More Data Mining with Weka

Class 1 – Lesson 1

Introduction

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More Data Mining with Weka

... a practical course on how to use advanced facilities of Weka for data mining (but not programming, just the interactive interfaces)

... follows on from *Data Mining with Weka*

... will pick up some basic principles along the way

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More Data Mining with Weka

- This course assumes that you know about
  - What data mining is and why it’s useful
  - The “simplicity-first” paradigm
  - Installing Weka and using the Explorer interface
  - Some popular classifier algorithms and filter methods
  - Using classifiers and filters in Weka ...
    and how to find out more about them
  - Evaluating the result, including training/testing pitfalls
  - Interpret Weka’s output and visualizing your data set
  - The overall data mining process

- See *Data Mining with Weka*

- (Refresher: see videos on YouTube WekaMOOC channel)
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- As you know, a Weka is
  - a bird found only in New Zealand?
  - Data mining workbench:
    Waikato Environment for Knowledge Analysis

Machine learning algorithms for data mining tasks

- 100+ algorithms for classification
- 75 for data preprocessing
- 25 to assist with feature selection
- 20 for clustering, finding association rules, etc
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What will you learn?
- Experimenter, Knowledge Flow interface, Command Line interfaces
- Dealing with “big data”
- Text mining
- Supervised and unsupervised filters
- All about discretization, and sampling
- Attribute selection methods
- Meta-classifiers for attribute selection and filtering
- All about classification rules: rules vs. trees, producing rules
- Association rules and clustering
- Cost-sensitive evaluation and classification

Use Weka on your own data ... and understand what you’re doing!
Class 1: Exploring Weka’s interfaces, and working with big data

- Experimenter interface
- Using the Experimenter to compare classifiers
- Knowledge Flow interface
- Simple Command Line interface
- Working with big data
  - Explorer: 1 million instances, 25 attributes
  - Command line interface: effectively unlimited
  - in the Activity you will process a multi-million-instance dataset
Course organization

Class 1  Exploring Weka's interfaces; working with big data

Class 2  Discretization and text classification

Class 3  Classification rules, association rules, and clustering

Class 4  Selecting attributes and counting the cost

Class 5  Neural networks, learning curves, and performance optimization
Course organization

Class 1: Exploring Weka’s interfaces; working with big data
- Lesson 1.1

Class 2: Discretization and text classification
- Lesson 1.2

Class 3: Classification rules, association rules, and clustering
- Lesson 1.3
- Lesson 1.4

Class 4: Selecting attributes and counting the cost
- Lesson 1.5

Class 5: Neural networks, learning curves, and performance optimization
- Lesson 1.6
Course organization

Class 1  Exploring Weka’s interfaces; working with big data
  Lesson 1.1
  Activity 1

Class 2  Discretization and text classification
  Lesson 1.2
  Activity 2

Class 3  Classification rules, association rules, and clustering
  Lesson 1.3
  Activity 3

Class 4  Selecting attributes and counting the cost
  Lesson 1.4
  Activity 4

Class 5  Neural networks, learning curves, and performance optimization
  Lesson 1.5
  Activity 5

Lesson 1.6
  Activity 6
Course organization

Class 1: Exploring Weka’s interfaces; working with big data

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Mid-class assessment 1/3

Post-class assessment 2/3
Download Weka now!

