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Association analysis - Lab 1

In the lab is three different experiments conducted. For each of the experiment is the data discretized into a number of different bins. The number of different states the features are divided into decides which data that is used in the SimpleKMeans clustering. The *k* that is specified for each SimpleKMeans clustering decides the number of clusters that are created. These clusters are then further analyzed with a association analysis where the best rules that has one of the respective clusters as consequents are the rules of interest.

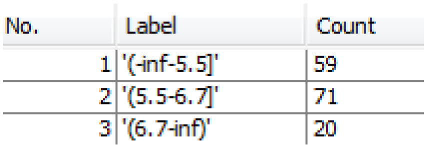
In the first experiment is the respective features discretized into three separate bins and for the simpleKMeans clustering is k=3. The two following experiments are variations of the first experiment. In the second experiment is *k* changed to 4 and the number of bins is held fixed. For the last experiment is it instead the number of bins that is 4 and the number of clusters is held fixed at k=3.

3 clusters and 3 bins

The bins

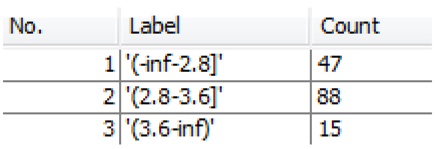
The features in the data set with numerical data is discretized into the following states.

Sepal length



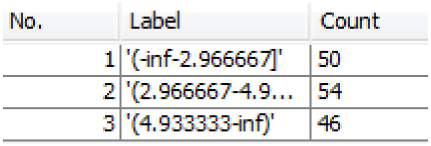
No.	Label	Count
1	'(-inf-5.5]'	59
2	'(5.5-6.7]'	71
3	'(6.7-inf)'	20

Sepal width



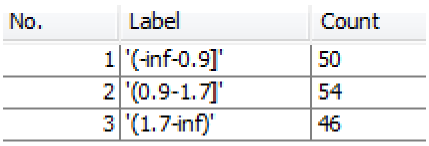
No.	Label	Count
1	'(-inf-2.8]'	47
2	'(2.8-3.6]'	88
3	'(3.6-inf)'	15

Petal length



No.	Label	Count
1	'(-inf-2.966667]'	50
2	'(2.966667-4.9...	54
3	'(4.933333-inf)'	46

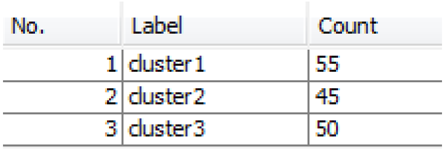
Petal width



No.	Label	Count
1	'(-inf-0.9]'	50
2	'(0.9-1.7]'	54
3	'(1.7-inf)'	46

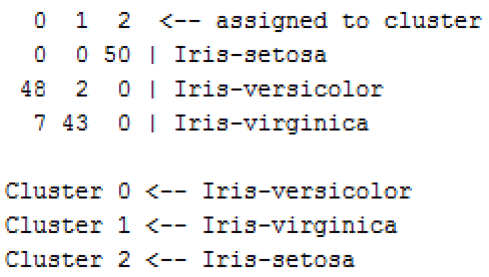
The clustering

Next is a brief analysis of the clustering for a SimpleKMeans with K=3 and seed=10 conducted. The number of observations assigned into the respective clusters is given by the table below.



