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Semantic Sensor Web

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Semantic Sensor Web

Talk at: Semantic Interoperability Community of Practice (SICoP)
Sensor Standards Harmonization WG
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1. Motivating Scenario

2. Sensor Web Enablement

3. Semantic Sensor Web

4. Prototype Application
Motivating Scenario

- How do we determine if $A-H = A-L$? (Same time? Same place?)

- How do we determine if $E-H = E-L$? (Same entity?)

- How do we determine if $E-H$ or $E-L$ constitutes a threat?
The Challenge

Collection and analysis of information from heterogeneous multi-layer sensor nodes
Why is this a Challenge?

• There is a lack of uniform operations and standard representation for sensor data.

• There exists no means for resource reallocation and resource sharing.

• Deployment and usage of resources is usually tightly coupled with the specific location, application, and devices employed.

• **Resulting in a lack of interoperability.**
Many diverse sensor data management *application* frameworks were compared, such as:

1. **GSN**
   - Global Sensor Network
   - Digital Enterprise Research Institute (DERI)

2. **Hourglass**
   - An Infrastructure for Connecting Sensor Networks and Applications
   - Harvard
   - [http://www.eecs.harvard.edu/~syrah/hourglass/](http://www.eecs.harvard.edu/~syrah/hourglass/)

3. **IrisNet**
   - Internet-Scale Resource-Intensive Sensor Network Service
   - Intel & Carnegie Mellon University
   - [http://www.intel-iris.net/](http://www.intel-iris.net/)

However, it soon became obvious that these application frameworks provided only localized interoperability and that a standards-based framework was necessary.
1. Motivating Scenario

2. Sensor Web Enablement

3. Sensor data evolution hierarchy

4. Prototype Application
What is Sensor Web Enablement?

- The **interoperability framework** for accessing and utilizing sensors and sensor systems in a space-time context via Internet and Web protocols
- A set of **web-based services** may be used to maintain a registry of available sensors.
- The **same** web technology standard for describing the sensors’ outputs, platforms, locations, and control parameters should be used **all across**.
- This enables the necessary **interoperability**.
- This standard encompasses **specifications** for interfaces, protocols, and encodings that enable the use of sensor data and services.

http://www.opengeospatial.org/projects/groups/sensorweb
Constellations of heterogeneous sensors

Vast set of users and applications

OGC Sensor Web Enablement

http://www.opengeospatial.org/projects/groups/sensorweb
SWE Languages and Encodings

- **Observations & Measurements (O&M)**
- **SensorML (SML)**
- **GeographyML (GML)**
- **TransducerML (TML)**

- Information Model for Observations and Sensing
- Sensor and Processing Description Language
- SWE Common Data Structure And Encodings
- Multiplexed, Real Time Streaming Protocol

1. Motivating Scenario

2. Sensor Web Enablement

3. Semantic Sensor Web

4. Prototype Application
What is the Semantic Sensor Web?

- Adding semantic annotations to existing standard Sensor Web languages in order to provide semantic descriptions and enhanced access to sensor data

- This is accomplished with *model-references* to ontology concepts that provide more expressive concept descriptions

- For example, using model-references to link SML annotated sensor data with concepts within an OWL-Time ontology allows one to provide temporal semantics of sensor data.
XLink

- Used for describing links between resources in XML documents.
- Several important attributes within XLink include:
  - **type**: describes the element type of the link (i.e., simple, extended)
  - **role**: semantic attribute that describes the meaning of resources within the context of a link
  - **href**: locator attribute that supplies the URI needed to find a remote resource

Other used Model Reference in Semantic Annotations

- **SAWSDL**: Defines mechanisms to add semantic annotations to WSDL and XML-Schema components (*W3C Recommendation*)
- **SA-REST**: Defines mechanisms to add semantic annotations to REST-based Web services.

W3C, XML Linking Language, [http://www.w3.org/TR/xlink](http://www.w3.org/TR/xlink)
Model Reference (SensorML)

Semantic Annotations (model-references) to temporal ontology

Instant

Interval

OWL-Time Ontology

 Timestamp: start time

 Timestamp: end time

 Lat/Long coordinates

 Timestamp: 2002-11-10T15:31:00.0Z

 Timestamp: 2002-11-10T15:34:31.0Z

 Lat: 39.779535, Long: -84.063821
Semantic Temporal Query

- Model-references from SML to OWL-Time ontology concepts provides the ability to perform semantic temporal queries
- Supported semantic query operators include:
  - **contains**: user-specified interval falls wholly within a sensor reading interval (also called **inside**)
  - **within**: sensor reading interval falls wholly within the user-specified interval (inverse of **contains** or **inside**)
  - **overlaps**: user-specified interval overlaps the sensor reading interval
- Example SPARQL query defining the temporal operator ‘within’

```
SELECT ?interval
WHERE {
    ?interval time-entry:ends ?e .
    ?b time-entry:inXSDDateTime ?b_datetime .
    ?e time-entry:inXSDDateTime ?e_datetime .

    FILTER (
        xsd:dateTime("2005-11-10T01:00:00.00") < xsd:dateTime(?b_datetime) &&
        xsd:dateTime("2008-11-10T01:00:00.00") > xsd:dateTime(?e_datetime)
    ) .
}
ORDER BY ASC(?b_datetime)
```
Knowledge
- Object-Event Relations
- Spatiotemporal Associations
- Provenance Pathways

Information
- Entity Metadata
- Feature Metadata

Data
- Raw Phenomenological Data

Ontologies
- Space Ontology
- Time Ontology
- Situation Theory Ontology
- Domain Ontology
Prototyping the Semantic Sensor Web
Prototype Architecture

Data Collection

- Data Source (e.g., YouTube)

Extraction & Metadata Creation

- Video Conversion
- Filtering & OCR
- SML Annotation Generation
- Time & Date information

Storage

- Converted Videos
- SML (XML-DB)
- Ontology (OWL/RDF-DB)

Query

- SML Interface
- Ontology Interface

UI

- Google Maps
- GWT (Java to Ajax)
Temporal Data Extraction

1. Channel Minimal Suppression
   - 8-neighbor median for 'bad' pixels

2. Temporal Minimal Suppression

3. Binarization via adaptive threshold

4. Tesseract OCR engine

Regular Expression parsing
SensorML output

Prototype Application

http://knoesis.wright.edu/library/demos/ssw/prototype.htm
Future Work

• Incorporation of spatial ontology in order to include spatial analytics and query (perhaps with OGC GML Ontology or ontology developed by W3C Geospatial Incubator Group - GeoXG)*

• Explore new datasets, including Buckeyetraffic.org

• Extension of SPARQL with enhanced spatiotemporal query and analytics (including semantic associations)

• Integration of framework with emergent applications, including video on mobile devices running Android OS

• Monitor Semantic Sensor Web page for further progress http://knoesis.wright.edu/projects/sensorweb/

* Kno.e sis/Wright State Univ. is a member of W3C and it's research led to the development of SAWSDL
References


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