2014 International Congress on Environmental Modelling and Software
June 18, 2014, San Diego, CA, USA

Abstractions from Sensor Data with Complex Event Processing and Machine Learning

Markus Stocker, Mauno Rönkkö, Mikko Kolehmainen

UNIVERSITY OF
EASTERN FINLAND

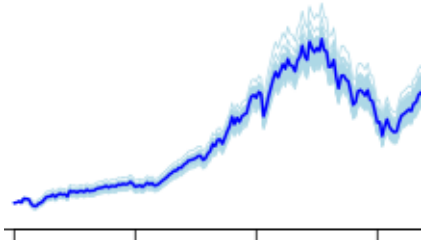
Introduction

- Environmental sensor networks (ESN)
  - Important tool in environmental science
- Large amounts of heterogeneous data
- Organize and interpret ESN data
- Building on ESNs
  - Environmental data systems
  - Environmental knowledge systems

Problem

What we have

```
1.12483456780
2.59901521668
3.93918999451
1.28316206864
8.15483832459
2.15588315924
1.12483456780
2.59901521668
3.93918999451
1.28316206864
8.15483832459
2.15588315924
```



What we need more

Starting point

- ESNs do not measure situational knowledge
  - But spatio-temporal change of physical properties
- We have data for properties
- We want situational knowledge
  - Information for situations
  - Situations are “structured parts of reality” [1]
  - Include objects, information for their state
- Assumed we can get from data to knowledge
  - Automatically using computational methods
  - Possibly (expert) supervised

Methods of interest

- Knowledge representation
  - Represent data and knowledge
- Knowledge extraction
  - Rule-based reasoning
  - Complex event processing (CEP)
  - Machine learning (ML)
  - Physically-based models
- Data processing
  - Aggregation, interpolation, filtering, ...

What we did

- Use CEP and ML to get from data to knowledge
- In Wavellite
  - Modelling and software framework
  - Situation awareness in environmental monitoring
  - Four layers with components and modules
  - Core data abstractions
    - Sensor observation, dataset observation, situation
    - These are ontological classes
- Learning modules of particular interest here
  - Implement program logic to extract knowledge
  - From dataset observations (input)
  - Represented as situations (output)

What we did

- Implementations for CEP with Esper and ML with WEKA
- CEP and Esper
  - Provide EPL statements
  - Executed by CEP engine on dataset observations
  - Events form situational knowledge
- ML and WEKA
  - Provide (trained) classifier
  - Classify dataset observations
  - Class labels form situational knowledge

Examples

- CEP and Esper
  - Sensor measures wind speed
  - Data represented as sensor observations
  - Processed to dataset observations
  - EPL statement for strong winds (wind speed > threshold)
  - CEP engine returns events matching EPL statement
  - Events include situational knowledge for strong winds
- ML and WEKA
  - Sensor observations for road pavement vibration
  - Processed to dataset observations for vibration patterns
  - Classify patterns to detect and characterize vehicles
  - Class label is situational knowledge for vehicle type

Take away

- In applications on ESNs
  - Problem-specific knowledge extraction
  - Support range of computational methods
  - Situation theory/awareness useful
  - Build knowledge representation into systems

References I

[1] K. Devlin.
Logic and information.
Cambridge University Press, 1995.

Pictures:
* Environmental monitoring station
http://ndep.nv.gov/baqp/monitoring.html
* Database
http://www.inkwellimages.ie/webdesign/uploads/images/stock/png/computer-database-psd-icon-400x320.png
* Timeseries
http://freakonometrics.blog.free.fr/public/perso6/sp500-ok-evol-jack.png
* Situation
http://www.relocateaz.com/wp-content/uploads/2014/05/monsoon-driving.jpg