No.	Label	Count
1	cluster1	55
2	cluster2	45
3	cluster3	50

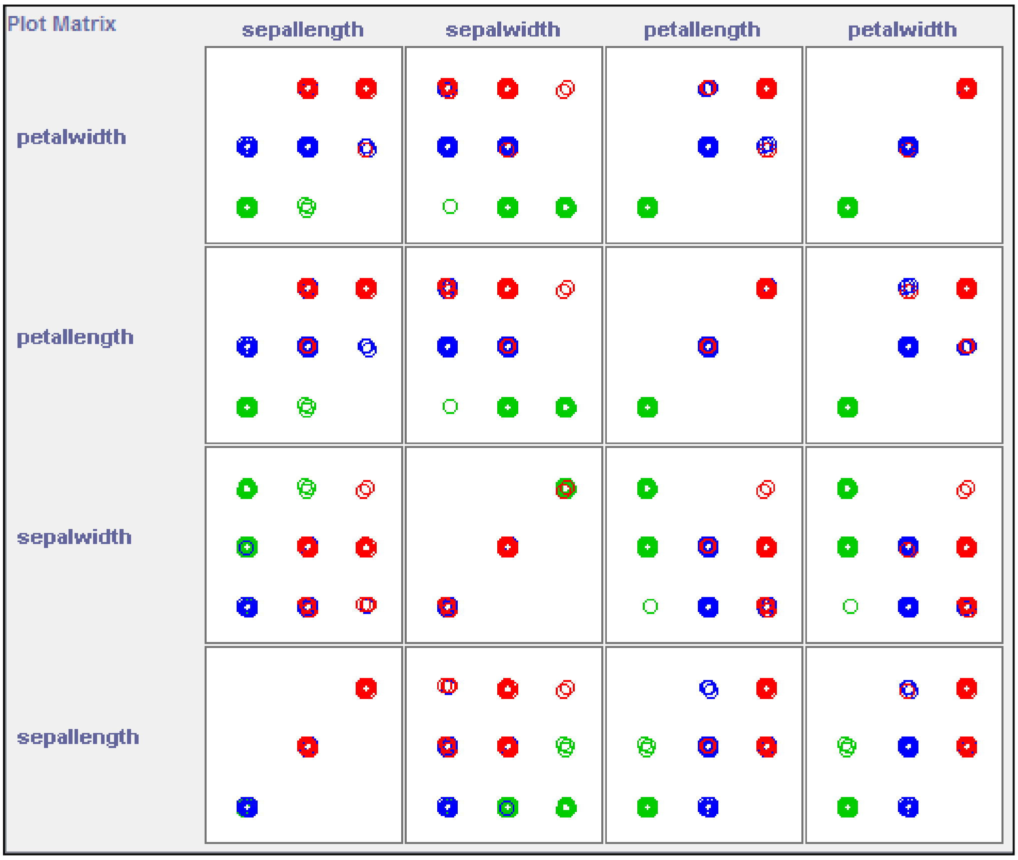
Since the true class is known for every data point, the classification performed by the clustering can be compared to the true classes. The table below gives this information and it can be concluded that nine data points has been clustered incorrectly.



```
  0  1  2  <-- assigned to cluster
  0  0 50 | Iris-setosa
 48  2  0 | Iris-versicolor
  7 43  0 | Iris-virginica

Cluster 0 <-- Iris-versicolor
Cluster 1 <-- Iris-virginica
Cluster 2 <-- Iris-setosa
```

A visual analysis of the clustering is performed with help of the following graph were cluster 0 is blue, cluster 1 is red and cluster 2 is green.



A short resume of the characteristics for each cluster:

- Cluster 0 contains the values in the "mid-bin" for petal width and values in the same interval for petal length it seems. Low values for sepal width and mostly low or mid-values for sepal length.
- Cluster 1 has high values for petal width and length. Mid-values for sepal width and mid- or high values for sepal length.
- Cluster 2 has low values for petal width and petal length. High or mid-values for sepal width and mostly low values for sepal length.

The association rules

Minimum support is 10 % and minimum confidence is 90 %. The names of the clusters have changed in the output of the association analysis. Cluster 0 now is cluster 1, cluster 1 is cluster 2 and cluster 2 is now called cluster 3.

Cluster 1 as consequent

The rules in the table below are the three best rules obtained when cluster 1 is the consequent and the attribute *class* not is in the antecedent. A petal length between 2.97 and 4.93, the mid-bin, and a petal width between 0.9-1.7, also the mid-bin, are the attributes in the antecedent in the rule with the highest support and cluster 1 as consequent. The antecedent for the second rule has the mid-bin interval for sepal length together with the objects in the antecedent for the first rule. In the third rule is also the last feature, sepal width, introduced. The first interval for this feature, -inf to 2.8, is combined with the mid-interval for petal width.

To summarize the rules it is concluded that cluster 1 contains the data points with mid-values for all the features except sepal width (lowest interval). The confidence is 100 % for all rules and the support is 48 % for the best rule and just over 30 % for the other rules.

