Rosetta

Rosetta is a toolkit for analyzing tabular data within the framework of rough set theory. Rosetta is designed to support the overall data mining and knowledge discovery process: From initial browsing and preprocessing of the data, via computation of minimal attribute sets and generation of if-then rules or descriptive patterns, to validation and analysis of the induced rules or patterns. It is available at http://www.idi.ntnu.no/~aleks/rosetta/. Rosetta is intended as a general-purpose tool for discernibility-based modelling, and is not geared specifically towards any particular application domain. The Rosetta framework is a general C++ class library for Rough Set data analysis. The Rosetta framework was developed by the Knowledge Systems group at the Institute of Computer and Information Science, The Norwegian University of Science and Technology. Prior to the development of Rosetta, a set of C++ modules, called RSES, was developed by the University of Warsaw, Poland. The computational kernel of the RSES is encompassed in the Rosetta system as legacy code. Rosetta was developed as part of the doctoral dissertation [Ohrn99]. Technical reference manual is also available at the site for using Rosetta.

The Rosetta system is designed as two separate parts:

The Rosetta Kernel

The Rosetta Kernel is a set of portable classes written in C++ with extensive use of templates and smart pointers. The computational kernel is also available as a
command-line program, suitable for being invoked from, e.g., Perl or Python scripts. Some features currently offered by the computational kernel include:

1 Import/export
   a. Partial integration with DBMSs via ODBC.
   b. Exporting of rules, reducts, tables, graphs and other objects to various formats, including XML, C++ and Prolog.

2 Preprocessing
   a. Completion of decision tables with missing values.
   b. Discretization of numerical attributes.

3 Computation
   a. Support for both unsupervised and supervised learning.
   b. Support for user-defined notions of discernibility.
   c. Efficient computation of exact or approximate reducts, for various types of discernibility.
   d. Generation of if-then rules or descriptive patterns via reducts.
   e. Execution of script files.
   f. Support for cross-validation.

4 Postprocessing
   a. Advanced filtering of sets of reducts and rules.

5 Validation and analysis
   a. Application of synthesized rules to unseen examples.
   b. Generation of confusion matrices, ROC curves and calibration curves.
   c. Evaluation of individual rules according to advanced measures of quality.
d. Utilities for statistical hypothesis testing.

6 Miscellaneous

a. Clustering via tolerance relations.

b. Computation of partitions and variable precision rough set approximations.

c. Support for random sampling of observations.

d. Open source code.

e. Documentation.

Rosetta offers an extensive array of alternative algorithms for most of the different options listed above, including algorithms from the RSES library. Script files are developed for using RS algorithms in Rosetta. Variations of the following script file are used for carrying the experiment \textit{n-fold CV} using RS. Filenames are altered as per the requirement. Number of folds is specified in the CVRSerailExecutor program in Rosetta.

```plaintext
% Training pipeline
BROthogonalScaler
{MASK = True; FILENAME = C:\Windows\desktop\paper3\temp\CUTS\cuts#ITERATION#.txt}
Saver
{FILENAME = C:\Windows\desktop\paper3\temp\DATA\train#ITERATION#.txt}
MyDecisionTableExporter
{FILENAME = C:\Windows\desktop\paper3\temp\data\trainasci#ITERATION#.txt}
JohnsonReducer
{DISCERNIBILITY =Full; MODULO.DECISION = True; SELECTION = All;}
Saver
{FILENAME = C:\Windows\desktop\paper3\temp\REDUCT\red#ITERATION#.txt}
MyReductExporter
{FILENAME = C:\Windows\desktop\paper3\temp\reduct\redasci#ITERATION#.txt}
RuleGenerator
{}
Saver
{FILENAME = C:\Windows\desktop\paper3\temp\RULES\rule#ITERATION#.txt}
```
The Rosetta Front-end

A user-friendly front-end to the Rosetta Kernel is currently available for the 32 bit Windows and NT platform. The front-end offers a highly intuitive GUI environment where data-navigational abilities are emphasized. The GUI is highly object-oriented in that all manipulable objects are represented as individual GUI items, each with their own set of context-sensitive menus.
Appendix A2

WEKA

Weka is a collection of machine learning algorithms for data mining tasks. The algorithms can either be applied directly to a dataset or called from the customised Java code. Weka contains tools for data pre-processing, classification, regression, clustering, association rules, and visualization. It is also well-suited for developing new machine learning schemes.

