A Review of Studies on Semantic Sensor Web

Xiang Wang, Xiaoming Zhang, Mei Li
School of Information Science & Engineering, Hebei University of Science & Technology, Shijiazhuang Hebei, China
{wangxiang, zhangxiaom, limei}@hebust.edu.cn

Abstract. As Sensor Network is used more and more widely in all fields, a large number of heterogeneous data is produced. In order to eliminate the heterogeneity and make these data shared and integrated semantically, semantic web technology is introduced in the sensor network. In this paper, we present a comprehensive review studies about Semantic Sensor Web (SSW) from the perspective of ontology, mapping and query respectively. Finally, the future research directions of SSW are proposed.

Keywords: Semantic Sensor Web, sensor ontology, mapping, query

1 Introduction

In recent years, the sensor network is received more and more attention and is deployed in all kinds of environments for different purposes, such as in Environment-Monitor, urban traffic planning, flood forecast, health care, satellite sounding, etc. Therefore, mass sensor data will produce continuously. However, the acquired sensor data is heterogeneous in the syntax, schema and semantic level and lack of semantic information, it’s hard to be shared and integrated. Semantic web technology is introduced in the sensor network in order to overcome the problem of lack of semantic in sensor network and manage a large number of heterogeneous data effectively. The combination of semantic web and sensor network is called Semantic Sensor Web which can construct the shared conceptual model, enhance the semantic of the sensor data, and realize interaction and access of sensor data on the web [1].

In this review, we investigate the related work of Semantic Sensor Web in recent years especially from the perspective of the ontology, mapping and query. The extensions of SSN ontology are discussed emphatically. Mapping languages and semantic query languages of stream data based on ontology are discussed too.

2 The problem description

We present the architecture of Semantic Sensor Web in this paper, and it uses three layers of semantics and technology to provide services. They are the sensor data source layer, the data integration layer and the application layer.
The data source layer of the sensor network is at the bottom. Sensor data has two representational forms: One sensor data form is stored in the relational stream database, and another sensor data form is the stream data which are collected in real time. When these data are integrated, different data of representational forms is processed by different method.

In the data integration layer, the sensor data are represented, managed and queried. The sensor ontology provides a kind of shared vocabulary and concepts existed in the sensor network areas and their properties along with the mutual relations. Along with the sensor ontology model, the mapping between the stream data and ontology must be established, and query can be conducted.

The purpose of the query is for applications which can be realized by the semantic query user interfaces. Semantic Sensor Web has wide applications, such as Geographic Information System, visualization, decision support, etc.

3 The state of the art of the sensor ontology

Ontologies played an important role in Semantic Sensor Web. Compton et al. [2] reviewed the typical sensor ontologies and analyzed their concept scope, expressive ability and reasoning ability. In 2009, the W3C working group [3] developed SSN ontology. SSN ontology is the integration and upgrade of the original ontologies which describes more clearly. It is a general sensor ontology which provides a unified standard to describe the sensor network data. In recent years, many ontologies established are mostly the extensions of SSN ontology. The main extension directions are:

(1) Extending according to different application

In order to meet the specific requirements of different applications, the extended ontologies add new concepts on SSN ontology.


(2) Extending by adding new contents to found more general ontology

The more general ontologies are extended on the basis of SSN ontology in order to have more extensively applicable scope.


(3) Extending by combining with the other ontology to solve actual problem

The combination of SSN ontology and the other ontologies is necessary because the sensor data is linked-data, the ontology combination can extend the application range greatly.

Alasdair J G Gray [10] proposed SemSorGrid4Env ontology network which is composed of different ontologies to play the biggest role in order to solve the flood emergency prediction. AEMET ontology is also formed by multiple ontologies [6].
The Time module reuses the OWL Time Ontology, and the location Ontology reuses part of geobuddies ontology network, and the measure ontology reuses the concepts of SSN Ontology.

4 The mapping and query of SSW

In Semantic Sensor Web, we need to solve the issue of how to find and generate the mapping and how to realize the mapping from the sensor stream data to the ontology. The stream data is an infinite sequence of tuples and with timestamp, so in the mapping process, we must consider the time characteristic.

The mapping from sensor stream data to the ontology has two main methods: (1) Using hard coding. Programs are designed to describe the correspondence between stream data and ontology. (2) Using mapping language. The mapping languages can describe the mapping relationships between the basic elements (such as relationship or attributes etc.) of the relational database and the basic elements (such as concepts, attributes and relationship etc.) of the RDFS/OWL ontology. The mapping of stream data and the ontology can be added manually or automatically by programming. Most of the mapping languages have mapping processor which can fill the data of the relational databases in the ontology automatically.

Sensor data stream are an unbounded sequence values, and each value has a timestamp to represent the value of happened time. People often concern about data values of the latest stream data than the previous tuples, so the stream query requires continuous long-term queries. SPARQL language is a kind of query language developed for RDF which can easily query in RDF files. It must be extended to achieve the goal of the continuous query of the stream data. The earliest query languages are T-SPARQL [11], C-SPARQL [12], and stSPARQL [13], etc. They all use RDF stream as the data model. The tuples of RDF streams are annotated by timestamp.

5 Conclusion

In this paper, the current research progress of Semantic Sensor Web was summarized. Three layers architectures of Semantic Sensor Web are proposed, and the ontology, mapping and query of SSW are discussed. The introductions of this paper are expected to promote the focus and research on this emerging technology by the related scholars.

In the future, Semantic Sensor Web has wider applications, such as in the cloud platform, in the social network, in the artificial intelligence, etc. Further research is needed to improve the combination of Semantic Sensor Web and these fields.
Acknowledgments. This work is supported by Science Foundation of Hebei Province (No. F2013208107), National Natural Science Foundation of China (No.51271033), Science Foundation Project of Hebei Education Department (No. QN20131138). It is also supported by Hebei University of Science and Technology Research Foundation for the Doctoral Program (No. QD201214).

References