THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Advanced Data Mining with Weka

Class 5 – Lesson 1

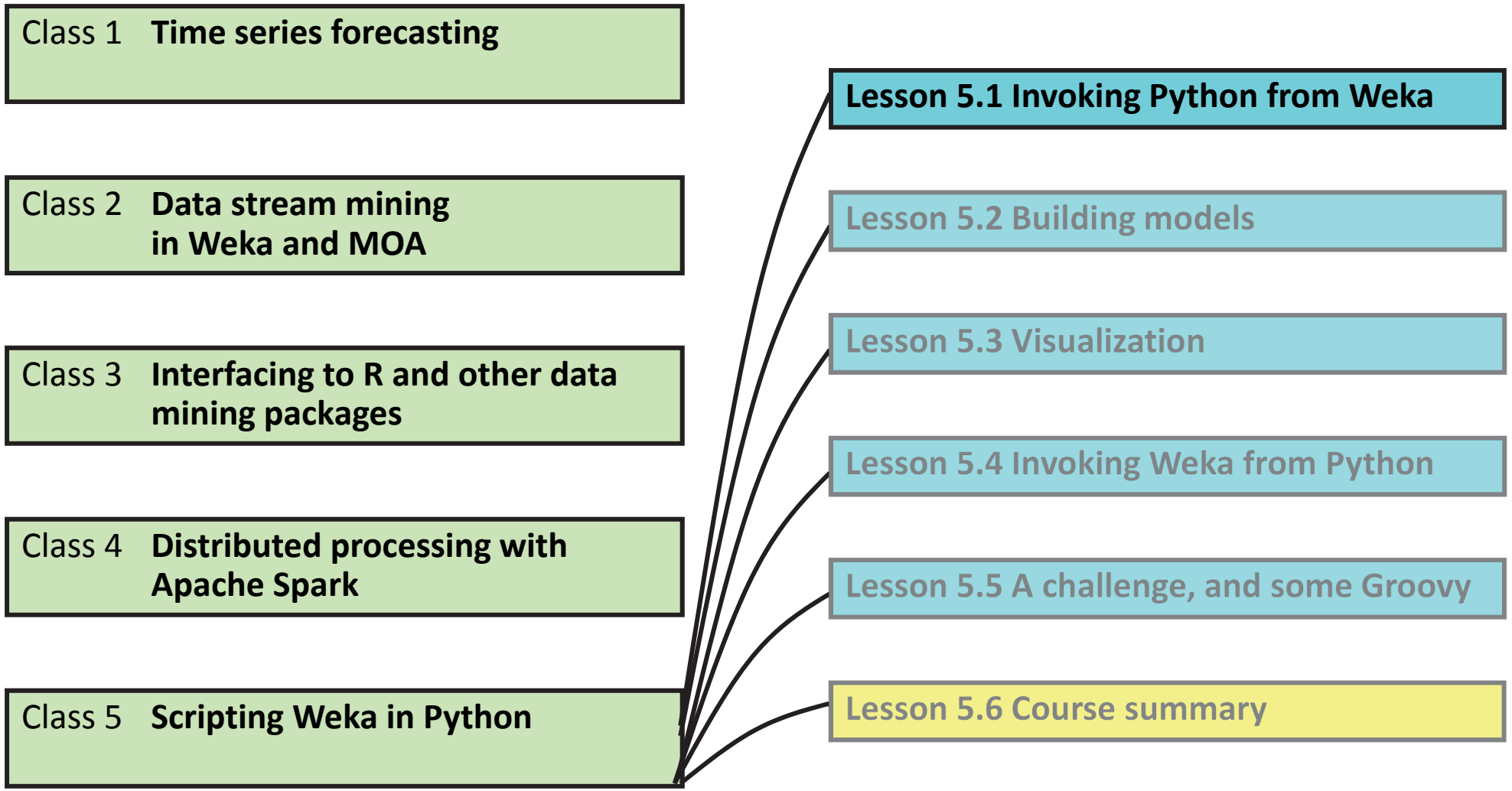
Invoking Python from Weka

Peter Reutemann

Department of Computer Science
University of Waikato
New Zealand

weka.waikato.ac.nz

Lesson 5.1: Invoking Python from Weka



Lesson 5.1: Invoking Python from Weka

Scripting

Pros

- ❖ script captures preprocessing, modeling, evaluation, etc.
- ❖ write script once, run multiple times
- ❖ easy to create variants to test theories
- ❖ no compilation involved like with Java

Cons

- ❖ programming involved
- ❖ need to familiarize yourself with APIs of libraries
- ❖ writing code is slower than clicking in the GUI

Invoking Python from Weka

Scripting languages

- **Jython** - https://docs.python.org/2/tutorial/
  - pure-Java implementation of Python 2.7
  - runs in JVM
  - access to all Java libraries on CLASSPATH
  - only pure-Python libraries can be used
- **Python**
  - invoking Weka from Python 2.7
  - access to full Python library ecosystem
- **Groovy** (briefly) - http://www.groovy-lang.org/documentation.html
  - Java-like syntax
  - runs in JVM
  - access to all Java libraries on CLASSPATH

Invoking Python from Weka

Java vs Python

Java

```
public class Blah {
  public static void main(String[] args) {
    for (int i = 0; i < 10; i++) {
      System.out.println(
        (i+1) + ": Hello WekaMOOC!");
    }
  }
}
```

Python

```
for i in xrange(10):
    print("%i: Hello WekaMOOC!" % (i+1))
```

Output

```
1: Hello WekaMOOC!
2: Hello WekaMOOC!
3: Hello WekaMOOC!
4: Hello WekaMOOC!
5: Hello WekaMOOC!
6: Hello WekaMOOC!
7: Hello WekaMOOC!
8: Hello WekaMOOC!
9: Hello WekaMOOC!
10: Hello WekaMOOC!
```

Invoking Python from Weka

Package manager

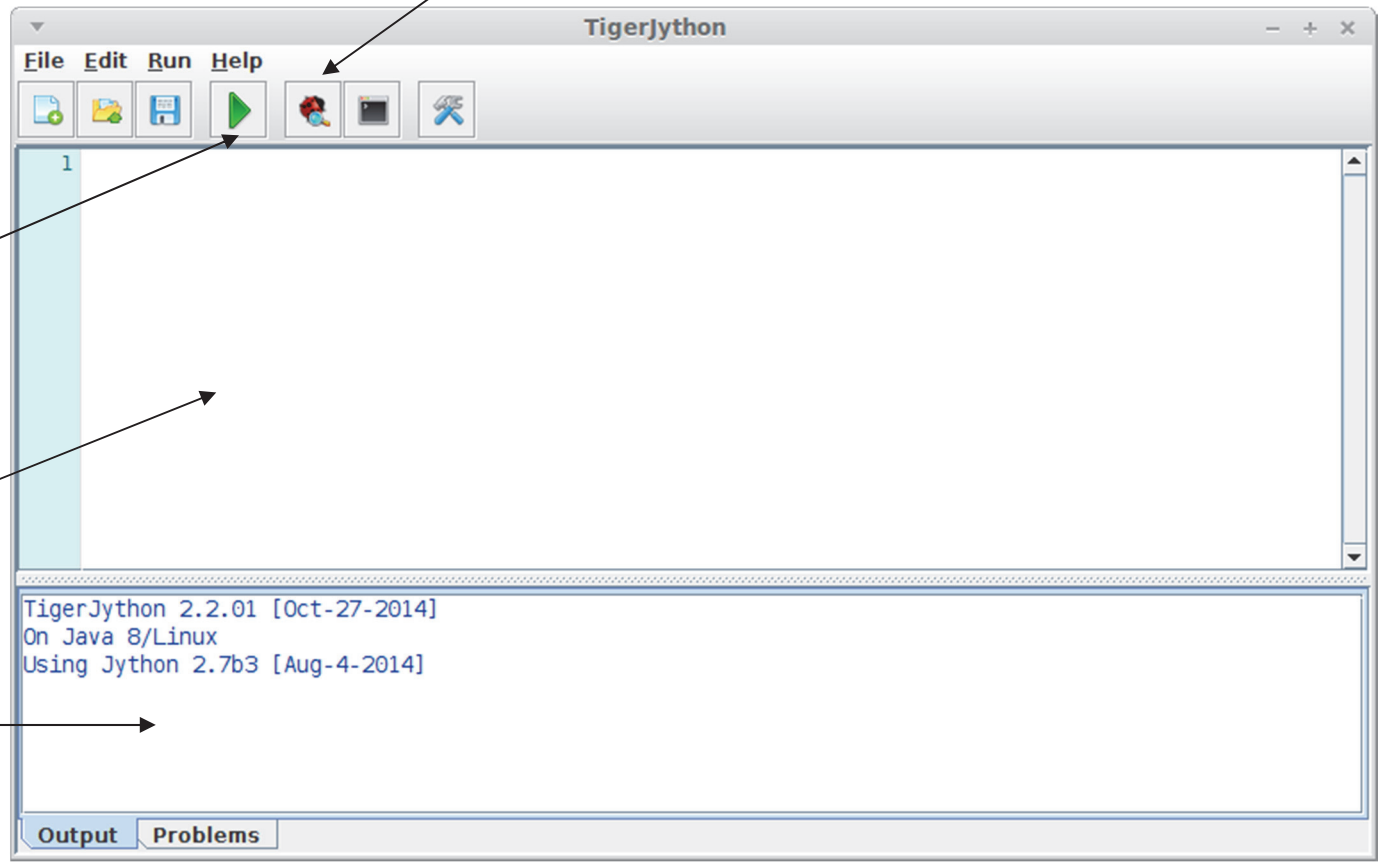
- ❖ start Package manager from the main GUI (from the *Tools* menu)
- ❖ install the following packages
  - tigerJython 1.0.0
    GUI for writing/running Jython scripts
  - jfreechartOffscreenRenderer 1.0.2
    JFreeChart offers nice plots (used in Lesson 3)
- ❖ after restarting Weka, you can start Jython GUI
  - Tools → Jython console