Weka is open source software issued under the GNU General Public License. WEKA stands for the Waikato Environment for the Knowledge Analysis. Weka is freely available on the World Wide Web (www.cs.waikato.ac.nz/ml/weka) for experiments. It provides java implementations of state-of-the-art learning algorithms. Weka is organized in packages that correspond to a directory hierarchy. The most detailed and up-to-date information is available in the online documentation on the Weka site. This documentation is generated directly from comments in the source code. Every java program is implemented as a class. Thus in Weka, a class represents the implementation of a learning algorithm. Decision tree algorithms such as ID3 and C4.5 (called J4.8 in WEKA) are used in this thesis for the experimental purpose. The algorithms can be applied to the dataset from the command line.

A2.1 ARFF Format

Weka expects the dataset to be in ARFF format because it is necessary to have type information about each attribute, which cannot be automatically deduced.
from the attribute values. ARFF format for the fruit dataset in Chapter 4 is as follows.

```arff
@relation Fruit

@attribute ID Real
@attribute Skin {hairy, smooth}
@attribute Colour {brown, green, red}
@attribute Size {large, small}
@attribute Flash {hard, soft}
@attribute Conclusion {safe, dangerous}

@data
ID, Skin, Colour, Size, Flash, Conclusion
1, hairy, brown, large, hard, safe
2, hairy, green, large, hard, safe
3, smooth, red, large, soft, dangerous
4, hairy, green, large, soft, safe
5, hairy, red, small, hard, safe
6, smooth, red, small, hard, safe
7, smooth, brown, small, hard, safe
8, hairy, green, small, soft, dangerous
9, smooth, green, small, hard, dangerous
10, hairy, red, large, hard, safe
11, smooth, brown, large, soft, safe
12, smooth, green, small, soft, dangerous
13, hairy, red, small, soft, safe
14, smooth, red, large, hard, dangerous
15, smooth, red, small, hard, safe
16, hairy, green, small, hard, dangerous
```

**A2.2 Using Weka**

To use C4.5 algorithm of Quinlan, J4.8 algorithm, which is Weka's implementation of this decision tree learner, is used. For example, the command

```
java weka.classifiers.j48.J48 -t fruit.arff
```
at the command line would generate the decision tree classifier from the training dataset contained in fruit.arff. Besides the decision tree, the output also contains the predictive performance of the decision tree followed by the confusion matrix. This incantation calls the Java virtual machine and instructs it to execute the J48 algorithm from the \textit{j48 package}. The \texttt{-t} option informs the algorithm that the next argument is the name of the training file. Weka also provides graphic user interface called Weka explorer. It is easier to use but command line feature enables use of batch files to facilitate the replication of the experiments at any time. The command line options used for the experiments in this thesis are described in Table A2.1.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{-t}</td>
<td>specify the training file</td>
</tr>
<tr>
<td>\texttt{-T}</td>
<td>specify the test file</td>
</tr>
<tr>
<td>\texttt{-x}</td>
<td>specify number of folds for the experiments</td>
</tr>
<tr>
<td>\texttt{-s}</td>
<td>specify the random number seed for cross-validation</td>
</tr>
<tr>
<td>\texttt{-U}</td>
<td>Use unpruned tree</td>
</tr>
<tr>
<td>\texttt{-C}</td>
<td>Specify confidence threshold for pruning</td>
</tr>
<tr>
<td>\texttt{-M}</td>
<td>Specify minimum number of instances in a leaf</td>
</tr>
<tr>
<td>\texttt{-R}</td>
<td>Use reduced-error pruning</td>
</tr>
<tr>
<td>\texttt{-N}</td>
<td>Specify number of folds for reduced error pruning. One fold is used as the pruning set.</td>
</tr>
</tbody>
</table>
Appendix A3

Entropy

Shannon [Sha48] developed the concept of entropy to measure the uncertainty of a discrete random variable. Suppose $X$ is a discrete random variable that obtains values from a finite set $x_1, ..., x_n$, with probabilities $p_1, ..., p_n$. We look for a measure of how much choice is involved in the selection of the event or how certain we are of the outcome. Shannon argued that such a measure $H(p_1, ..., p_n)$ should obey the following properties

1. $H$ should be continuous in $p_i$.
2. If all $p_i$ are equal then $H$ should be monotonically increasing in $n$.
3. If a choice is broken down into two successive choices, the original $H$ should be the weighted sum of the individual values of $H$.

