |    |    region = INNER_CITY: YES
|    |    |    region = TOWN
|    |    |    |    sex = FEMALE: YES
|    |    |    |    sex = MALE: NO
|    |    |    region = RURAL: null
|    |    |    region = SUBURBAN: YES
```

```
|    |    age = '(-inf-27.8]': null
|    |    age = '(27.8-37.6]': null
|    |    age = '(37.6-47.4]': YES
|    |    age = '(47.4-57.2]': YES
|    |    age = '(57.2-inf)'
|    |    |    sex = FEMALE: YES
|    |    |    sex = MALE: YES
|    income = e: YES
children = 3
|    income = a: NO
|    income = b
|    |    age = '(-inf-27.8]': NO
|    |    age = '(27.8-37.6]': NO
|    |    age = '(37.6-47.4]': NO
|    |    age = '(47.4-57.2]'
|    |    |    sex = FEMALE
|    |    |    |    save_act = NO: NO
|    |    |    |    save_act = YES: YES
|    |    |    sex = MALE: NO
|    |    age = '(57.2-inf)': NO
|    income = c
|    |    age = '(-inf-27.8]': null
|    |    age = '(27.8-37.6]'
|    |    |    sex = FEMALE: NO
|    |    |    sex = MALE: YES
|    |    age = '(37.6-47.4]': NO
|    |    age = '(47.4-57.2]': NO
|    |    age = '(57.2-inf)': NO
|    income = d
|    |    mortgage = NO
|    |    |    age = '(-inf-27.8]': null
|    |    |    age = '(27.8-37.6]': null
|    |    |    age = '(37.6-47.4]': YES
|    |    |    age = '(47.4-57.2]'
|    |    |    |    sex = FEMALE: YES
|    |    |    |    sex = MALE: YES
|    |    |    age = '(57.2-inf)': YES
|    |    mortgage = YES: NO
|    income = e: YES
```

准确率=(70+87)/200=78.5%

错误率=1-78.5%=11.5%

精确率=70/(70+6)=92.1%

召回率=70/(70+23)=75.3%

3. **Data: weather-nominal.arff, which is included in the path of weka.**

1) use weka with ID3 to construct a tree.

决策树：

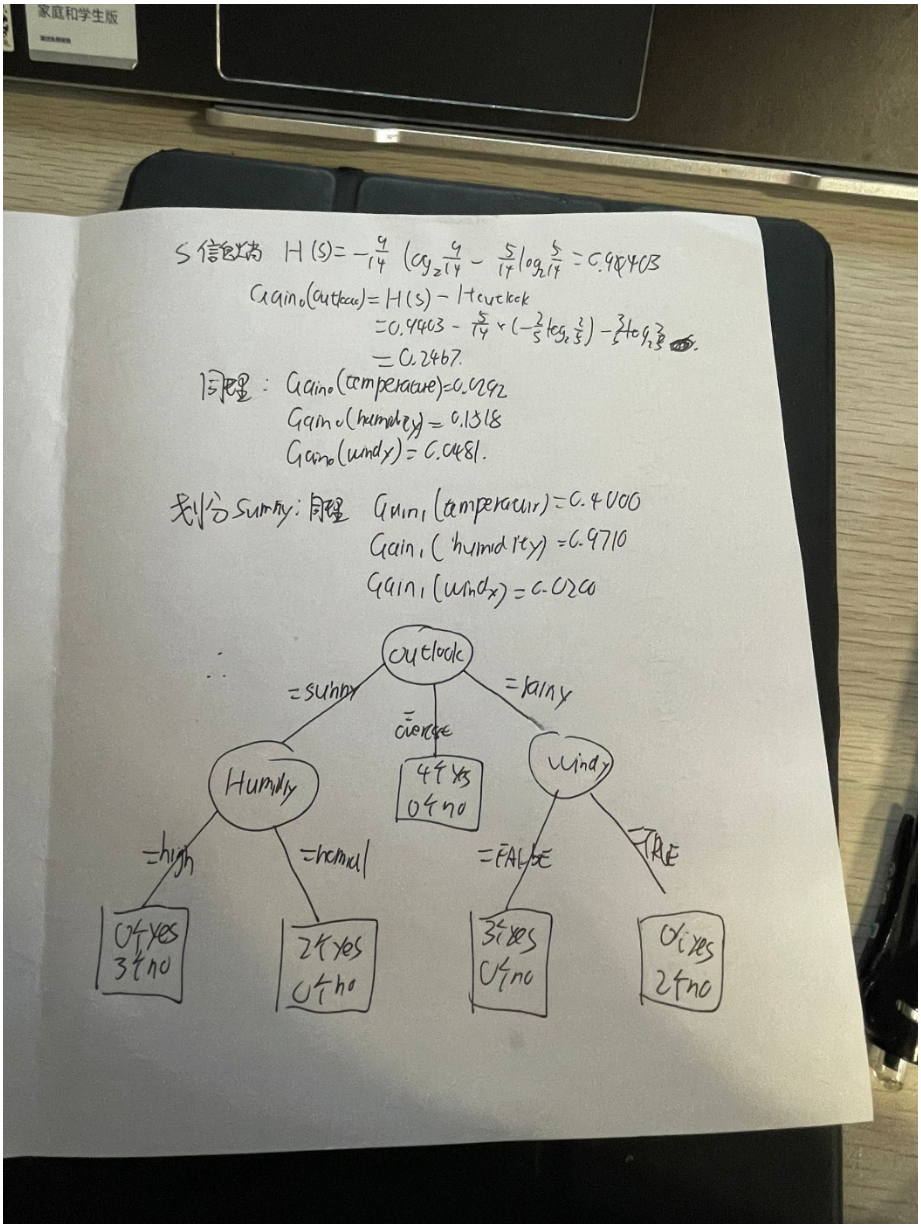
```
outlook = sunny
|    humidity = high: no
|    humidity = normal: yes
outlook = overcast: yes
outlook = rainy
|    windy = TRUE: no
|    windy = FALSE: yes
```

混淆矩阵：

```
=== Confusion Matrix ===

 a b   <-- classified as
 8 1 | a = yes
 1 4 | b = no
```

2） construct a tree manually

No.	1: outlook Nominal	2: temperature Nominal	3: humidity Nominal	4: windy Nominal	5: play Nominal
1	sunny	hot	high	FALSE	no
2	sunny	hot	high	TRUE	no
3	overcast	hot	high	FALSE	yes
4	rainy	mild	high	FALSE	yes
5	rainy	cool	normal	FALSE	yes
6	rainy	cool	normal	TRUE	no
7	overcast	cool	normal	TRUE	yes
8	sunny	mild	high	FALSE	no
9	sunny	cool	normal	FALSE	yes
10	rainy	mild	normal	FALSE	yes
11	sunny	mild	normal	TRUE	yes
12	overcast	mild	high	TRUE	yes
13	overcast	hot	normal	FALSE	yes
14	rainy	mild	high	TRUE	no



3) compare the upper two methods.

两种方法，所得实验结果相同