Rule	Support	Confidence
petallength='(2.966667-4.933333]' petalwidth='(0.9-1.7]' 48 ==> cluster=cluster1	48 %	100 %
sepallength='(5.5-6.7]' petallength='(2.966667-4.933333]' petalwidth='(0.9-1.7]' ==> cluster=cluster1	33 %	100 %
sepalwidth='(-inf-2.8]' petalwidth='(0.9-1.7]' ==> cluster=cluster1	31 %	100 %

Cluster 2 as consequent

With cluster 2 as consequent the antecedent for the first rule contains the highest intervals for the features petal length and petal width. The second rule combines the mid-interval for sepal width with petal width and the third rule combines sepal width with petal length.

Hence, the second cluster consists of data points with high values for petal length and petal width and mid-values for sepal width. The confidence is 100 % for all rules and the support is 40 % for the best rule and just below 30 % for the other rules.

Rule	Support	Confidence
petallength='(4.933333-inf)' petalwidth='(1.7-inf)' ==> cluster=cluster2	40 %	100 %
sepalwidth='(2.8-3.6]' petalwidth='(1.7-inf)' ==> cluster=cluster2	29 %	100 %
sepalwidth='(2.8-3.6]' petallength='(4.933333-inf)' ==> cluster=cluster2	28 %	100 %

Cluster 3 as consequent

Low values of petal length points to cluster 3 and so does also low values of petal width and the rule where these intervals for the two features are combined. All of the rules has an support of 50 % and a confidence level of 100 %.

Rule	Support	Confidence
petallength='(-inf-2.966667]' ==> cluster=cluster3	50 %	100 %
petalwidth='(-inf-0.9]' ==> cluster=cluster3	50 %	100 %

petallength='(-inf-2.966667]' petalwidth='(-inf-0.9]' ==> cluster=cluster3	50 %	100 %

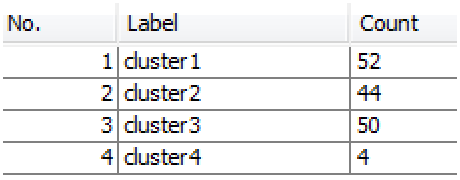
4 clusters and 3 bins

The bins

In this experiment is the states of the bins exactly the same as in the first experiment.

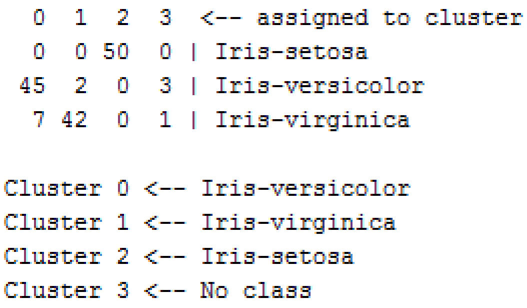
The clustering

The clusters for a SimpleKMeans with K=4 and seed=10.