Shannon showed that the only $H$ that satisfies these three assumptions is of the form

$$H = k \sum_{i=1}^{n} p_i \log p_i$$

and termed it the entropy of $X$, since it coincides with the notion of entropy defined in certain formulations of statistical mechanics. $k$ is a constant that determines the units of measure, and can be absorbed in the base of the log. The current thesis adheres to the computer science literature and uses the log in base 2.

To summarize, we define entropy as
**Definition A5.1: Entropy**
The entropy of a discrete random variable $X$ is defined by

$$H(X) = \sum_x p(x) \log p(x)$$

The notation $H[P]$ can also be used to denote the entropy of a random variable that has a probability distribution $p$. For given several random variables, joint entropy is defined as:

**Definition A5.2: Joint Entropy**
The joint entropy $H(X,Y)$ of a pair of discrete random variables $X$ and $Y$ with a joint distribution $p(x,y)$ is defined by

$$H(X,Y) = \sum_x \sum_y p(x,y) \log p(x,y)$$

**Definition A5.3 Conditional Entropy**
Let $X$ and $Y$ be discrete random variables with joint distribution $p(x,y)$ and conditional distributions $p(x|y)$, then the entropy conditioned on a single symbol is defined by

$$H(X \mid Y = y) = \sum_x p(x \mid y) \log p(x \mid y)$$

The conditional entropy is defined by

$$H(X \mid Y) = \sum_y p(y) H(X \mid Y = y)$$

$$= \sum_y p(y) \sum_x p(x \mid y) \log p(x \mid y)$$

$$= \sum_{x,y} p(x,y) \log p(x \mid y)$$
Several properties of entropy are worth mentioning.

**A5.4 Properties of $H(X)$**

The entropies $H(X)$ of a discrete random variable $X$ that can obtain the values $x_1$, ..., $x_n$, and the joint entropy $H(X, Y)$, obey the following properties

1. **Non-negativity** $H(X) \geq 0$

2. **Upper bound** $H(X) \leq \log(n)$

3. **Chain rule:** $H(X, Y) = H(X) + H(Y \mid X)$

4. **Conditioning reduces entropy** $H(X \mid Y) \leq H(X)$

5. $H(p)$ is concave in $p$
Appendix A4
Student's t-test

A4.1 Purpose
For a variable, mean, sample size, standard deviation, and standard error of the
mean are computed in statistics. Similarly, for each pair of variables, correlation,
average difference in means, t-test, and confidence interval for mean difference or
the confidence level, standard deviation and standard error of the mean difference
are usually required. The paired-samples t-test procedure compares the means of
two variables for a single group. It computes the differences between values of the
two variables for each case and tests whether the average differs from zero.

Example 1
In a study on high blood pressure, all patients are measured at the beginning of the
study, given a treatment, and measured again. Thus, each subject has two
measures, often called before and after measures. An alternative design for which
this test is used is a matched-pairs or case-control study. Here, each record in the
data file contains the response for the patient and for his or her matched control
subject. In a blood pressure study, patients and controls might be matched by age
e.g. a 75-year-old patient with a 75-year-old control group member.
A4.2 Method and Description

Like normal distribution for large samples, \( t \)-distribution is used for small samples. Rather than just one \( t \)-distribution, there is a \( t \)-distribution for each sample size from 1 to \( \infty \). These different \( t \)-distributions are described as having different degrees of freedom (\( df \)), and there is a different \( t \)-distribution for each degree of freedom. As \( df \) approaches \( \infty \), the \( t \) distribution approaches the normal distribution. In \( t \)-tables, for each \( df \) four points on the distribution namely 0.1, 0.05, 0.01 and 0.001 are given (refer to the statistical tables). These points are commonly chosen as \( \alpha \)-levels by the experimenters.

