Chapter 49

Web–Based Information Exploration of Sensor Web Using the HTML5/ X3D Integration Model

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ABSTRACT

This chapter investigates how the visualization of sensor resources on a 3D Web-based globe organized by level-of-detail can enhance search and exploration of information by easing the formulation of geo-spatial queries against the metadata of sensor systems. The case study provides an approach inspired by geographical mashups in which freely available functionality and data are flexibly combined. The authors use PostgreSQL, PostGIS, PHP, X3D-Earth, and X3DOM to allow the Web3D standard and its geospatial component to be used for visual exploration and level-of-detail control of a dynamic scene. The proposed approach facilitates the dynamic exploration of the Sensor Web and allows the user to seamlessly focus in on a particular sensor system from a set of registered sensor networks deployed across the globe. In this chapter, the authors present a prototype metadata exploration system featuring levels-of-detail for a multi-scaled Sensor Web and use it to visually explore sensor data of weather stations.

INTRODUCTION

While most environmental scientists rely on the sensor data portals hosted by a few large-scale government and research institutes, finding information on the Web is generally done using an ordinary text query or tree-based hierarchical text exploration interface. This approach is useful in that people routinely find sensor data from specific data portals. However, searching and exploration can be frustrating when queries return a tremendous number of sensor resources. Often the query output does not match what they are seeking. Search remains primarily textual and result lists are usually unstructured and not interactive. Therefore there is need for an efficient discovery and exploration interface for large distributed sensor resources.

In this chapter, we introduce an approach for sensor metadata discovery by exploring a Web-based 3D virtual globe on which the metadata of distributed sensor systems are queried and visualized through interaction with the information seeker. In order to provide a more intuitive exposure of metadata for sensor networks, we implement a dynamic 3D scene of sensor information on the globe by interactive navigation using HTML5 and X3D integration model (X3DOM) (Behr *et al.,* 2009; Behr *et al.*, 2010). Multiple levels-of-detail for metadata visualization are proposed for the display of a multi-scaled sensor network. We apply the proposed approach to the exploration of metadata of personal weather stations which are deployed across the globe in order to investigate how the visualization of metadata on a 3D Web-based globe organized by level-of-detail can enhance the search and exploration of information.

BACKGROUND

Similar to the W3C Web standards enabling the WWW, the Open Geospatial Consortium's Sensor Web Enablement (SWE) standards enable researchers and developers to make sensing resources discoverable, accessible, and re-useable via the Web. The SWE is composed of candidate specifications including Observation and Measurement (O&M), Sensor Model Language (SensorML), and Sensor Observation Service (SOS). The Sensor Instance Registry (SIR) was introduced as a web service interface for discovering sensors, collecting sensor metadata, handling sensor status information and to close the gap between the SensorML based metadata model and the information models used by Open Geospatial Consortium (OGC) Catalogs (Jirka & Nüst, 2010). A reader can refer to the recent publication (Bröring *et al.*, 2011) to get detail information about examples and applications of SWE.

A semantic approach is necessary to facilitate discovery of heterogeneous sensor resources and their datasets. Research on the Semantic Sensor Web (Sheth *et al.*, 2008) investigates the role of semantic annotation, ontologies, and reasoning to improve Sensor Web functionality including sensor discovery and sensor integration. Related work in this field includes methods for linking geosensor databases with ontologies (Hornsby & King, 2008), a semantically-enabled Sensor Observation Service (SemSOS) (Henson *et al.*, 2009) or the semantic annotation of sensor services with terms from ontologies (Babitski *et al.*, 2009).

Ontologies need to serve as the basis for semantic reasoning. Various research groups have started to specify sensor, stimuli, and observation ontologies. Examples include the Semantic Web for Earth and Environmental Terminology (SWEET) (Raskin & Pan, 2005) focusing on modeling of observed properties, observation based ontologies influenced by O&M (Probst, 2006), and a sensor-centric ontology with a strong relation to SensorML (Russomanno *et al.*, 2005). There are also domain-specific ontologies, such as the Marine Metadata Interoperability project, which is particularly designed for oceanographic sensors (Bermudez *et al.*, 2006). The observation-centric ontology was also developed in a consensus process within the W3C Semantic Sensor Network Incubator Group (Janowicz & Compton, 2010). An ontology for sensor data exchange was derived from the Content Standard for Digital Geospatial Metadata (CSDGM) (Federal Geographic Data Committee, 1998), SensorML and SWEET, and used for its prototype service (Feng & Yu, 2010). However it still has the limitation of a text-based query interface. Thus this paper focuses on enhancing the user interface for search and exploration of sensor resources.

For dynamic exploration of the Sensor Web proposed in this paper, a metadata model and ontology for sensor data are necessary. We utilize the CSDGM standard model for harvesting sensor metadata and

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