MOA: Massive Online Analysis, a Framework for Stream Classification and Clustering

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Workshop on Applications of Pattern Analysis 2010
Mining Massive Data

2007
- Digital Universe: 281 exabytes (billion gigabytes)
- The amount of information created exceeded available storage for the first time

Eric Schmidt, August 2010
Every two days now we create as much information as we did from the dawn of civilization up until 2003.

5 exabytes of data

Twitter
- 106 million registered users
- 3 billion requests a day via its API.
Evolving Data Streams

Extract information from
- potentially infinite sequence of data
- possibly varying over time
- using few resources

Stream Mining Algorithms

- Fast methods without storing all dataset in memory
- Traditional methods don’t deal with restrictions
What is MOA?

{M}assive {O}nline {A}nalyses is a framework for online learning from data streams.

- It is closely related to WEKA
- It includes a collection of offline and online as well as tools for evaluation:
  - classification
  - clustering
- Easy to extend
- Easy to design and run experiments
WEKA

- **Waikato Environment for Knowledge Analysis**
- Collection of state-of-the-art machine learning algorithms and data processing tools implemented in Java
  - Released under the GPL
- Support for the whole process of experimental data mining
  - Preparation of input data
  - Statistical evaluation of learning schemes
  - Visualization of input data and the result of learning

- Used for education, research and applications
- Complements “Data Mining” by Witten & Frank
WEKA: the bird
The Moa (another native NZ bird) is not only flightless, like the Weka, but also extinct.
MOA: the bird

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Data stream learning cycle

1. Process an example at a time, and inspect it only once (at most)
2. Use a limited amount of memory
3. Work in a limited amount of time
4. Be ready to predict at any point
Classification Experimental setting

MOA Graphical User Interface

Classification  Clustering

Configure  EvaluateModel

<table>
<thead>
<tr>
<th>command</th>
<th>status</th>
<th>time elapsed</th>
<th>current activity</th>
<th>% complete</th>
</tr>
</thead>
</table>

Pause  Resume  Cancel  Delete

No preview available

Refresh  Auto refresh: every second

Export as .txt file...
Classification Experimental setting

Evaluation procedures for Data Streams
- Holdout
- Interleaved Test-Then-Train or Prequential

Environments
- Sensor Network: 100Kb
- Handheld Computer: 32 Mb
- Server: 400 Mb
Classification Experimental setting

Data Sources

- Random Tree Generator
- Random RBF Generator
- LED Generator
- Waveform Generator
- Hyperplane
- SEA Generator
- STAGGER Generator
Classification Experimental setting

Classifiers
- Naive Bayes
- Decision stumps
- Hoeffding Tree
- Hoeffding Option Tree
- Bagging and Boosting
- ADWIN Bagging and Leveraging Bagging

Prediction strategies
- Majority class
- Naive Bayes Leaves
- Adaptive Hybrid
Clustering Experimental setting
## Clustering Experimental setting

<table>
<thead>
<tr>
<th>Internal measures</th>
<th>External measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma</td>
<td>Rand statistic</td>
</tr>
<tr>
<td>C Index</td>
<td>Jaccard coefficient</td>
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<tr>
<td>Point-Biserial</td>
<td>Folkes and Mallow Index</td>
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<tr>
<td>Log Likelihood</td>
<td>Hubert Γ statistics</td>
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<tr>
<td>Dunn’s Index</td>
<td>Minkowski score</td>
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<td>Tau</td>
<td>Purity</td>
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<td>Tau A</td>
<td>van Dongen criterion</td>
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<td>Tau C</td>
<td>V-measure</td>
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<tr>
<td>Somer’s Gamma</td>
<td>Completeness</td>
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<tr>
<td>Ratio of Repetition</td>
<td>Homogeneity</td>
</tr>
<tr>
<td>Modified Ratio of Repetition</td>
<td>Variation of information</td>
</tr>
<tr>
<td>Adjusted Ratio of Clustering</td>
<td>Mutual information</td>
</tr>
<tr>
<td>Fagan’s Index</td>
<td>Class-based entropy</td>
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<tr>
<td>Deviation Index</td>
<td>Cluster-based entropy</td>
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<tr>
<td>Z-Score Index</td>
<td>Precision</td>
</tr>
<tr>
<td>D Index</td>
<td>Recall</td>
</tr>
<tr>
<td>Silhouette coefficient</td>
<td>F-measure</td>
</tr>
</tbody>
</table>

*Table:* Internal and external clustering evaluation measures.
Clusterers
- StreamKM++
- CluStream
- ClusTree
- Den-Stream
- D-Stream
- CobWeb
Web

http://www.moa.cs.waikato.ac.nz

Massive Online Analysis

Massive Online Analysis is an environment for massive data mining.

MOA is a framework for learning from a data stream, a continuous supply of examples, includes tools for evaluation and a collection of machine learning algorithms. Related to the WEKA project, also written in Java, while scaling to more demanding problems.
java -cp .:moa.jar:weka.jar -javaagent:sizeofag.jar moa.gui.GUI
This command creates a comma separated values file:

- training the DecisionStump classifier on the WaveformGenerator data,
- using the first 100 thousand examples for testing,
- training on a total of 100 million examples, and
- testing every one million examples:
Easy Design of a MOA classifier

- void resetLearningImpl ()
- void trainOnInstanceImpl (Instance inst)
- double[] getVotesForInstance (Instance i)
Easy Design of a MOA clusterer

- void resetLearningImpl ()
- void trainOnInstanceImpl (Instance inst)
- Clustering getClusteringResult()
Extensions of MOA

- Multi-label Classification
- Itemset Pattern Mining
- Sequence Pattern Mining
Summary

Massive Online Analysis is a framework for online learning from data streams.

http://www.moa.cs.waikato.ac.nz

- It is closely related to WEKA
- It includes a collection of offline and online as well as tools for evaluation:
  - classification
  - clustering
- MOA deals with evolving data streams
- MOA is easy to use and extend
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