One can perform \( t \)-test on the difference between means on any two independent groups of data by computing a \( t \)-value using the formula

\[
 t = \frac{\bar{X}_1 - \bar{X}_2}{s_{X_1-X_2}}
\]

where \( X_1 \) and \( X_2 \) are the variables to denote the groups of data with \( N_1 \) and \( N_2 \) number of observations respectively and the formula for deviation in the denominator is:

\[
s_{X_1-X_2} = \sqrt{\frac{\sum x_1^2 + \sum x_2^2}{N_1 + N_2 - 2} \left( \frac{1}{N_1} + \frac{1}{N_2} \right)}
\]

where \( x_1 \) and \( x_2 \) are the individual observations.

For \( N_1 = N_2 \), the formula for \( s_{X_1-X_2} \) is simplified to

\[
s_{X_1-X_1} = \frac{\sum x_1^2 + \sum x_2^2}{N(N-1)}
\]

In order to compare effectiveness of treatments or algorithms, a kind of correlated sample design is used. It is also called a repeated-measures design because more than one measure is taken on each subject by applying different
algorithms or treatments. In many statistics texts, it is also referred to as paired-t test. For correlated samples, the formula for t in this case has a familiar theme: a difference between means divided by the standard error of the difference. The standard error of the difference between means of correlated samples is symbolized $s_B$. Let $N$ be the number of pairs of scores, $D = X - Y$ refers to the difference between the scores. Thus the formula for a paired t-test is

$$t = \frac{\bar{X} - \bar{Y}}{s_B} \text{ where } s_D = \sqrt{\frac{\sum D^2 - (\sum D)^2}{N}} \frac{N}{N-1}$$

The number of degrees of freedom in this case is the number of pairs minus one. To use $t$-distribution for comparing difference between means following three assumptions are made by the statisticians.

1. The dependent variable score for both populations are normally distributed.
2. The variances of the dependent variable scores for the two populations are equal.
3. The scores on the dependent variable are random samples from the population.

The $t$-test is a robust test, which means that the $t$-distribution is an accurate reflection of the probabilities, even when data do not meet assumptions 1 and 2. Experiments by the statisticians show that even if populations violate the assumptions, the $t$-distributions reflect the actual probabilities. Assumption 3 ensures the independence of scores. That is, knowing one score within a group does not help to predict other scores in that same group.
Appendix A5

PWM Dataset

Table A7.1: Data relating to Powdery Mildew Mango crop at Lucknow for the period 1987-1997 and the year 2000

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<th>Month</th>
<th>Year</th>
<th>Max. Temperature</th>
<th>Min. Temperature</th>
<th>Relative Humidity</th>
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Appendix A6
Observation Tables

This appendix contains detailed observation tables pertaining to the experiments in some of the chapters.

A6.1 Rough Set based Decision Tree

Table A6.1: Performance Measures as Obtained using Leave One Out Experiment on Sunburn Dataset

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### A6.2 RDT for Continuous Attributes

Table A6.4: Evaluation Measures for 5 Folds Cross Validation Experiments with Australian credit Card Dataset

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| 2     | 7.24 | 13.04| 15.94| 17.39| 15.21| 9.42 | 19.56|      |      |
| 3     | 5.07 | 13.04| 15.94| 17.39| 15.21| 9.42 | 19.56|      |      |
| 5     | 5.07 | 16.67| 32.61| 21.01| 15.94| 15.94| 31.88| 22.46|      |
| Avg   | 5.34 | 15.65| 24.92| 16.81| 16.52| 14.34| 28.54|      |      |

|       |      |      |     |      |      |      |      |      |      |
| 1     | 74.63| 9.42 | 14.49| 0    | 0    | 0    | 0    |      |      |
| 2     | 71.01| 5.07 | 12.31| 0    | 0    | 0    | 0    |      |      |
| 3     | 71.74| 7.25 | 17.39| 0    | 0    | 0    | 0    |      |      |
| 4     | 73.91| 5.8  | 12.32| 0    | 0    | 0    | 0    |      |      |
| 5     | 79.71| 10.87| 10.87| 0    | 0    | 0    | 0    |      |      |
| Avg   | 74.2 | 7.682| 13.47| 0    | 0    | 0    | 0    |      |      |