Note: *I'm using Weka 3.7.13*

Invoking Python from Weka

TigerJython Interface

Debug mode on/off



Execute your script

Write your script here

Output/errors

Preferences

- decrease font
- add support for tabs

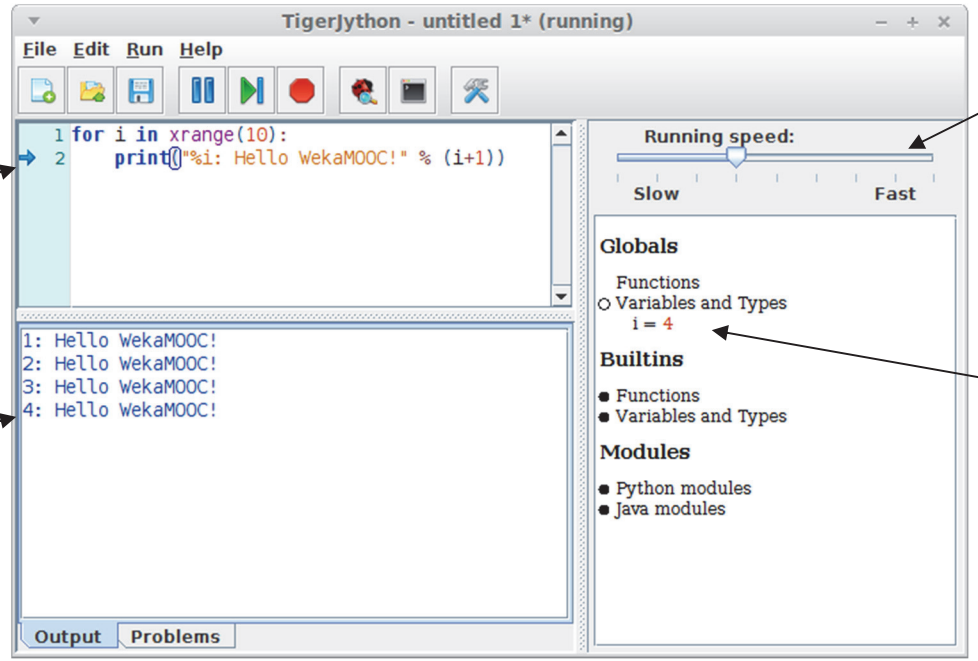
Invoking Python from Weka

Debugging your scripts

- Let's re-use example from *Java vs Python* comparison

```
for i in xrange(10):
    print("%i: Hello WekaMOOC!" % (i+1))
```

- Select "Toggle debugger" from the "Run" menu
- Execute the script



Speed of execution

Current execution pointer

Current state of variables

Output generated so far

Invoking Python from Weka

Information sources for Weka API

- Javadoc - detailed, per-class information
  - online (latest developer version)
  - http://weka.sourceforge.net/doc.dev/
  - Weka release/snapshot
  - see the **doc** directory of your Weka installation
- Example code
  - check the **wekaexamples.zip** archive of your Weka installation
- Weka Manual
  - check **WekaManual.pdf** of your Weka installation
  - Appendix → Using the API

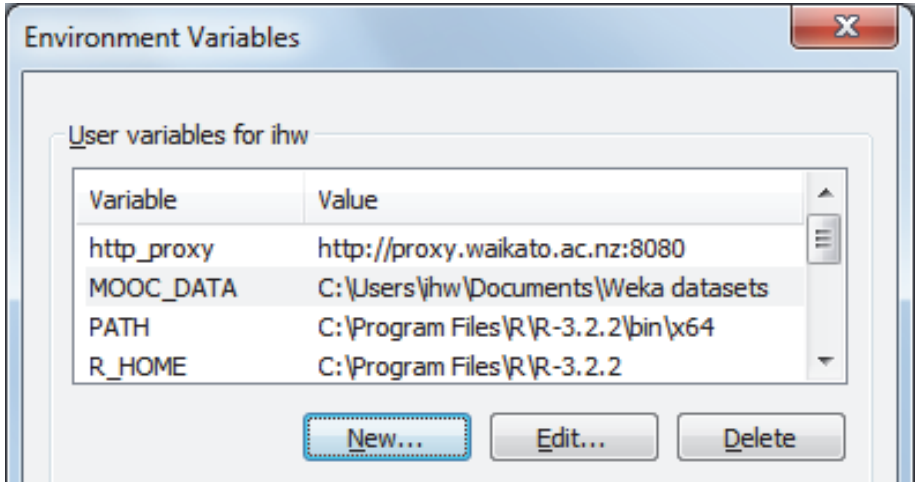
Invoking Python from Weka

What we need...

- Weka
  - **weka.filters.Filter** - for filtering datasets
  - **weka.filters.unsupervised.attribute.Remove** - removes attributes
  - **weka.core.converters.ConverterUtils.DataSource** - loads data
- Environment variable
  - set **MOOC_DATA** to point to your datasets

In Windows:

Control panel ->
System and Security ->
System ->
Advanced system settings ->
Environment Variables ->
New



Invoking Python from Weka

Load data and apply filter

You can download this script from the course page for this lesson

import Weka classes

```
import weka.filters.Filter as Filter
import weka.filters.unsupervised.attribute.Remove as Remove
import weka.core.converters.ConverterUtils.DataSource as DS
import os
```

read dataset (auto detection of file type using extension)

```
data = DS.read(os.environ.get("MOOC_DATA")+os.sep+"iris.arff")
```

setup filter

```
rem = Remove()
rem.setOptions(["-R", "last"])
```

notify filter about data, push data through

```
rem.setInputFormat(data)
dataNew = Filter.useFilter(data, rem)
```

output filtered data

```
print(dataNew)
```

Invoking Python from Weka

What we did...

- ❖ Installed tigerJython
- ❖ Seen that Python is easy to read and write
- ❖ Learned about API documentation resources
- ❖ Wrote our first Jython script

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Advanced Data Mining with Weka

Class 5 – Lesson 2

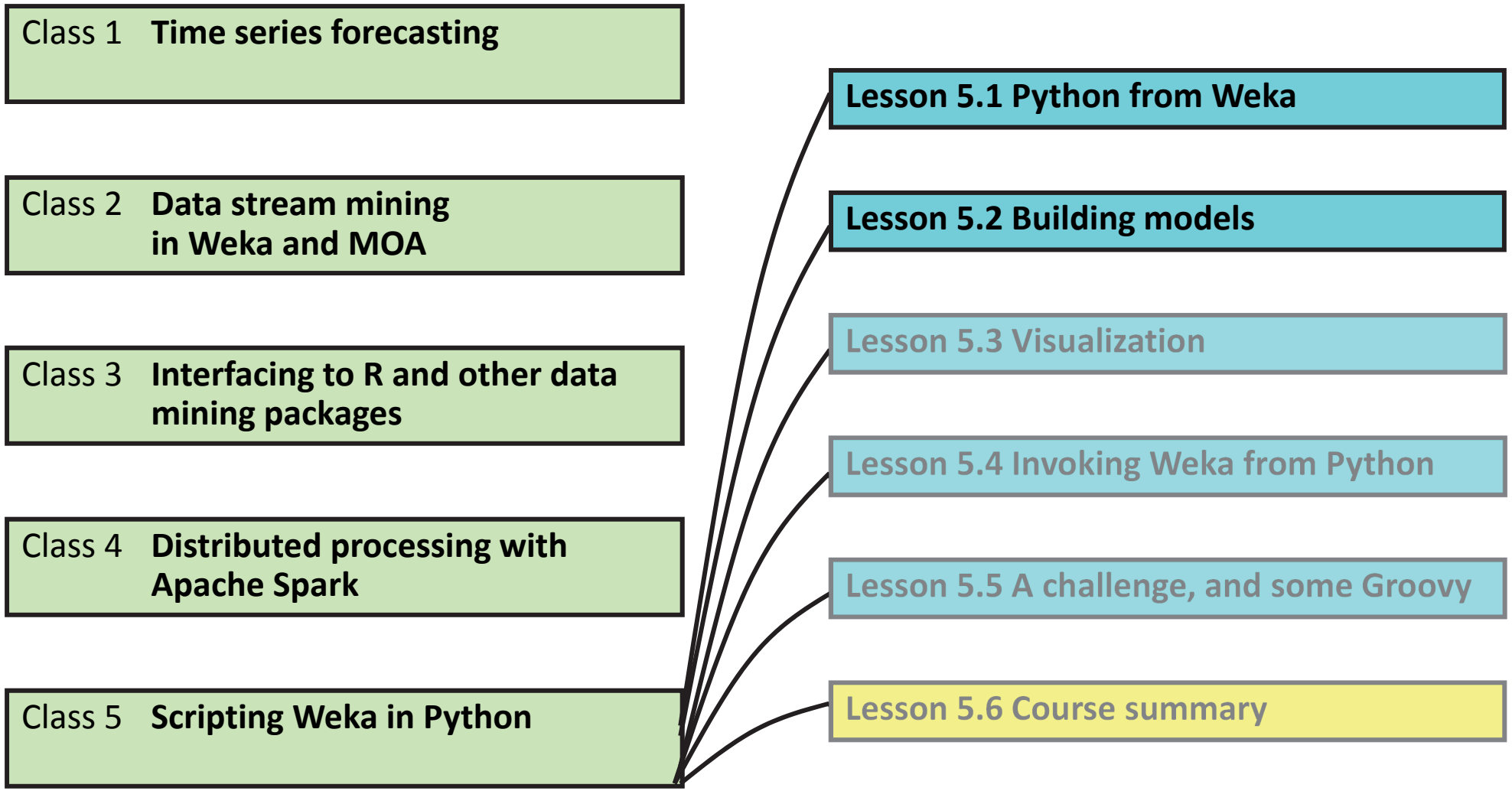
Building models

Peter Reutemann

Department of Computer Science
University of Waikato
New Zealand

weka.waikato.ac.nz

Lesson 5.2: Building models



Building models

What we need...