Download from

http://www.cs.waikato.ac.nz/ml/weka
  for Windows, Mac, Linux

Weka 3.6.11
  the latest stable version of Weka
  includes datasets for the course
  it’s important to get the right version!
This textbook discusses data mining, and Weka, in depth:

*Data Mining: Practical machine learning tools and techniques*,
by Ian H. Witten, Eibe Frank and Mark A. Hall. Morgan Kaufmann, 2011

The publisher has made available parts relevant to this course in ebook format.
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Class 1 – Lesson 2

*Exploring the Experimenter*

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Lesson 1.2: Exploring the Experimenter

Class 1  Exploring Weka’s interfaces; working with big data
Lesson 1.1 Introduction

Class 2  Discretization and text classification
Lesson 1.2 Exploring the Experimenter

Class 3  Classification rules, association rules, and clustering
Lesson 1.3 Comparing classifiers

Class 4  Selecting attributes and counting the cost
Lesson 1.4 Knowledge Flow interface

Class 5  Neural networks, learning curves, and performance optimization
Lesson 1.5 Command Line interface
Lesson 1.6 Working with big data
Lesson 1.2: Exploring the Experimenter

- Graphical interface
- Command-line interface
- Trying out classifiers/filters
- Performance comparisons
- Graphical interface
- Command-line interface
Lesson 1.2: Exploring the Experimenter

Use the Experimenter for ...

- determining mean and standard deviation performance of a classification algorithm on a dataset
  ... or several algorithms on several datasets
- Is one classifier better than another on a particular dataset?
  ... and is the difference statistically significant?
- Is one parameter setting for an algorithm better than another?
- The result of such tests can be expressed as an ARFF file
- Computation may take days or weeks
  ... and can be distributed over several computers
Lesson 1.2: Exploring the Experimenter
Lesson 1.2: Exploring the Experimenter

One dataset

Training data

ML algorithm

Classifier

Test data

Evaluation results

Deploy!

Basic assumption: training and test sets produced by independent sampling from an infinite population
Lesson 1.2: Exploring the Experimenter

Evaluate J48 on segment-challenge (Data Mining with Weka, Lesson 2.3)

- With segment-challenge.arff ...
- and J48 (trees>J48)
- Set percentage split to 90%
- Run it: 96.7% accuracy
- Repeat
- [More options] Repeat with seed 2, 3, 4, 5, 6, 7, 8, 9, 10

Accuracy results:
0.967
0.940
0.940
0.967
0.953
0.967
0.920
0.947
0.933
0.947
Lesson 1.2: Exploring the Experimenter

Evaluate J48 on segment-challenge (Data Mining with Weka, Lesson 2.3)

Sample mean \( \bar{x} = \frac{\sum x_i}{n} \)

Variance \( \sigma^2 = \frac{\sum (x_i - \bar{x})^2}{n - 1} \)

Standard deviation \( \sigma \)

\( \bar{x} = 0.949, \ \sigma = 0.018 \)
Lesson 1.2: Exploring the Experimenter

10-fold cross-validation (Data Mining with Weka, Lesson 2.5)

- Divide dataset into 10 parts (folds)
- Hold out each part in turn
- Average the results
- Each data point used once for testing, 9 times for training

Stratified cross-validation

- Ensure that each fold has the right proportion of each class value
Lesson 1.2: Exploring the Experimenter

Setup panel
- click New
- note defaults
  - 10-fold cross-validation, repeat 10 times
- under Datasets, click Add new, open segment-challenge.arff
- under Algorithms, click Add new, open trees>J48

Run panel
- click Start

Analyse panel
- click Experiment
- Select Show std. deviations
- Click Perform test
  \[ \bar{x} = 95.71\%, \; \sigma = 1.85\% \]
Lesson 1.2: Exploring the Experimenter

To get detailed results

- return to Setup panel
  - select .csv file
  - enter filename for results
  - Train/Test Split; 90%
Lesson 1.2: Exploring the Experimenter

- switch to Run panel
  - click Start
  - Open results spreadsheet
Lesson 1.2: Exploring the Experimenter

Re-run cross-validation experiment

- Open results spreadsheet
Lesson 1.2: Exploring the Experimenter

Setup panel

- Save/Load an experiment
- Save the results in Arff file ... or in a database
- Preserve order in Train/Test split (can’t do repetitions)
- Use several datasets, and several classifiers
- Advanced mode