No.	Label	Count
1	cluster1	52
2	cluster2	44
3	cluster3	50
4	cluster4	4

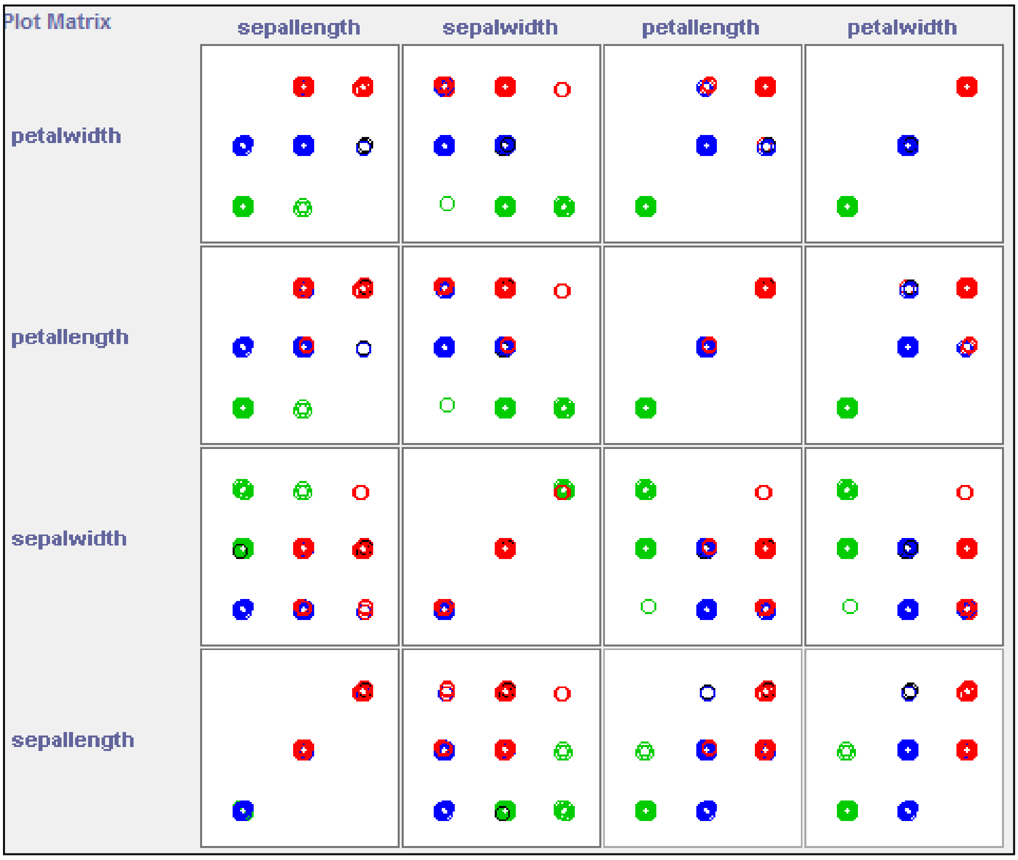
13 of the data points has been clustered incorrectly.



```
   0  1  2  3  <-- assigned to cluster
   0  0 50  0 | Iris-setosa
  45  2  0  3 | Iris-versicolor
   7 42  0  1 | Iris-virginica

 Cluster 0 <-- Iris-versicolor
 Cluster 1 <-- Iris-virginica
 Cluster 2 <-- Iris-setosa
 Cluster 3 <-- No class
```

Cluster 0 is blue, cluster 1 is red, cluster 2 is green and cluster 3 is black.



A short resume of the characteristics for each cluster:

- Cluster 0 contains the values in the mid-bins for petal width and petal length. For sepal width and sepal length it mostly seem to contain low values.
- Cluster 1 has high values for petal width and petal length. It is slightly harder to analyze the remaining features but it looks like the red cluster in general has mid-values for sepal width and sepal length.
- Cluster 2 has low values for petal width, petal length and sepal length. For sepal width it has mid- or high values.
- The characteristics of cluster 3 are hard to analyze visually since it contains so few data points.

The association rules

To obtain rules for these clusters the support had to been lowered substantially since the fourth cluster only contains four data points. The earlier minimum support was 10 % and is now 1 %. The minimum confidence on the other hand remains unchanged. The names of the clusters have changed in the same way as in the first experiment.

Cluster 1 as consequent

The best rules with cluster 1 as consequent has an support around 30 % and a confidence at 100 %. In the antecedent for the first rule are the mid-bins for sepal length, petal length and petal width. Both the second and the third rule contains the lowest interval for sepal width values. In one case combined with petal width and in the other with petal length.

Thus, the antecedent for the rules associated with cluster 1 has mid-values for all features except sepal width which has the bin with low values associated to the cluster.

Rule	Support	Confidence
sepallength='(5.5-6.7]' petallength='(2.966667-4.933333]' petalwidth='(0.9-1.7]' ==> cluster=cluster1	33 %	100 %
sepalwidth='(-inf-2.8]' petalwidth='(0.9-1.7]' ==> cluster=cluster1	31 %	100 %
sepalwidth='(-inf-2.8]' petallength='(2.966667-4.933333]' ==> cluster=cluster1	30 %	100 %

Cluster 2 as consequent

The first rule has high values of petal length and petal width in the antecedent, a support of 40 % and a confidence of 100 %. In the next rule is the mid-values for sepal width combined with petal width. The third rule combines the first rule with sepal width. For the second and third rule is the support just below 30 % and the confidence is 100 %.

By looking on the best rules the cluster seem to include the data points with high values for petal length and petal width and the mid-values for sepal width.