- Weka
  - **weka.classifiers.Evaluation** - for evaluating classifiers
  - **weka.classifiers.*** - some classifiers
  - **weka.filters.Filter** - for filtering datasets
  - **weka.filters.*** - some filters
- Java
  - **java.util.Random** - for randomization

Building models

Build J48 classifier

- Script: build_classifier.py
- Output

```
J48 pruned tree
------------------

hardness <= 70
|   strength <= 350
|   |   family = ?
|   |   |   surface-quality = ?
|   |   |   |   condition = ?: 3 (68.0/1.0)
|   |   |   |   condition = S
|   |   |   |   |   thick <= 0.75: 3 (5.0)
|   |   |   |   |   thick > 0.75
|   |   |   |   |   |   thick <= 2.501: 2 (81.0/1.0)
|   |   |   |   |   |   thick > 2.501: 3 (2.0)
|   |   |   |   condition = A: 2 (0.0)
|   |   |   |   condition = X: 2 (0.0)
|   |   |   surface-quality = D: 3 (55.0)
...
```

You can download the scripts and data files from the course page for this lesson

Hint: ensure that anneal.arff is in the directory indicated by your MOOC_DATA environment variable

Building models

Cross-validate J48

- Script: crossvalidate_classifier.py
- Output

```
=== J48 on anneal (stats) ===
Correctly Classified Instances         884               98.441  %
Incorrectly Classified Instances        14                1.559  %
Kappa statistic                          0.9605
Mean absolute error                      0.0056
Root mean squared error                  0.0669
Relative absolute error                  4.1865 %
Root relative squared error             25.9118 %
Coverage of cases (0.95 level)          98.7751 %
Mean rel. region size (0.95 level)      16.7223 %
Total Number of Instances              898

=== J48 on anneal (confusion matrix) ===
   a   b   c   d   e   f   <-- classified as
   5   0   3   0   0   0 |   a = 1
   0  99   0   0   0   0 |   b = 2
   0   2 680   0   0   2 |   c = 3
...
```

Building models

Predict class labels

Ensure that anneal_train.arff and anneal_unlbl.arff are in the appropriate directory

- Script: make_predictions-classifier.py
- Output

```
array('d', [0.0, 0.0, 1.0, 0.0, 0.0, 0.0]) - 2.0 - 3
array('d', [0.02173913043478260 8, 0.0, 0.9782608695652174, 0.0, 0.0, 0.0]) - 2.0 - 3
array('d', [0.0, 0.0, 1.0, 0.0, 0.0, 0.0]) - 2.0 - 3
array('d', [0.0, 0.0, 1.0, 0.0, 0.0, 0.0]) - 2.0 - 3
array('d', [0.0, 0.0, 1.0, 0.0, 0.0, 0.0]) - 2.0 - 3
array('d', [0.0, 0.0, 1.0, 0.0, 0.0, 0.0]) - 2.0 - 3
array('d', [0.0, 0.9811320754716981, 0.018867924528301886, 0.0, 0.0, 0.0]) - 1.0 - 2
array('d', [0.02173913043478260 8, 0.0, 0.9782608695652174, 0.0, 0.0, 0.0]) - 2.0 - 3
...
```

Building models

What we did...

- built a classifier
- output statistics from cross-validation
- used built model to make predictions

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Advanced Data Mining with Weka

Class 5 – Lesson 3

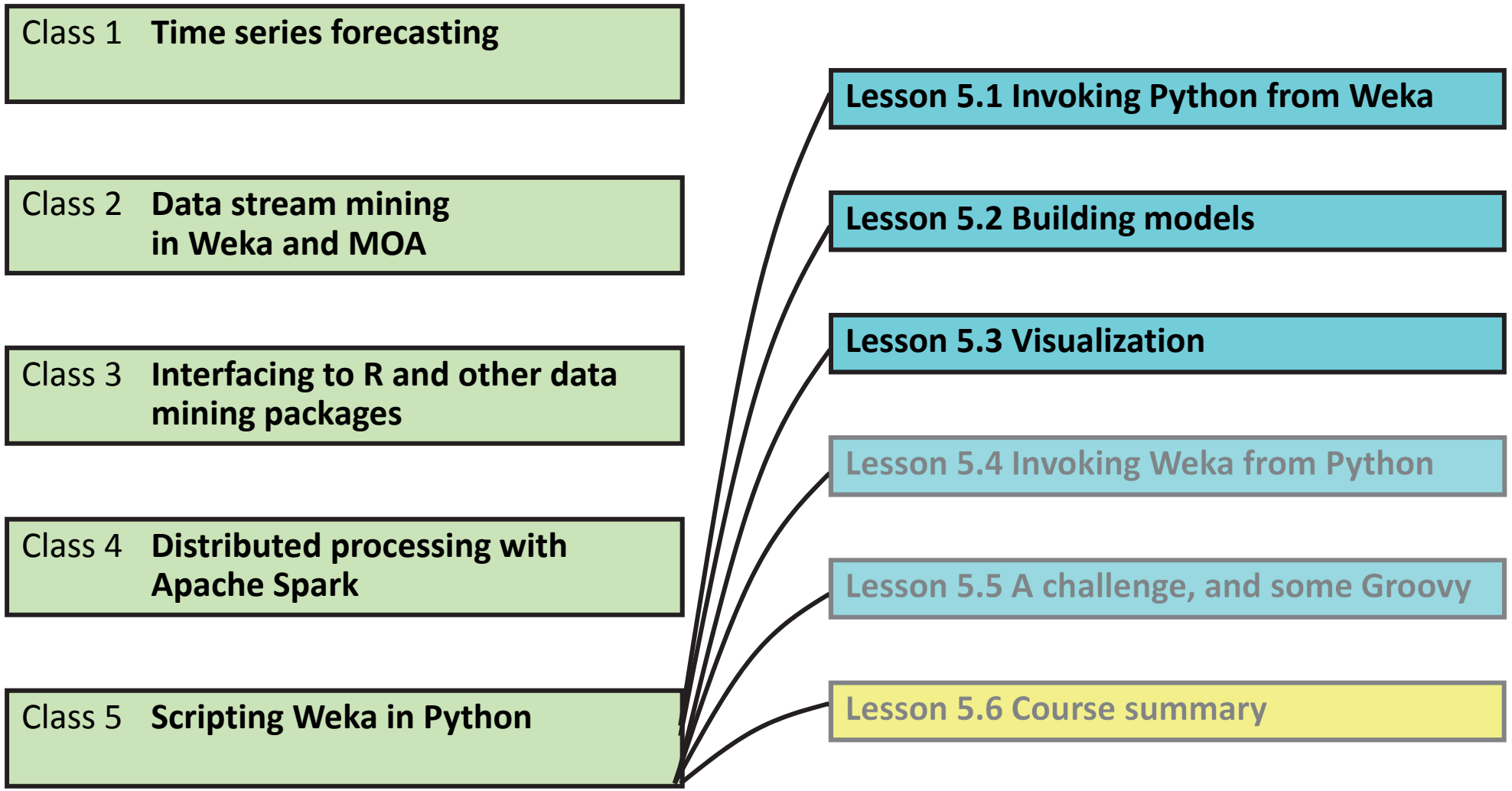
Visualization

Peter Reutemann

Department of Computer Science
University of Waikato
New Zealand

weka.waikato.ac.nz

Lesson 5.3: Visualization



Visualization

What we need...

- JFreeChart
  - easier to use than some of Weka's plotting
  - install the *jfreechartOffscreenRenderer* package
  - Javadoc
  - http://www.jfree.org/jfreechart/api/javadoc/
  - classes

    org.jfree.data.* - some dataset classes

    org.jfree.chart.ChartFactory - for creating plots

    org.jfree.chart.ChartPanel - for displaying a plot

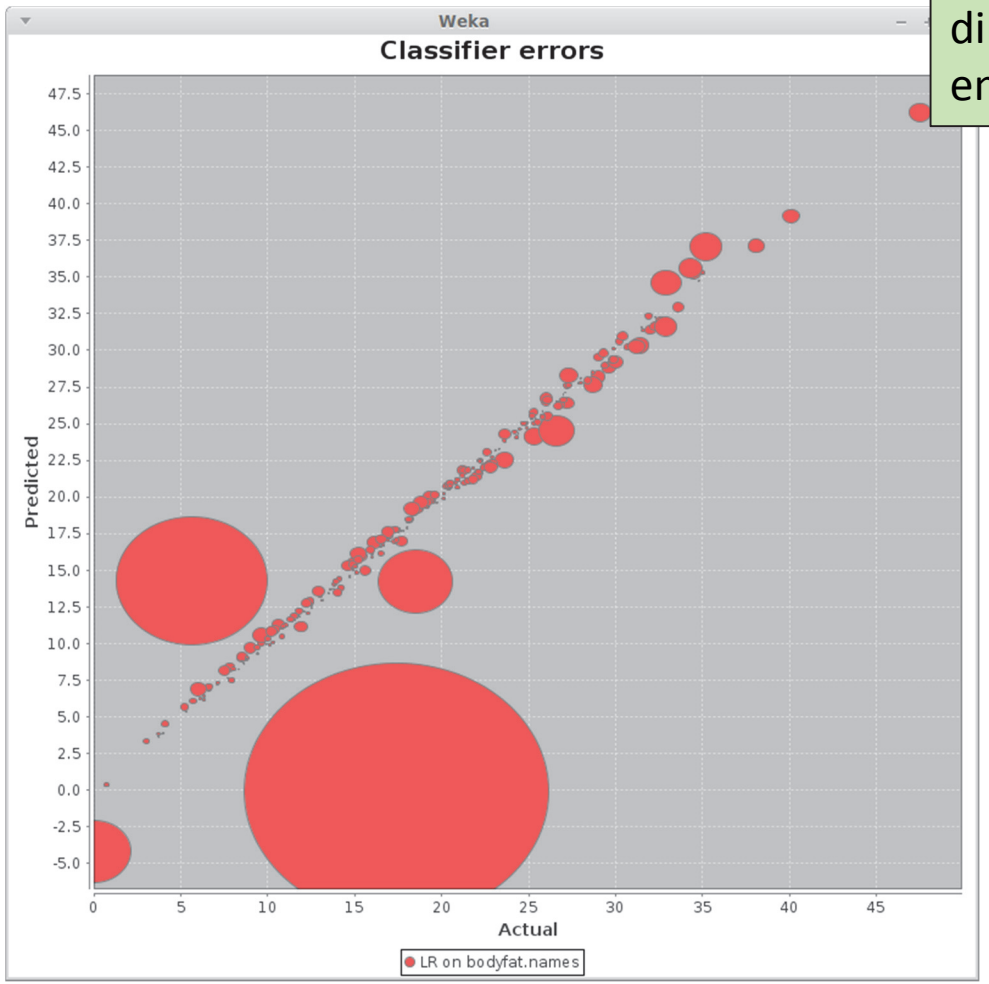
    weka.gui.* - for tree/graph visualizations
- Java

