Integration Of Geosensor Data By Means Of An Event Abstraction Layer

Alejandro Llaves
Institute for Geoinformatics, University of Muenster
Weselerstr. 253, 48151 Muenster, Germany
Supervisor: Prof. Dr. Werner Kuhn
alejandro.llaves@uni-muenster.de

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1. Motivation

With the new generation of Sensor Web Enablement[1] (SWE) [2] the number of possibilities to access sensor observations has increased considerably. Nowadays, more and more data providers are making their data sets available in the Web using standard services, e.g. Sensor Observation Service (SOS) [7]. These services are easily integrated in Service Oriented Architectures (SOA), which allow users to get the sensor data following a polling procedure, i.e. sending a request with some parameters and receiving the data in the service response.

Some applications deal with time-sensitive issues which require quick responses to certain occurrences, e.g. environmental change monitoring. Handling all the data provided by sensors in near real-time and obtain valuable information is challenging from a technical and a scientific point of view.

Event processing methods provide real-time processing capabilities and event filtering on continuous time-series of data. The main problem to integrate event processing into existing architectures is the lack of a common vocabulary for event concepts and their relations [3], which causes interoperability issues between event-driven applications.

2. Background

The subjectivity of event categorization was discussed by Allen and Ferguson. They claimed that events do not exist in our real world, but events are the result of the classification of patterns of change by individuals acting as observer agents [1]. This statement highlights that two communities may have different conceptual representations of the same occurrence, e.g. a heavy rainfall in Egypt may not be considered as such in Germany.

[1] http://www.opengeospatial.org/projects/groups/sensorweb

2.1. Observations as Geospatial Events

Probst suggested to categorize observations as subconcepts of events [8]. An event has spatial and temporal location, meaning that can be assigned to a geographic position and to a point or interval of time. In the case of observations, Probst argued that the spatial location of an observation can be defined regarding either the physical endurants being observed or the sensing device performing the observation. This approach fits well with our purpose of applying event processing techniques to observation data. The Semantic Sensor Network Incubator Group[2] (SSN-XG) presented a new version of the SSN ontology[3] as a result of reviewing[4] seventeen sensor-centric and observation-centric ontologies. In the SSN ontology, observations are considered contexts or situations which link stimulus, sensor, and observation result. However, this point of view is compatible with Probst's proposal since both accept that a sensor provides a value for an observed property [4].

Worboys and Hornsby introduced a modeling approach for dynamic geospatial domains (Geospatial Event Model - GEM) with three main elements: object, event and setting [9]. In that model, events which are situated on a spatiotemporal setting are categorized as spatiotemporal events. Following Probst's argumentation [8], we will consider observations as geospatial events because of the spatiotemporal setting implicit in the observation process.

2.2. CEP vs ESP

There are two well-known approaches to address event processing on continuous data flows: Complex Event Processing (CEP) and Event Stream Processing (ESP). Whilst the latter performs event processing on streams of events, the former is able to work on event clouds [6]. In an event stream, events arrive ordered in time. An event cloud can contain several event streams and there is no relationship that orders the events, that is why many consider ESP as a subset of CEP.

3. Research Questions

There are two main questions that this research work tries to answer:

1. How to abstract real world occurrences from sensor observations?
2. How to link event patterns to ontological representations of events?

The first question addresses the problem of processing sensor data to obtain information about changes in our environment in form of events. The study of different event processing techniques will be reported, as well as best practices to represent real world events abstracted from observation data. The second question deals with the nexus between patterns, which are used in event processing engines to filter events, and the ontological representation of those events. As explained in the previous section, different event patterns can be used to represent the same real world event. Here, the realization of this many-to-one relationship will be investigated.