Rule	Support	Confidence
petallength='(4.933333-inf)' petalwidth='(1.7-inf)' ==> cluster=cluster2	40 %	100 %
sepalwidth='(2.8-3.6]' petalwidth='(1.7-inf)' ==> cluster=cluster2	29 %	100 %
sepalwidth='(2.8-3.6]' petallength='(4.933333-inf)' petalwidth='(1.7-inf)' ==> cluster=cluster2	26 %	100 %

Cluster 3 as consequent

The support is 50 % and confidence 100 % for the three best rules. In the first rule is low values for petal length the antecedent and in the second rule low values of petal width. The third rule is a combination of the two first.

Cluster 3 is concluded to be a cluster with data points that has low values for petal length and petal width.

Rule	Support	Confidence
petallength='(-inf-2.966667]' ==> cluster=cluster3	50 %	100 %
petalwidth='(-inf-0.9]' ==> cluster=cluster3	50 %	100 %
petallength='(-inf-2.966667]' petalwidth='(-inf-0.9]' ==> cluster=cluster3	50 %	100 %

Cluster 4 as consequent

The rules obtained for the fourth cluster has much lower support since it only is four data points in the cluster. The first rule has a support of 3 % and says that data points with high values of sepal length and mid-values of sepal width and petal width with a confidence of 100 % belongs to cluster 4. The second rule in the table has a support of 2 % and the only difference compared to the first rule is that petal width is replaced by the mid-bin for petal length.

Rule	Support	Confidence
sepallength='(6.7-inf)' sepalwidth='(2.8-3.6]' petalwidth='(0.9-1.7]' ==> cluster=cluster4	3 %	100 %

sepallength='(6.7-inf)' sepalwidth='(2.8-3.6]' petallength='(2.966667-4.933333]' ==> cluster=cluster4	2 %	100 %

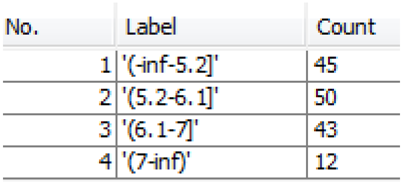
3 clusters and 4 bins

In the next experiment is the performed clustering a SimpleKMeans with K=3 and seed=10 and the number of bins is exceeded from 3 to 4.

The bins

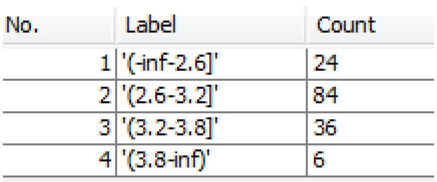
The states for the bins now are the following. Regarding for example sepal length is the main difference that the middle bin is divided into two separate parts and that the first and last bin are slightly smaller than before.

Sepal length



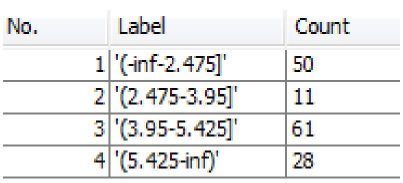
No.	Label	Count
1	'(-inf-5.2]'	45
2	'(5.2-6.1]'	50
3	'(6.1-7]'	43
4	'(7-inf)'	12

Sepal width



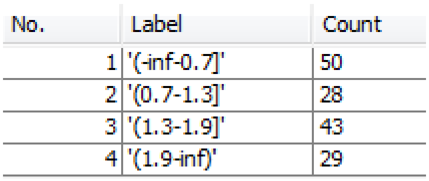
No.	Label	Count
1	'(-inf-2.6]'	24
2	'(2.6-3.2]'	84
3	'(3.2-3.8]'	36
4	'(3.8-inf)'	6

Petal length



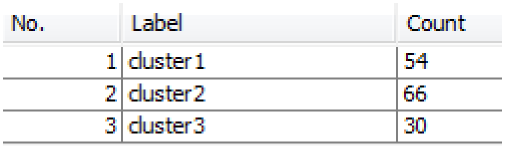
No.	Label	Count
1	'(-inf-2.475]'	50
2	'(2.475-3.95]'	11
3	'(3.95-5.425]'	61
4	'(5.425-inf)'	28