  javax.swing.JFrame - window for displaying plot

Visualization

Classifier errors with size of error

- Script: crossvalidate_classifier-errors-bubbles.py
- Output



You can download the scripts and data files from the course page for this lesson

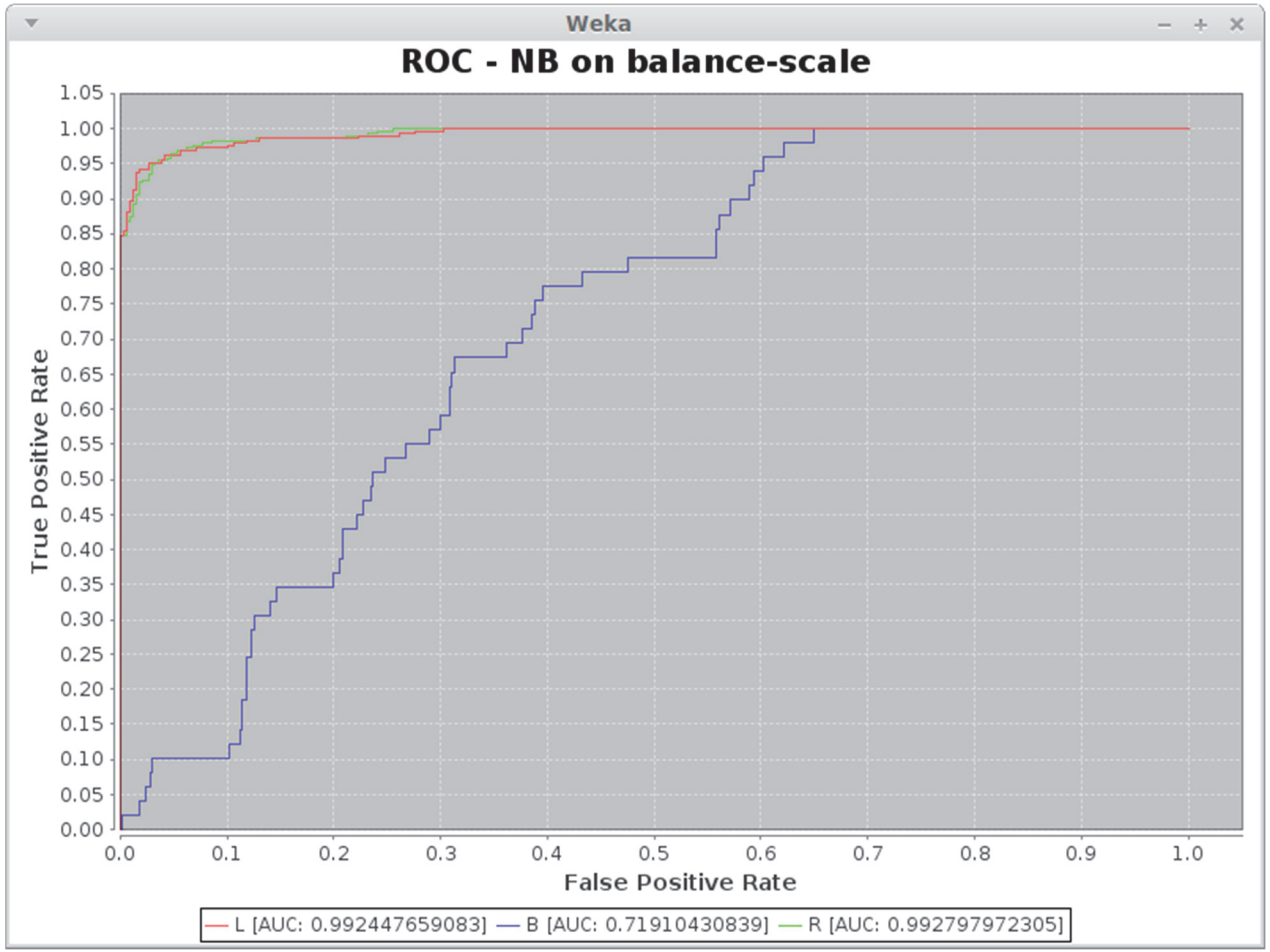
Hint: ensure that bodyfat.arff is in the directory indicated by your MOOC_DATA environment variable