Run panel

Analyse panel

- Load results from .csv or Arff file ... or from a database
- Many options
Lesson 1.2: Exploring the Experimenter

- Open Experimenter
- Setup, Run, Analyse panels
- Evaluate one classifier on one dataset
  - ... using cross-validation, repeated 10 times
  - ... using percentage split, repeated 10 times
- Examine spreadsheet output
- Analyse panel to get mean and standard deviation
- Other options on Setup and Run panels

Course text
- Chapter 13  The Experimenter
More Data Mining with Weka

Class 1 – Lesson 3

Comparing classifiers

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Lesson 1.3: Comparing classifiers

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Lesson 1.3: Comparing classifiers

Is J48 better than (a) ZeroR and (b) OneR on the Iris data?

- In the Explorer, open iris.arff
- Using cross-validation, evaluate classification accuracy with...
  - ZeroR (rules>ZeroR) 33%
  - OneR (rules>OneR) 92%
  - J48 (trees>J48) 96%

But how reliable is this?
What would happen if you used a different random number seed??
Lesson 1.3: Comparing classifiers

- In the Experimenter, click New
- Under Datasets, click Add new, open iris.arff
- Under Algorithms, click Add new, open trees>J48 rules>OneR rules>ZeroR
Lesson 1.3: Comparing classifiers

- Switch to Run; click Start
- Switch to Analyse, click Experiment
  click Perform test
Lesson 1.3: Comparing classifiers

- ZeroR (33.3%) is significantly worse than J48 (94.7%)
- Cannot be sure that OneR (92.5%) is significantly worse than J48
- ... at the 5% level of statistical significance
- J48 seems better than ZeroR: pretty sure (5% level) that this is not due to chance
- ... and better than OneR; but this may be due to chance (can’t rule it out at 5% level)

<table>
<thead>
<tr>
<th>Dataset</th>
<th>(1) trees.J4</th>
<th>(2) rules (3) rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>iris</td>
<td>(100) 94.73</td>
<td>92.53 33.33 *</td>
</tr>
<tr>
<td></td>
<td>(v/ /*)</td>
<td>(0/1/0) (0/0/1)</td>
</tr>
</tbody>
</table>

Key:
(1) trees.J48  ,
(2) rules.OneR
(3) rules.ZeroR
Lesson 1.3: Comparing classifiers

J48 is significantly (5% level) better than:

- both OneR and ZeroR on Glass, ionosphere, segment
- OneR on breast-cancer, german_credit
- ZeroR on iris, pima_diabetes
Lesson 1.3: Comparing classifiers

Comparing OneR with ZeroR

Change “Test base” on Analyse panel

- significantly worse on german-credit
- about the same on breast-cancer
- significantly better on all the rest
Lesson 1.3: Comparing classifiers

- Row: select Scheme (not Dataset)
- Column: select Dataset (not Scheme)
Lesson 1.3: Comparing classifiers

- Statistical significance: the “null hypothesis”
  
  *Classifier A’s performance is the same as B’s*

- The observed result is highly unlikely if the null hypothesis is true
  
  “The null hypothesis can be rejected at the 5% level”
  
  [of statistical significance]

  “A performs significantly better than B at the 5% level”

- Can change the significance level (5% and 1% are common)

- Can change the comparison field (we have used % correct)

- Common to compare over a set of datasets
  
  “On these datasets, method A has xx wins and yy losses over method B”

- Multiple comparison problem
  
  *if you make many tests, some will appear to be “significant” just by chance!*
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Class 1 – Lesson 4

The Knowledge Flow interface

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Lesson 1.4: The Knowledge Flow interface

Class 1 Exploring Weka’s interfaces; working with big data

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Lesson 1.4: The Knowledge Flow interface