|       |      |      |     |      |      |      |      |      |      |
| 1     | 482  | 223  | 272 | 112  | 28   | 147  | 25   | 199  | 6    |
| 2     | 471  | 188  | 266 | 134  | 36   | 153  | 10   | 197  | 13   |
| 3     | 498  | 213  | 391 | 124  | 23   | 148  | 2    | 196  | 9    |
| 4     | 491  | 201  | 58  | 112  | 30   | 193  | 34   | 155  | 10   |
| 5     | 505  | 205  | 27  | 91   | 32   | 142  | 31   | 182  | 9    |
| Avg   | 489.4| 206  | 271.8| 114.6| 29.8 | 156.6| 20.4 | 185.8| 9.4  |

|       |      |      |     |      |      |      |      |      |      |
| 1     | 2592 | 916  | 1125| 646  | 135  | 691  | 112  | 749  | 9    |
| 2     | 2826 | 770  | 1105| 651  | 188  | 669  | 27   | 740  | 29   |
| 3     | 2988 | 894  | 1254| 552  | 101  | 649  | 2    | 732  | 18   |
| 4     | 2946 | 864  | 1167| 579  | 121  | 952  | 162  | 603  | 25   |
| 5     | 3030 | 872  | 1151| 493  | 176  | 660  | 135  | 697  | 22   |
| Avg   | 2876 | 863.2| 1160| 584.2| 144.2| 724.2| 87.6 | 704.2| 20.6 |

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| Avg   | 6    | 11.6 | 6   | 7.6  | 5.6  | 13   | 5.6  | 6    | 2.8  |

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Table A6.6: Evaluation Measures for 5 Folds Cross Validation Experiments with Iris Dataset and Computed Cumulative Scores

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### A6.3 RDT for Predictive Modelling

#### Table A6.7: Accuracy of Training and Test Data Obtained from the Logistic Regression Model for PWM Dataset

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<th>8(^{\text{TH}}) TO 14(^{\text{TH}}) DAY</th>
<th>AVG-YEAR</th>
</tr>
</thead>
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<td>Test</td>
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<td>55.56</td>
</tr>
<tr>
<td>1987-95</td>
<td>54.55</td>
<td>100</td>
<td>50</td>
<td>100</td>
<td>55.56</td>
</tr>
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</tr>
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<tr>
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Table A6.10: Accuracy of Training and Test data Obtained from the CJP for PWM Dataset

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<th>8 TH TO 13 TH DAY</th>
<th>8 TH TO 14 TH DAY</th>
<th>AVG-YEAR</th>
</tr>
</thead>
<tbody>
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<td>Train</td>
<td>Test</td>
<td>Train</td>
</tr>
<tr>
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<td>100</td>
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<td>55.56</td>
</tr>
<tr>
<td>1987-95</td>
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<td>50</td>
<td>100</td>
<td>55.56</td>
</tr>
<tr>
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<td>77.78</td>
</tr>
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Table A6.11: Accuracy of Training and Test data Obtained from the RDT for PWM Dataset

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<th>8 TH TO 13 TH DAY</th>
<th>8 TH TO 14 TH DAY</th>
<th>AVG-YEAR</th>
</tr>
</thead>
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<td>66.67</td>
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Table A6.12: Accuracy of Training and Test Data Obtained from the RJU for PWM Dataset

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<th>8 TH TO 14 TH DAY</th>
<th>AVG-YEAR</th>
</tr>
</thead>
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<td>Test</td>
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<td>77.78</td>
<td>66.67</td>
<td>77.78</td>
</tr>
<tr>
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Table A6.13: Accuracy of Training and Test data Obtained from the RJP for PWM Dataset

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<th>8 TH TO 13 TH DAY</th>
<th>8 TH TO 14 TH DAY</th>
<th>AVG-YEAR</th>
</tr>
</thead>
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<td>Train</td>
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