Visualization

Ensure that balance-scale.arff is in the appropriate directory

Multiple ROC

- Script: display_roc-multiple.py
- Output

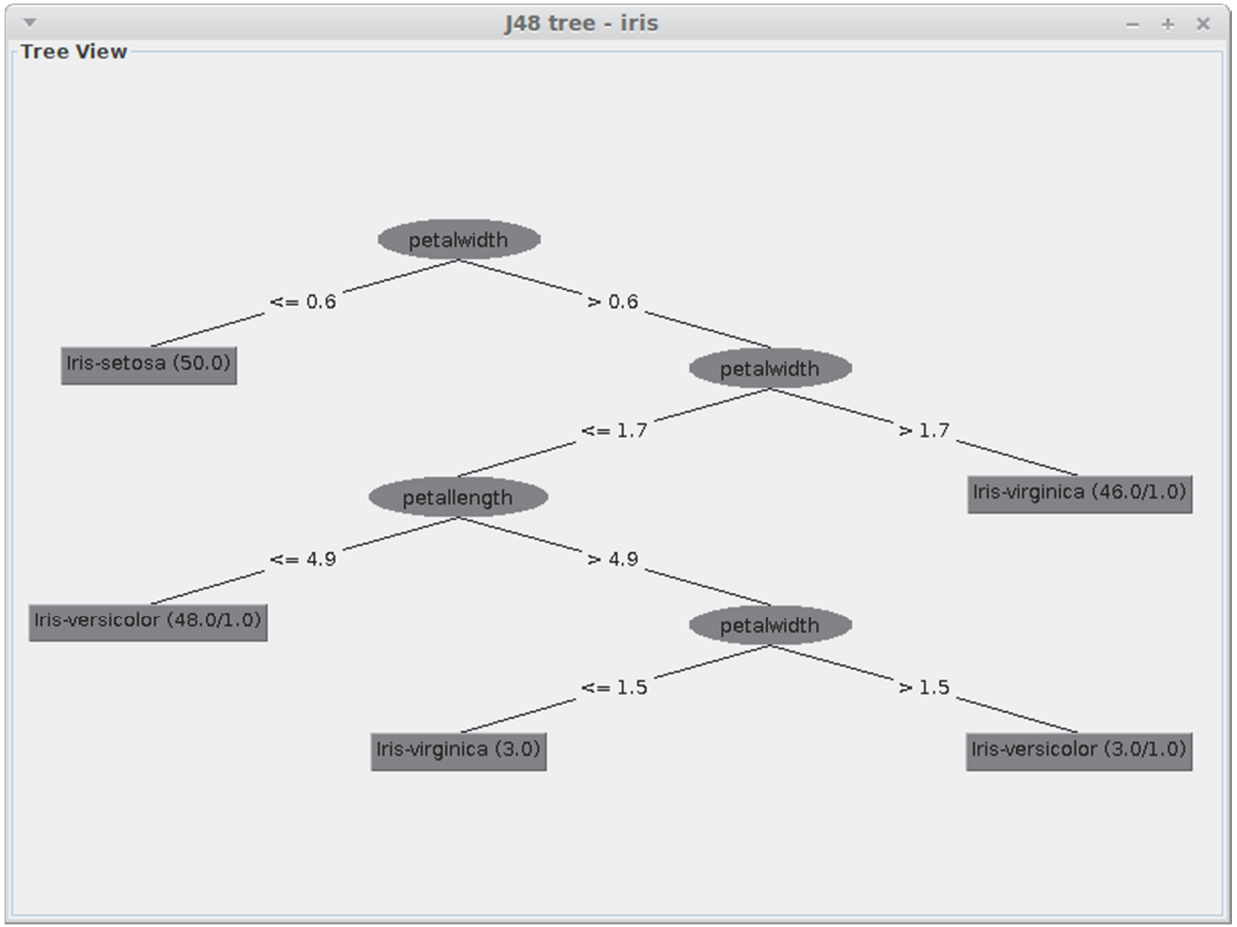


Visualization

Ensure that iris.arff is in the appropriate directory

Tree

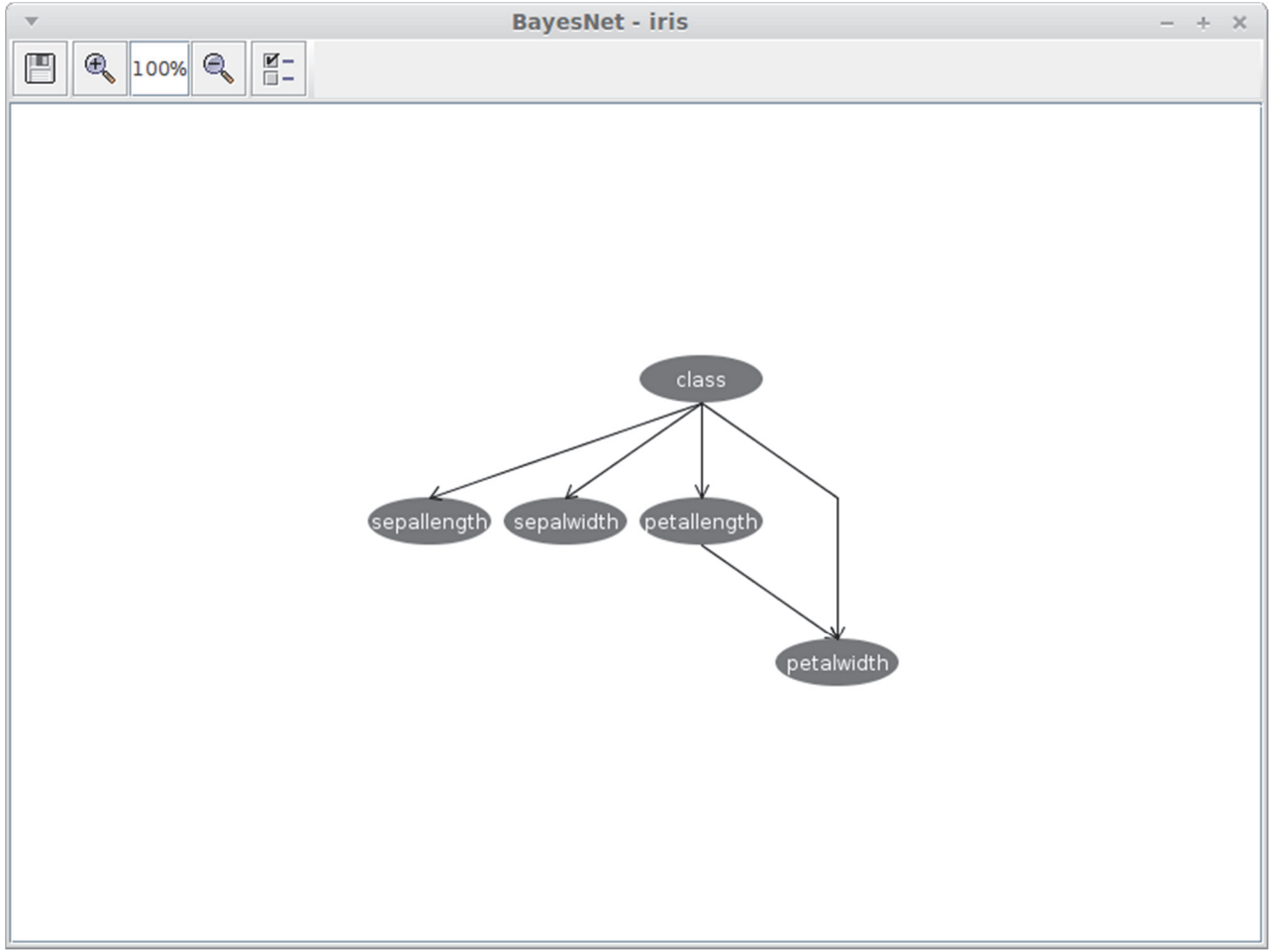
- Script: display_tree.py
- Output



Visualization

Network graph

- Script: display_graph.py
- Output



Visualization

What we did...

- Used JFreeChart for plotting
  - classifier errors
  - ROC
- Displayed J48 decision tree
- Visualized BayesNet network graph

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Advanced Data Mining with Weka

Class 5 – Lesson 4

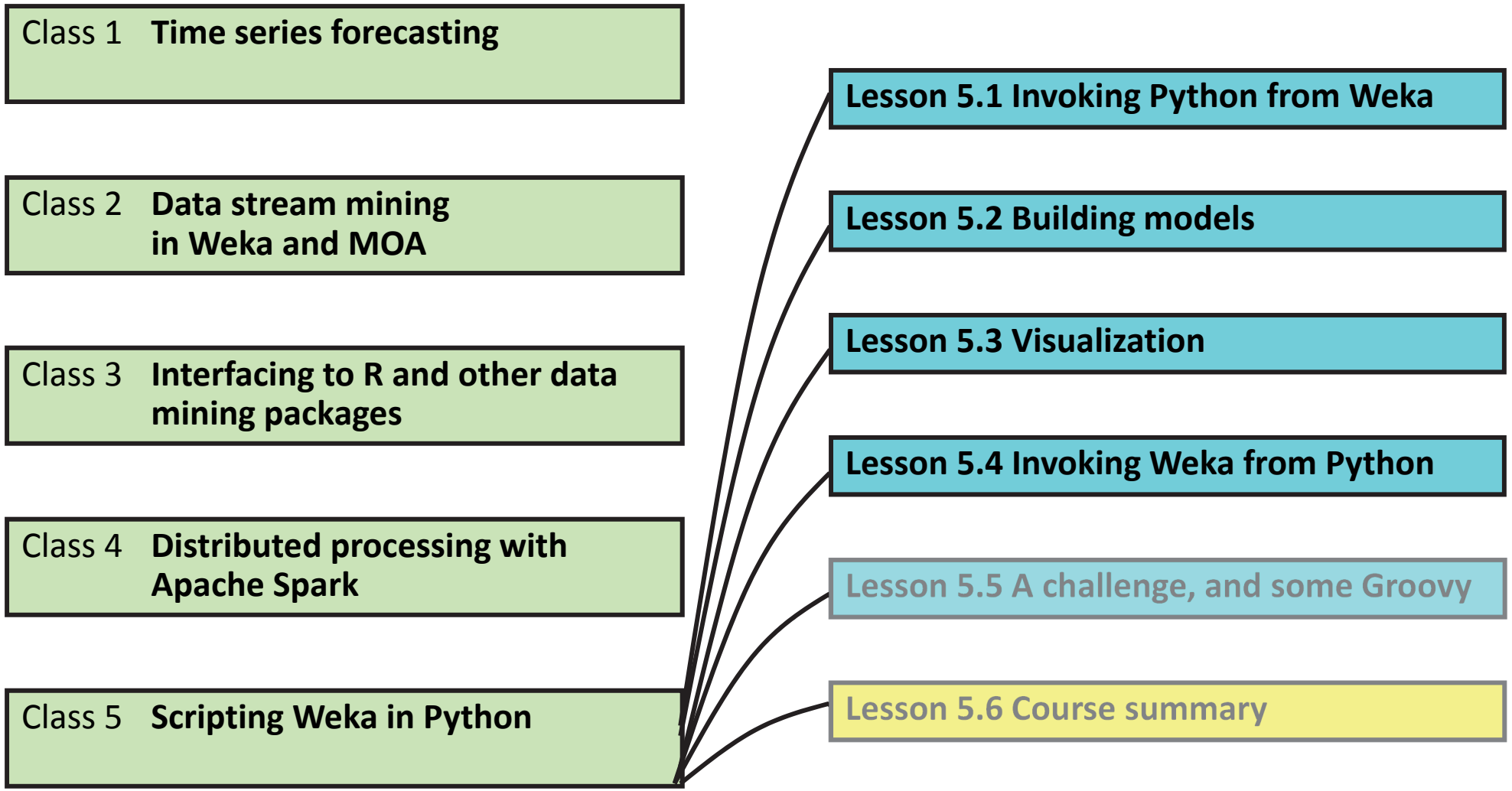
Invoking Weka from Python

Peter Reutemann

Department of Computer Science
University of Waikato
New Zealand

weka.waikato.ac.nz

Lesson 5.4: Invoking Weka from Python



Invoking Weka from Python

Why the other way?

- Jython limits you to pure-Python or Java libraries
- Weka provides only modeling and some visualizations
- Python offers much more:
  - NumPy - e.g., efficient arrays and matrices
  - SciPy - e.g., linear algebra, optimization, integration
  - matplotlib - plotting library
  - more info: https://wiki.python.org/moin/NumericAndScientific

Invoking Weka from Python

What we need...