The Knowledge Flow interface is an alternative to the Explorer

- Lay out filters, classifiers, evaluators interactively on a 2D canvas
- Components include data sources, data sinks, evaluation, visualization
- Different kinds of connections between the components
  - Instance or dataset
  - test set, training set
  - classifier
  - output, text or chart
- Can work incrementally, on potentially infinite data streams
- Can look inside cross-validation at the individual models produced
Lesson 1.4: The Knowledge Flow interface

Load an ARFF file, choose J48, evaluate using cross-validation

- Choose an ArffLoader; Configure to set the file iris.arff
- Connect up a ClassAssigner to select the class
- Connect the result to a CrossValidationFoldMaker
- Connect this to J48
- Make two connections, one for trainingSet and the other for testSet
- Connect J48 to ClassifierPerformanceEvaluator
- Connect this to a TextViewer

Then run it! (ArffLoader: Start loading)
Lesson 1.4: The Knowledge Flow interface
Lesson 1.4: The Knowledge Flow interface

- **TextViewer**: Show results

![TextViewer Image]

- Add a `ModelPerformanceChart`
- Connect the `visualizableError` output of `ClassifierPerformanceEvaluator` to it
- Show chart (need to run again)
Lesson 1.4: The Knowledge Flow interface

Working with stream data

“instance” connection

“updateable” classifier

“incremental” evaluator

“StripChart” visualization
Lesson 1.4: The Knowledge Flow Interface

- Panels broadly similar to the Explorer’s, except
  - *DataSource* are separate from *Filters*
  - Write data or models to files using *DataSinks*
  - *Evaluation* is a separate panel

- Facilities broadly similar too, except
  - Can deal incrementally with potentially infinite datasets
  - Can look inside cross-validation at the models for individual folds

- Some people like graphical interfaces

Course text
- Chapter 12  *The Knowledge Flow Interface*
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Class 1 – Lesson 5

The Command Line interface

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Lesson 1.5: The Command Line interface

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Lesson 1.1 Introduction
Lesson 1.2 Exploring the Experimenter
Lesson 1.3 Comparing classifiers
Lesson 1.4 Knowledge Flow interface
Lesson 1.5 Command Line interface
Lesson 1.6 Working with big data
Lesson 1.5: The Command Line interface

Run a classifier from within the CLI

- Print options for J48:

  `java weka.classifiers.trees.J48`

- General options

  `-h` print help info
  `-t <name of training file> [absolute path name ...]`
  `-T <name of test file>`

- Options specific to J48 (from Explorer configuration panel)

- Run J48:

  `java weka.classifiers.trees.J48 -C 0.25 -M 2`  
  `–t “C:\Users\ihw\My Documents\Weka datasets\iris.arff”`
Lesson 1.5: The Command Line interface

Classes and packages

- J48 is a “class”
  - a collection of variables, along with some “methods” that operate on them
- “Package” is a directory containing related classes
  
  \[
  \text{weka.classifiers.trees.J48} \\
  \text{\textarrow{\textleftarrow}{\textuparrow}{\textrightarrow}{\textuparrow}} \\
  \text{packages} \quad \text{class}
  \]
- Javadoc: the definitive documentation for Weka
  
  Weka-3-6\documentation.html
- ... find J48 in the “All classes” list
Lesson 1.5: The Command Line interface

Using the Javadoc

“What’s all this geeky stuff?” – Forget it. Try to ignore things you don’t understand!

- Find the “converter” package
  weka.core.converters

- Find the “databaseLoader” class
  weka.core.converters.DatabaseLoader

- Can load from any JDBC database
  specify URL, password, SQL query

- It’s in the Explorer’s Preprocess panel, but the documentation is here
Lesson 1.5: The Command Line interface

- Can do everything the Explorer does from the command line
- People often open a terminal window instead
  - then you can do scripting (if you know how)
  - ... but you need to set up your environment properly
- Can copy and paste configured classifiers from the Explorer
- Advantage: more control over memory usage (next lesson)
- Javadoc is the definitive source of Weka documentation

Course text

- Chapter 14  The Command-Line Interface
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Class 1 – Lesson 6