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[2]http://www.w3.org/2005/Incubator/ssn/charter

[3]http://www.w3.org/2005/Incubator/ssn/wiki/images/3/36/Ssn.xml

[4]http://www.w3.org/2005/Incubator/ssn/wiki/Review_of_Sensor_and_Observations_Ontologies

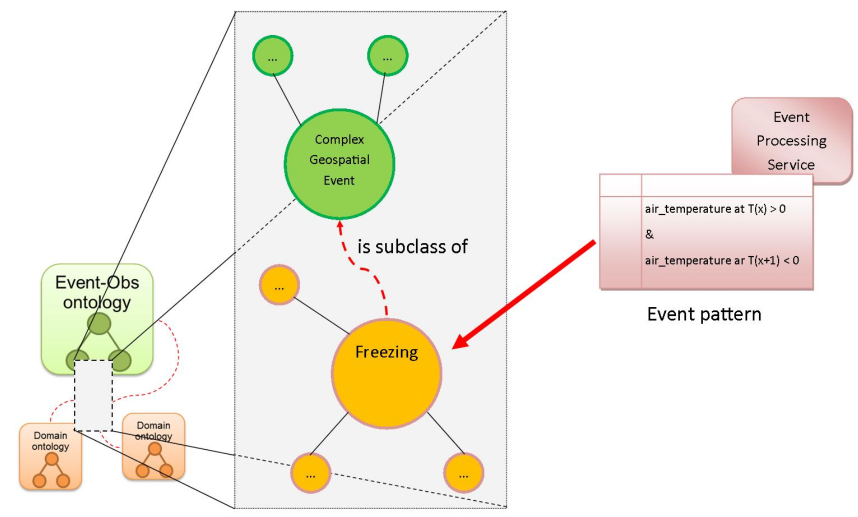

Figure 1. Link between the event pattern for *Freezing* and the ontological representation of the event.

4. Approach

CEP works with simple and complex events. A simple event is an event that cannot be divided into sub-events, i.e. the atomic unit of processing in CEP. A complex event is composed of other events called its members [6]. An analogy between CEP and GEM (see section 2.1) was presented in [5], where observations are considered simple geospatial events, and sets of observations matching an event pattern are categorized as complex geospatial events. This analogy is used to establish observations as the atomic unit of processing in our event processing engine, and it is a first step to model the abstraction of real occurrences from time-series of observations.

An event pattern describes an occurrence that is relevant for a user, e.g. air temperature going below zero degrees Celsius. Properties of the observation, like sampling time or location, are used to define the pattern. Our approach investigates the enrichment of event patterns by adding semantic references (see figure 1). CEP is able to filter events from observation data streams, creating an event abstraction layer on top of the data. Users will register their annotated event patterns to an Event Processing Service. When an event is filtered, the service will create an RDF representation of the event using the properties of the filtered observations.

On the one hand, a knowledge representation of the relationships between observations, events, and event patterns will be created with the name of Event-observation ontology. To avoid reinventing the wheel, the SSN ontology (see section 2.1) will be used and extended if necessary. The purpose of the Event-observation ontology is to provide a common vocabulary to be used across different domains. On the other hand, a domain ontology will formalize a representation of reality for a particular domain. That domain ontology has to include the potential events that are detectable from the observation data, allowing users to annotate event patterns. The RDF events produced by the Event Processing Service will be used to populate the domain ontology, so ontology axioms can be triggered and new knowledge inferred.

5. Expected Outcomes

As a result of this Ph.D. thesis, a methodology to link event patterns to ontological representations of events will be provided. An Event Processing Service will be implemented to allow users registering their patterns and evaluate our methodology. On top of this service, an Event Bus will collect observation data provided mainly by Sensor Observation Services (SOS). The Event-observation ontology together with a domain ontology describing potential events that can affect landslides will also be part of the results of this work.

6. Conclusion

The major contribution of this research work is the semantic enablement of event processing techniques for the analysis of observation data. Some applications performing environmental monitoring are focused on change detection. We represent change in the form of events. Our approach deals with abstracting events from observations having into account the changes in the observed properties reflected in the data. An ontological representation of the relations between events, event patterns and observations serves as a common vocabulary to be used in different domains. As a result, annotated services providing observation data and event processing applications are semantically enabled and, therefore, able to interoperate. Real-time analysis offered by event processing approaches, e.g. Complex Event Processing, can be used to identify relevant events in time-series of observations in near real-time.

Currently, a prototype for the Event Processing Service is being developed. During my stay in Taiwan on June, landslide experts will contribute with their domain knowledge to the building of a landslide risk domain ontology. The advanced sensor platforms deployed on Taiwan are collecting data continuously, which will be part of the prototype evaluation. Building the Event-observation ontology requires an exhaustive analysis of the SSN ontology and potential alternatives, and is part of the future work.

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[5] http://www.envision-project.eu

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