- Install Python 2.7
  - https://www.python.org/downloads/
  - Java and Python need the same “bitness” (either 32bit or 64bit)
- Set up environment for compiling libraries
  - on Linux a no-brainer
  - OSX and Windows quite a bit of work involved
- Install python-weka-wrapper library
  - https://pypi.python.org/pypi/python-weka-wrapper
- Instructions and videos for all this can be found here
  - http://pythonhosted.org/python-weka-wrapper/install.html

Py{WE KA}

Invoking Weka from Python

python-weka-wrapper

- ❖ fires up JVM in the background and communicates with JVM via JNI
- ❖ provides a thin wrapper around Weka's superclasses (classifiers, filters, ...)
- ❖ provides a more “pythonic” API - some examples:
  - Python properties instead of get/set-method pairs
    options instead of **getOptions/setOptions**
  - lowercase + underscore instead of Java's camel case
    crossvalidate_model instead of **crossValidateModel**
- ❖ convenience methods
  data.class_is_last() instead of **data.setClassIndex(data.numAttributes()-1)**
- ❖ plotting is done by matplotlib

Py{WE KA}

Invoking Weka from Python

Cross-validate J48

- Script: pww-crossvalidate_classifier.py
- Output

You can download the scripts and data files from the course page for this lesson

Hint: ensure that anneal.arff is in the directory indicated by your MOOC_DATA environment variable

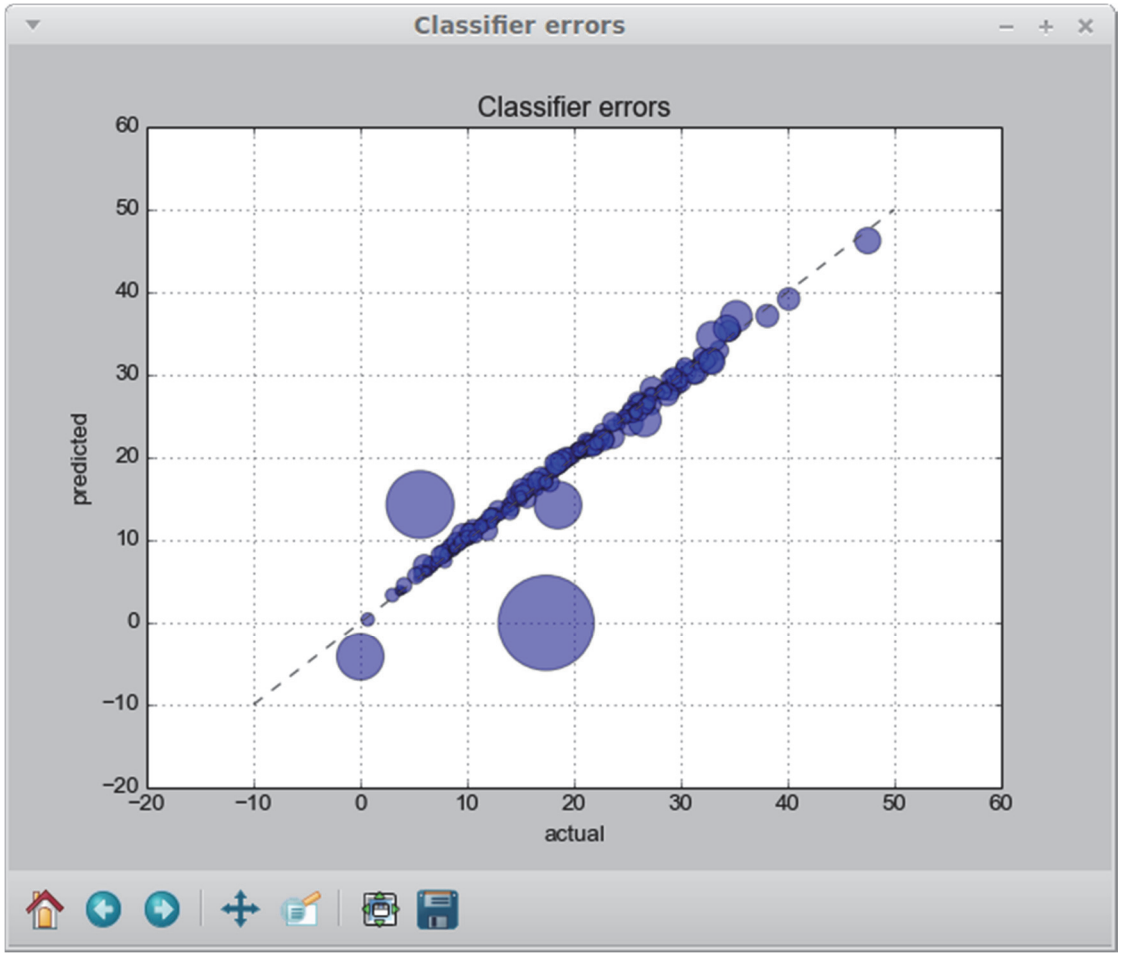
```
DEBUG:weka.core.jvm:Adding bundled jars
DEBUG:weka.core.jvm:Adding Weka packages
DEBUG:weka.core.jvm:package_dir=/home/fracpete/wekafiles/packages
...
DEBUG:weka.core.jvm:MaxHeapSize=default
DEBUG:javabridge.jutil:Creating JVM object
DEBUG:javabridge.jutil:Signalling caller
...
=== J48 on anneal (stats) ===
Correctly Classified Instances         884               98.441  %
Incorrectly Classified Instances        14                1.559  %
Kappa statistic                          0.9605
Mean absolute error                      0.0056
Root mean squared error                  0.0669
Relative absolute error                  4.1865 %
Root relative squared error             25.9118 %
Coverage of cases (0.95 level)          98.7751 %
Mean rel. region size (0.95 level)      16.7223 %
Total Number of Instances              898
```

Invoking Weka from Python

Ensure that bodyfat.arff is in the appropriate directory

Classifier errors with size of error

- Script: pww-crossvalidate_classifier-errors-bubbles.py
- Output

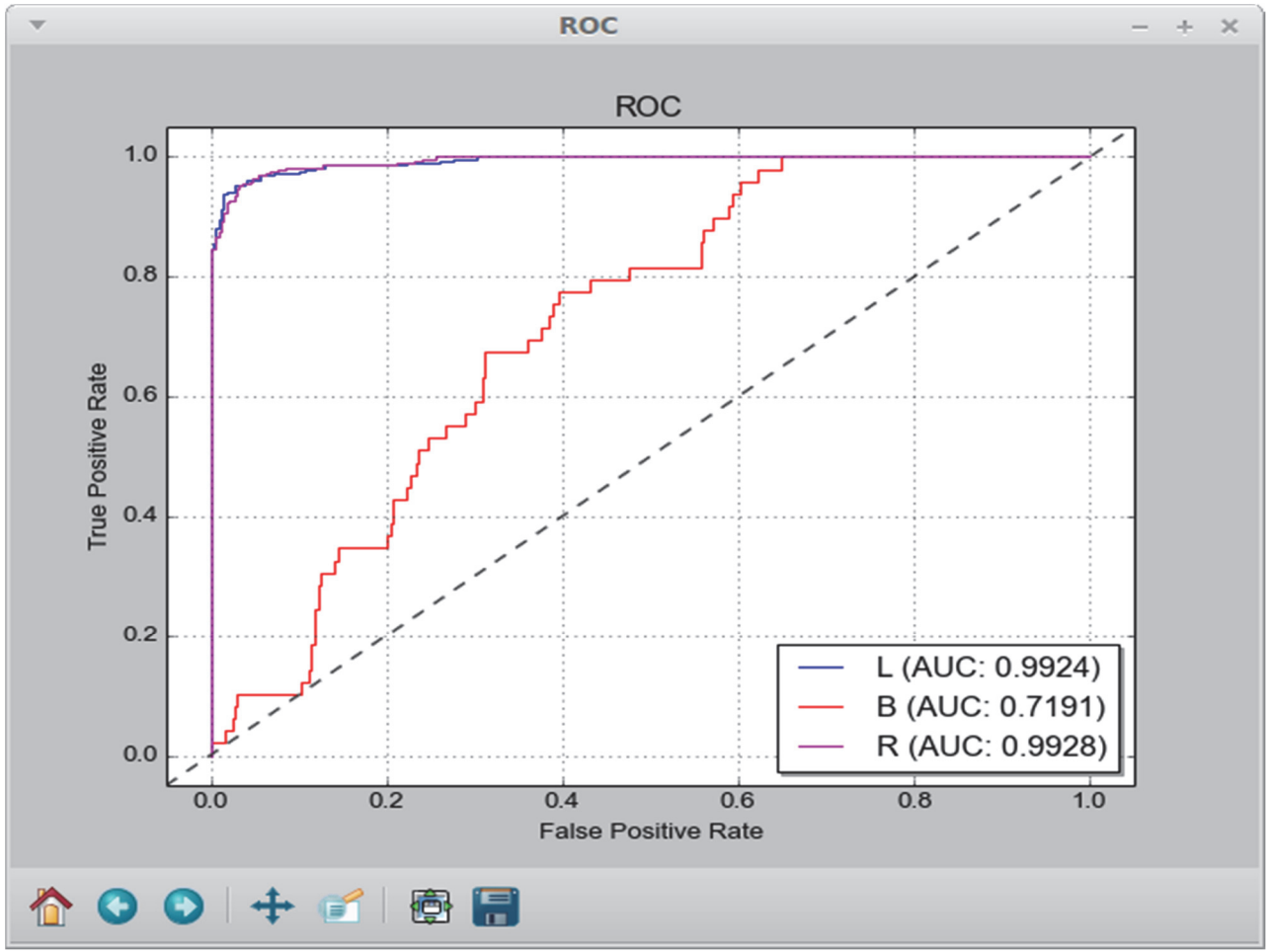


Invoking Weka from Python

Ensure that balance-scale.arff is in the appropriate directory

Multiple ROC

- Script: pww-display_roc-multiple.py
- Output



Invoking Weka from Python

What we did...