Petal width



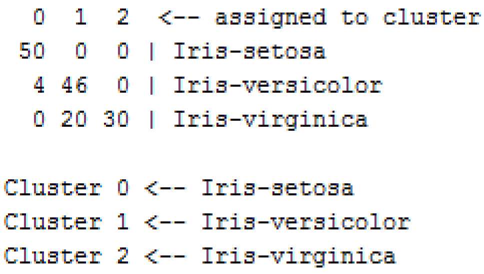
No.	Label	Count
1	'(-inf-0.7]'	50
2	'(0.7-1.3]'	28
3	'(1.3-1.9]'	43
4	'(1.9-inf)'	29

The clustering



No.	Label	Count
1	cluster1	54
2	cluster2	66
3	cluster3	30

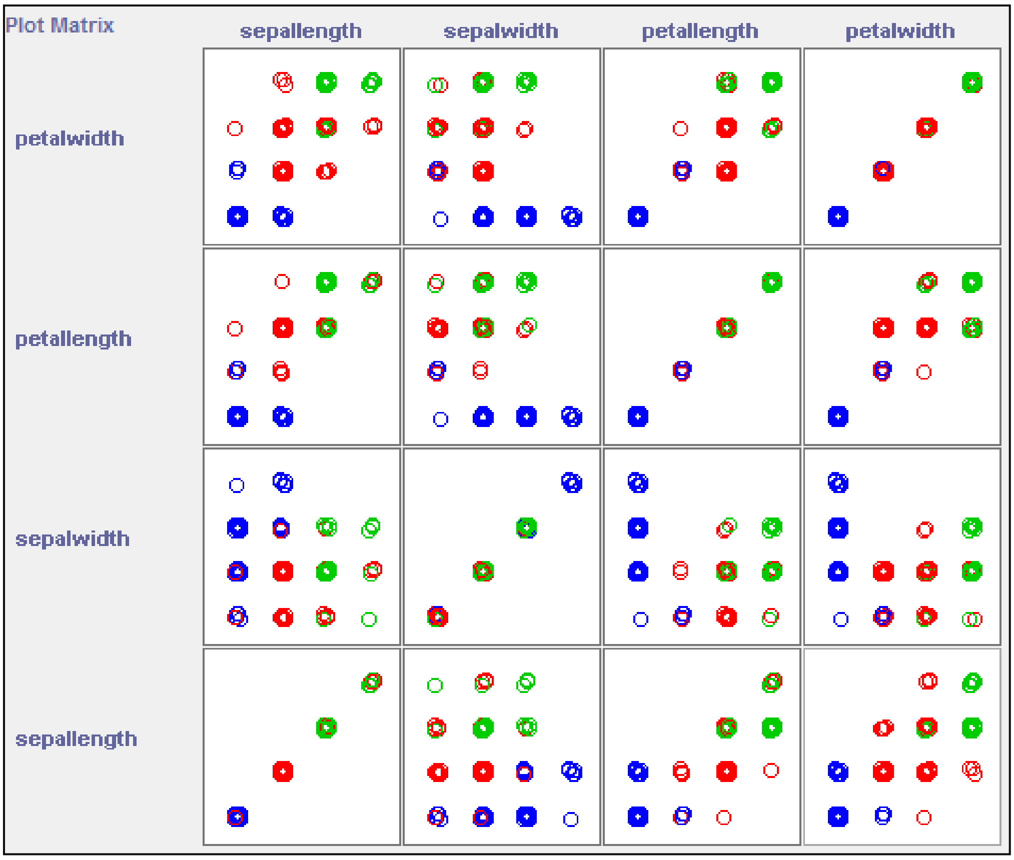
24 of the data points has been clustered incorrectly.



```
  0  1  2  <-- assigned to cluster
 50  0  0 | Iris-setosa
  4 46  0 | Iris-versicolor
  0 20 30 | Iris-virginica

Cluster 0 <-- Iris-setosa
Cluster 1 <-- Iris-versicolor
Cluster 2 <-- Iris-virginica
```

Cluster 0 is blue, cluster 1 is red and cluster 2 is green.



A short resume of the characteristics for each cluster:

- Cluster 0 contains the low values for petal width, petal length and sepal length. For sepal width it contains the high or moderately high values.
- Cluster 1 has either moderately low or moderately high values for petal width. Moderately high values for petal length and moderately low values for sepal width and sepal length.
- Cluster 2 has high values for petal width and high or moderately high for petal length and sepal length. For sepal width the values seem to be either moderately low or moderately high.