Working with big data

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Lesson 1.6: Working with big data

Class 1: Exploring Weka’s interfaces; working with big data
- Lesson 1.1 Introduction
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- Lesson 1.6 Working with big data
Class 2: Discretization and text classification
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Class 5: Neural networks, learning curves, and performance optimization
Lesson 1.6: Working with big data

How much can Explorer handle? (~ 1M instances, 25 attributes)

- Memory information: in Explorer, right-click on “Status”
  - Free/total/max: 226,366,616 / 236,453,888 / 954,728,448 (bytes) [1 GB]
  - Meaning what? Geeks, check out Java’s freeMemory(), totalMemory(), maxMemory() commands

- Let’s break it!

- Download a large dataset?
  - “covertype” dataset used in the associated Activity
  - 580,000 instances, 54 attributes (0.75 GB uncompressed)

- Weka data generator
  - Preprocess panel, Generate, choose LED24; show text: 100 instances, 25 attributes
  - 100,000 examples (use % split!) NaiveBayes 74% J48 73%
  - 1,000,000 examples NaiveBayes 74% J48 runs out of memory
  - 2,000,000 examples Generate process grinds to a halt

- (Run console version of Weka)
Lesson 1.6: Working with big data

Not enough memory (less than 50MB left on heap). Please load a smaller dataset or use a larger heap size.
- initial heap size: 0MB
- current memory (heap) used: 973.4MB
- max. memory (heap) available: 1011.3MB

Note:
The Java heap size can be specified with the -Xmx option.
E.g., to use 128MB as heap size, the command line looks like this:
  java -Xmx128m -classpath ...
This does NOT work in the SimpleCLI, the above java command refers to the one with which Weka is started. See the Weka FAQ on the web for further info.
Lesson 1.6: Working with big data

“Updateable” classifiers

- Incremental classification models: process one instance at a time
  - AODE, AODEsr, DMNBtext, IB1, IBk, KStar, LWL, NaiveBayesMultinomialUpdateable, NaiveBayesUpdateable, NNge, RacedIncrementalLogitBoost, SPegasos, Winnow
- \textit{NaiveBayesUpdateable}: same as \textit{NaiveBayes}
- \textit{NaiveBayesMultinomialUpdateable}: see lessons on Text Mining
- \textit{IB1, IBk} (but testing can be very slow)
- \textit{KStar, LWL} (locally weighted learning): instance-based
- \textit{SPegasos} (in functions)
  - builds a linear classifier, SVM-style (restricted to numeric or binary class)
- \textit{RacedIncrementalLogitBoost}: a kind of boosting
Lesson 1.6: Working with big data

How much can Weka (Simple CLI) handle? – unlimited (conditions apply)

- Create a huge dataset
  `java weka.datagenerators.classifiers.classification.LED24 -n 100000 -o C:\Users\ihw\test.arff`
  - Test file with 100 K instances, 5 MB
  `java weka.datagenerators.classifiers.classification.LED24 -n 10000000 -o C:\Users\ihw\train.arff`
  - Training file with 10 M instances; 0.5 GB

- Use NaiveBayesUpdateable
  `java weka.classifiers.bayes.NaiveBayesUpdateable -t ...train.arff -T ...test.arff`
  - 74%; 4 mins
  - Note: if no test file specified, will do cross-validation, which will fail (non-incremental)

- Try with 100 M examples (5 GB training file) – no problem (40 mins)
Lesson 1.6: Working with big data

- Explorer can handle ~1M instances, 25 attributes (50 MB file)
- Simple CLI works incrementally wherever it can
- Some classifier implementations are “Updateable”
  - find them with Javadoc; see Lesson 1.5 Activity
- Updateable classifiers deal with arbitrarily large files (multi GB)
  - but don’t attempt cross-validation
- Working with big data can be difficult and frustrating
  - see the associated Activity
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