- Installed Python and additional modules via Python's pip
- Used Weka from within a “native” Python environment

Py{WE KA}

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Advanced Data Mining with Weka

Class 5 – Lesson 5

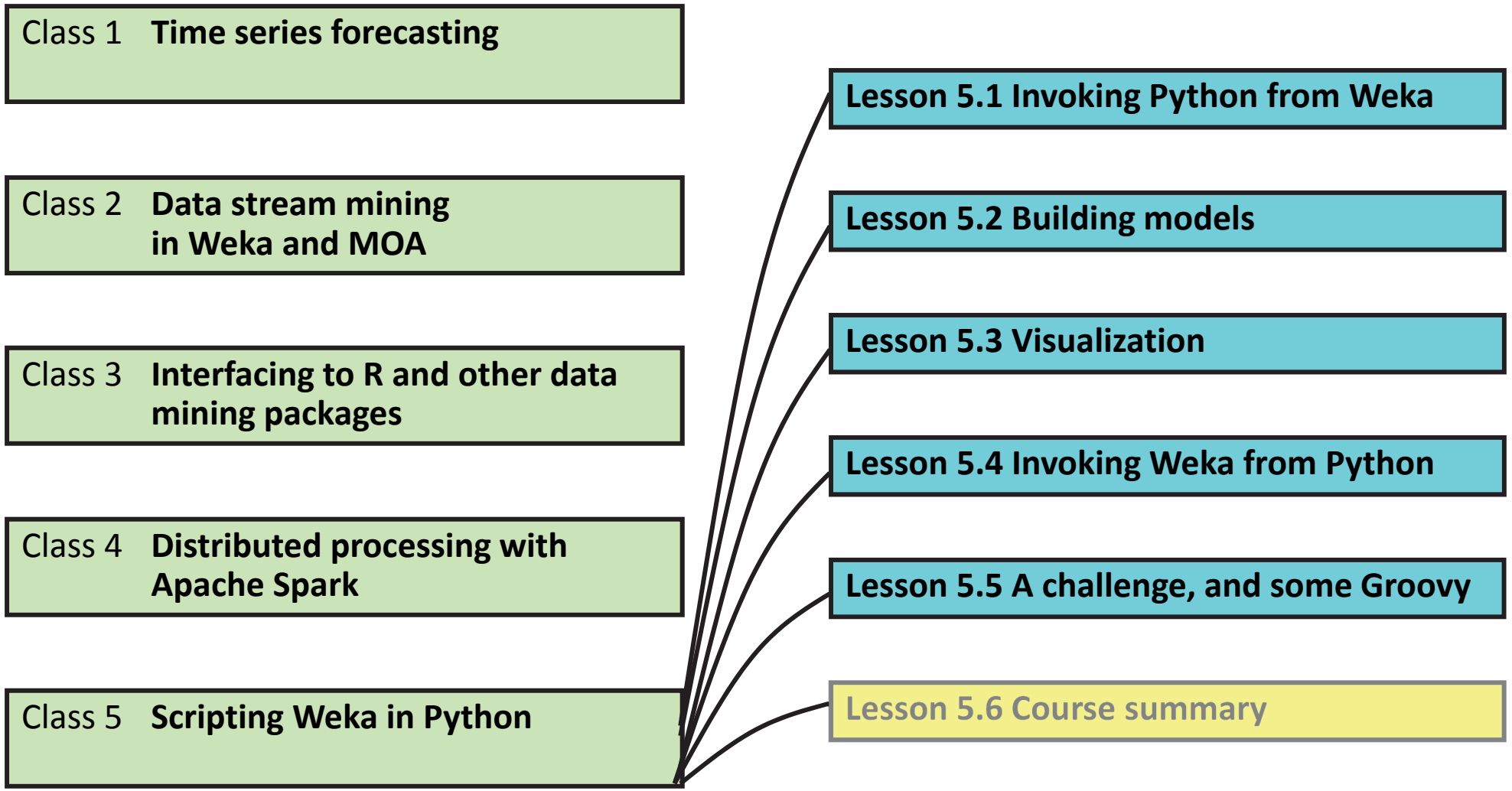
A challenge, and some Groovy

Peter Reutemann

Department of Computer Science
University of Waikato
New Zealand

weka.waikato.ac.nz

Lesson 5.5: A challenge, and some Groovy



A challenge and some Groovy

You can download the file challenge.text from the course page for this lesson. It gives information about the challenge

The challenge

- Annual shoot-out of the Council for Near-Infrared Spectroscopy (CNIRS)
- Shoot-out process
  - Build data on training data ("calibration")
  - Validate model on separate dataset ("validation")
  - Generate and submit predictions ("test set")
- We use the 2014 datasets

  http://cnirs.clubexpress.com/content.aspx?page_id=22&club_id=409746&module_id=159234

A challenge and some Groovy

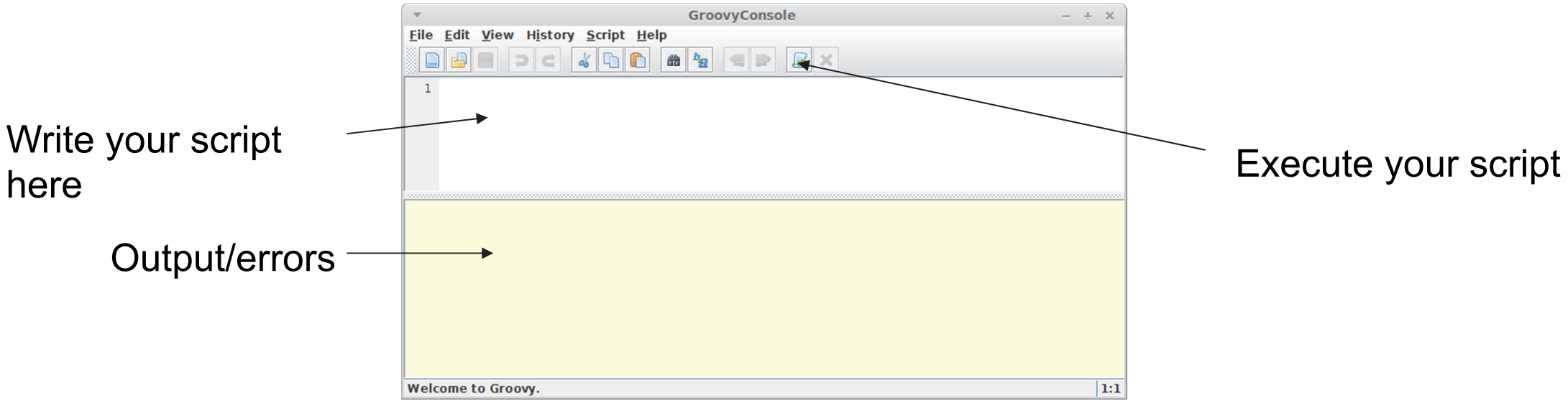
The challenge

- What to do?
  - Download the CSV files for Dataset 1 and 2 (calibration/test)
  - Generate data for Weka, build (“calibration”) and evaluate models (“test”)
  - Class attribute is “reference value”
  - Don't include “sample #”
- What to beat?
  - Dataset 1
    CC = 0.8644
    RMSE = 0.384
  - Dataset 2
    CC = 0.9986
    RMSE = 0.0026

A challenge and some Groovy

Install Groovy

- open *Package manager* (under *Tools*)
- scroll down and select *kfGroovy*
- click on Install
- after restarting Weka, open *Groovy console* (under *Tools*)



A challenge and some Groovy

Groovy basics

- Grammar is derived from Java (but no semicolons!)
  - http://groovy-lang.org/syntax.html
- “def” defines a variable, no type required
- lists are similar to Python ones: [1, “a”, true]
- maps are similar to Python dictionaries: [red: '#FF0000', green: '#00FF00']
- Enhances Java syntax, e.g.:
  - multi-line strings using triple single quotes
  - string interpolation
  - default imports of commonly used packages
  - closures (not the same as Java 8 lambdas)
    http://groovy-lang.org/closures.html
- Differences
  - http://groovy-lang.org/differences.html

A challenge and some Groovy

Groovy loops

- standard Java for-loop and while-loop
- using java.lang.Number object methods
  - http://docs.groovy-lang.org/latest/html/groovy-jdk/java/lang/Number.html
  - **upto**

    0.upto(10) {println(it)}

    prints numbers 0 to 10
  - **times**

    5.times {println(it)}

    prints numbers 0 to 4
  - **step**

    0.step(10, 2) {println(it)}

    prints numbers 0, 2, 4, 6, 8

A challenge and some Groovy

Make predictions

- Script: make_predictions-classifier.groovy
- Output

```
J48 pruned tree
------------------

hardness <= 70
|   strength <= 350
|   |   family = ?
|   |   |   surface-quality = ?
|   |   |   |   condition = ?: 3 (46.0/1.0)
|   |   |   |   condition = S
...

#: 1,2,3,4,5,U
1: 0.0,0.0,1.0,0.0,0.0,0.0
2: 0.021739130434782608,0.0,0.9782608695652174,0.0,0.0,0.0
3: 0.0,0.0,1.0,0.0,0.0,0.0
4: 0.0,0.0,1.0,0.0,0.0,0.0
5: 0.0,0.0,1.0,0.0,0.0,0.0
6: 0.0,0.0,1.0,0.0,0.0,0.0
...
```