The association rules

Minimum support is 10 % and minimum confidence is 90 %. The names of the clusters have changed in the same way as in the earlier experiments.

Cluster 1 as consequent

Support of 50 % and confidence of 100 % for all of the three best rules. The first rule has the lowest values of petal length in the antecedent and the second rule the lowest values of petal width. The last rule has an antecedent that combines the two earlier rules.

Associated to the cluster is low values of petal length and petal width.

Rule	Support	Confidence
petallength='(-inf-2.475]' ==> cluster=cluster1	50 %	100 %
petalwidth='(-inf-0.7]' ==> cluster=cluster1	50 %	100 %
petallength='(-inf-2.475]' petalwidth='(-inf-0.7]' ==> cluster=cluster1	50 %	100 %

Cluster 2 as consequent

The support for the rules is around 30 % and the confidence is 100 % for all rules. In the antecedent for the first rule are moderately high values of both petal length and petal width The second rule includes moderately low values of sepal length together with petal length rule. In the last rule is the same interval of values or sepal length combined with moderately low values of sepal width.

So, the values in cluster 2 is associated with moderately high values for petal length and petal width and moderately low values for sepal length and sepal width.

Rule	Support	Confidence
petallength='(3.95-5.425]' petalwidth='(1.3-1.9]' ==> cluster=cluster2	33 %	100 %
sepallength='(5.2-6.1]' petallength='(3.95-5.425]' ==> cluster=cluster2	32 %	100 %
sepallength='(5.2-6.1]' sepalwidth='(2.6-3.2]' ==> cluster=cluster2	26 %	100 %

Cluster 3 as consequent

The support is just under 20 % for all rules and the confidence is 100 %. High values of petal length and petal width is in the antecedent for the first rule. Petal width with moderately high values of sepal length in the antecedent for the second rule and sepal length together with petal length is the antecedent of the third best rule.

Cluster 3 is associated to high values of petal length and petal width and moderately high values of sepal length.

Rule	Support	Confidence
petallength='(5.425-inf)' petalwidth='(1.9-inf)' ==> cluster=cluster3	19 %	100 %
sepallength='(6.1-7]' petalwidth='(1.9-inf)' ==> cluster=cluster3	18 %	100 %
sepallength='(6.1-7]' petallength='(5.425-inf)' ==> cluster=cluster3	15 %	100 %

Summary

The best clustering was obtained in the first experiment with three bins and three clusters. Although the difference between the clustering for the first and second experiment was very small. Only four more observations was wrongly classified, 9 versus 13, when the number of clusters changed from to three the four and the number of bins were held fixed. In the last experiment was the number of bins increased from three to four and the number of clusters held fixed at three. The effect of this change on the clustering was that more observations than before, 24, were misclassified. The new, higher amount, of categories did not seem to be fit the clustering as well as the former categories did.

Regarding the support of the rules was the highest support on average gained in the first experiment. When the number of clusters were increased to four , the minimum support had to be lowered substantially since one of the clusters had so few data points. In the last example when the number of bins changed from three to four the number of potential antecedents increased. The higher number of alternatives did it harder to find as general rules as before, hence the support became lower for the rules in the third experiment than for the rules in the first experiment.

A more detailed look at the obtained clusters and the association analysis conducted in the respective experiments gives that the results were quite alike for all cases. In all experiments there was a cluster with low values of petal width and petal length. Also a cluster with high values for petal width and petal length and mid- or moderately high values for sepal length were found in all experiments. A cluster with mid-values for all features except sepal width (low values) were found in experiment two and three. The corresponding cluster in the last experiment included data points with moderately high values for sepal width and sepal length and moderately low values for sepal width and sepal length.

In general was the visual interpretation of the clusters performed before the association analysis confirmed by the rules. The role of the rules obtained by the association analysis was mostly to bring some additional clarity since it was hard to interpret which the strongest connections between the features and the clusters was just out of the visual analysis.

Regardless of the quality of the clustering did the association analysis find the same type of rules. It managed to pick out the most important and strongest connections rather independently of the selected data (number of bins) and clustering.