You can download the scripts and data files from the course page for this lesson

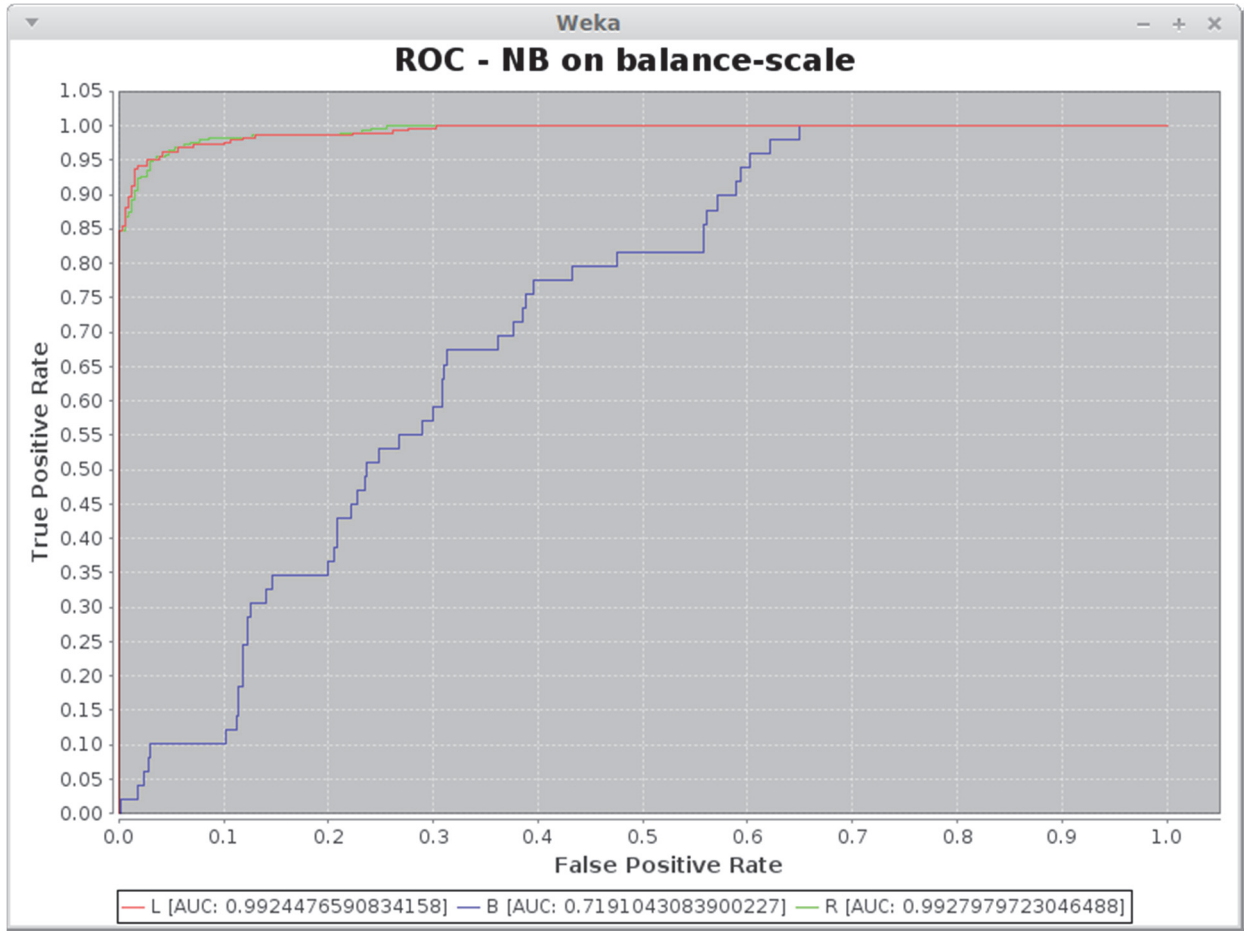
Hint: ensure that that anneal_train.arff and anneal_unlbl.arff are in the directory indicated by your MOOC_DATA environment variable

A challenge and some Groovy

Ensure that balance-scale.arff is in the appropriate directory

Multiple ROC

- Script: roc_multiple.groovy
- Output



A challenge and some Groovy

What we did...

- ❖ Tried our hands at some real-world data modeling
- ❖ Learned another scripting language

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Advanced Data Mining with Weka

Class 5 – Lesson 6

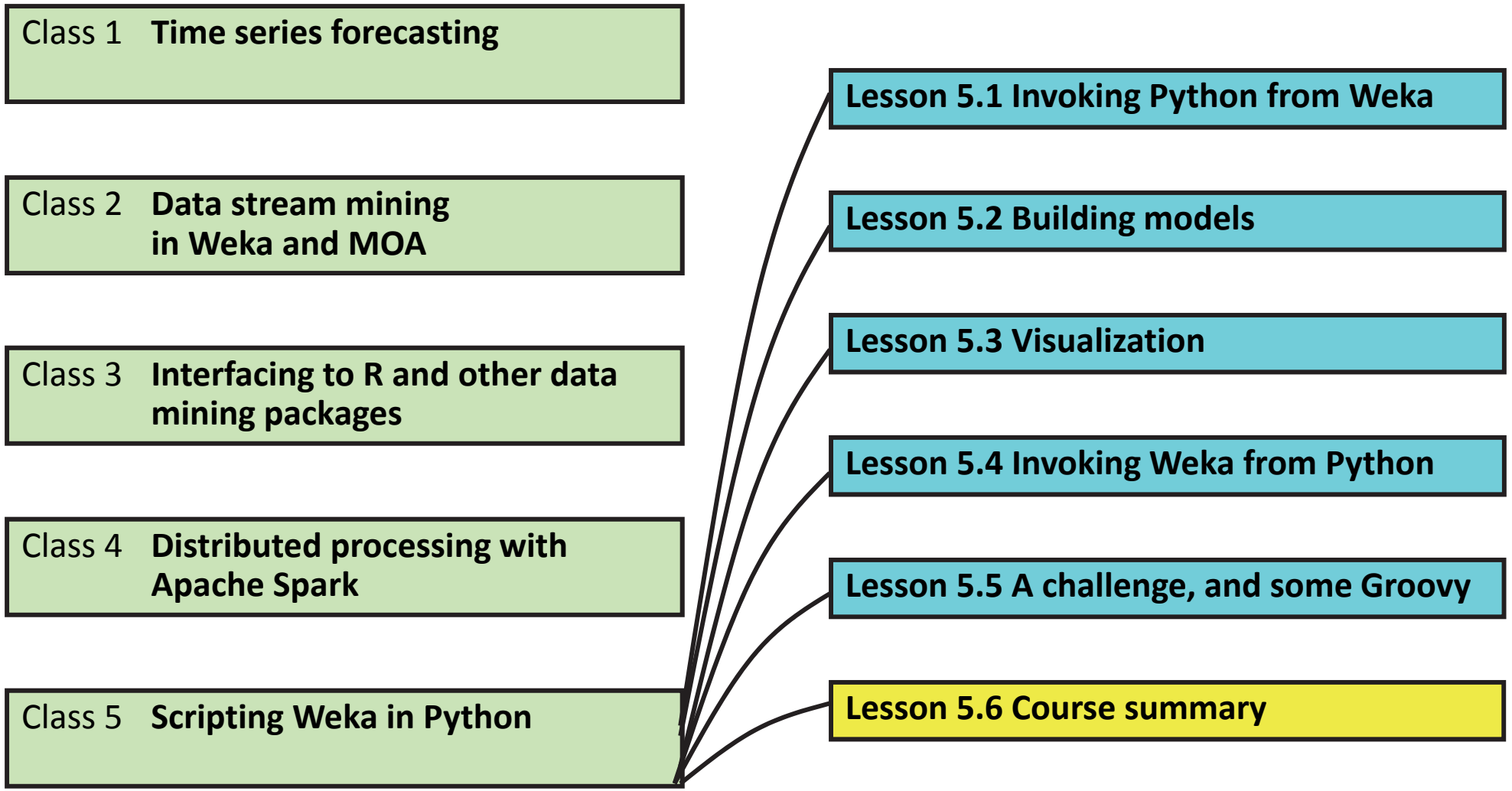
Course summary

Ian H. Witten

Department of Computer Science
University of Waikato
New Zealand

weka.waikato.ac.nz

Lesson 5.6: Course summary



Summary

From "More Data Mining with Weka"

What have we missed?

- **Time series analysis** — *Environment for time series forecasting*
- **Stream-oriented algorithms** — *MOA system for massive online analysis*
- **Multi-instance learning** — *Bags of instances labeled positive or negative, not single instances*
- **One-class classification**
- **Interfaces to other data mining packages** — ***LibSVM, LibLinear, R***
- **Di… Weka with Hadoop**
- **…ent Semantic Analysis**

Advanced Data Mining with Weka??

These are available as Weka "packages"

Summary

Advanced Data Mining with Weka

What did we do?

- ✓ ❖ **Time series analysis** — *Environment for time series forecasting*
- ✓ ❖ **Stream-oriented algorithms** — *MOA system for massive online analysis*
- ❖ **Multi-instance learning** — *Bags of instances labeled positive or negative, not single instances*
- ✓ ❖ **One-class classification (Activity 3.1)**
- ✓ ❖ **Interfaces to other data mining packages** — ***LibSVM, LibLinear, R***
- ✓ ❖ **Distributed Weka with Hadoop and SPARK**
- ❖ **Latent Semantic Analysis**

- ✓ ❖ **Scripting in Python and Groovy**
- ✓ ❖ **Applications**

- ✓ **These are available as Weka “packages”**

Summary

Applications

- **Infrared data from soil samples**
  - *Hard to achieve sufficiently good performance for practical application*
  - *Need to investigate outliers, more classifier/filter tweaking*
- **Bioinformatics: signal peptide prediction**
  - *Domain knowledge is vital: collaborate with experts!*
  - *Accurate prediction vs explanatory model?*
  - *Overfitting the data*
- **Functional MRI Neuroimaging data**
  - *Enormous 4D data*
  - *Amalgamating data from different runs?*
  - *Combining data from different subjects*
  - *In an early competition, demographic data alone did well!*
- **Image classification**
  - *Specialist feature extraction techniques for different kinds of data*

Summary

More practical data mining: Kaggle competitions (*https://www.kaggle.com/*)

- **Featured competitions**
  - *Win money!*
- **Recruitment competitions**
  - *Get jobs!*
- **Interesting datasets/Playground**
  - *Play around*
- **Getting started**
  - *Educational*
- **Completed competitions**
  - *Past solutions*
  - *Kaggle blog*
  - *Interviews with winners*
  - *Descriptions of winner's solution*

Summary

Ethics: don’t forget!

- “More than ever, knowingly or unknowingly, consumers disseminate personal data in daily activities”
- “As companies seek to capture data about consumer habits, privacy concerns have flared”
- “Data mining: where legality and ethics rarely meet”
- “Big data might be big business, but overzealous data mining can seriously destroy your brand”
- “What big data needs: A code of ethical practices”

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Advanced Data Mining with Weka

Department of Computer Science
University of Waikato
New Zealand

weka.waikato.ac.nz