# Intelligent Information Management of Tourist Attractions Based on Semantic Sensor Web

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**Abstract.** With the development of newly emerging technologies such as sensor network, Internet of Things and Semantic Web, our lifestyles are changing gradually. Sensors deployed in tourist attractions can collect lots of information which can be used to support decision making for tourist attraction managers. However, different sensors have different data format, so it is not easy to let these sensor data work together. Moreover, there is also implicit knowledge hidden in sensor data collected from tourist attractions. This paper proposes an approach for tourist attractions information management based on semantic sensor web. A semantic model for scenery sensor data is designed as an OWL ontology, and based on the semantic model an architecture for intelligent information management of tourist attractions is illustrated. As a case study, an experimental prototype demonstrates the effectiveness of the proposed approach.

**Keywords:** tourist attraction, semantic web, sensor data, ontology.

## 1 Introduction

The newly emerging technologies such as sensor network, Internet of Things and Semantic Web are gradually changing our lifestyles. Sensor network makes it possible that people can be aware of the circumstances of the specified places, where sensors are deployed, by collecting the sensor data. Towards the tourism domain, information management of tourist attractions is very important, which includes tourist information, scenery information, culture relic information, environmental information, and the relationships between them. Sensors deployed in tourist attractions can help us collect lots of useful information which can support decision making for tourist attraction managers.

However, different sensors have different data format, so it is not easy to let these sensor data work together. Moreover, there is also implicit knowledge hidden in sensor data collected from tourist attractions. Semantic Web provides a series of technologies to realize the vision of the Web of linked data [1]. The technologies in Semantic Web stack, such as ontology and logic rules, can facilitate the semantic integration of sensor data as well as serve a lot for logic reasoning to implement intelligent informa-

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tion management. Therefore, the research area known as semantic sensor Web [2] is a hot topic being concerned recently.

This paper proposes an approach based on semantic sensor web. A semantic model for tourist attractions sensor data is designed as an OWL ontology, and based on the semantic model an architecture for intelligent information management of tourist attractions is illustrated. As a case study, an experimental prototype demonstrates the effectiveness of our proposed approach.

The reminder of the paper is organized as follows. Section 2 summarizes the related work. Section 3 gives the motivation. In section 4, we propose the semantic model and architecture. Section 5 introduces the experimental prototype. Section 6 concludes the paper.

## 2 Related Work

Recently, more and more researchers focus on the joint area of Semantic Web and Sensor network. Gray et al. [3] present a service-oriented architecture of a semantic sensor web for environmental decision support systems. In this architecture, a serials of OWL ontologies are used to represent sensor data, schema metadata, web services, features in a specific domain (which is flood emergency planning in this research), etc. Kung et al. [4] propose a food recommendation system for patients. The system uses rule-based reasoning over the sensor data from vital sensors for a specific patient, so as to judge the health status of the patient and give the food recommendations for him/her. Pfisterer et al. [5] argue that the research of semantic sensor web should pay more attention to high-level entities. They describe a vision of Semantic Web of Things, which is toward mapping sensors to high-level semantic entities and connecting sensors and things with the Linked Open Data. SemSOS [6] and the work of Devaraju et al. [7] are the similar researches to use rules-based reasoning over semantic sensor data for detecting Blizzard. The latter research supports the temporal descriptions of a blizzard event.

In tourism domain, SPETA [8] is a social pervasive e-tourism advisor which integrates not only pervasive system and GIS system but also social network and semantics to recommend contextual services to tourists. Grammalidis et al. [9] propose a system that uses optical and infrared cameras as well as wireless sensor networks to realize automatic early warning for the protection of cultural heritage. Garcia et al. [10] present a tourism information representation architecture based on ontology and metadata for both tourists and tourism providers. The motivation of this architecture is to retrieve tourism information more efficiently and precisely. MultimediaN E-Culture project [11] is a Semantic Web application in cultural-heritage domain. By semantic annotation, semantic metadata is harvested for semantic query as well as semantic search. The researches mentioned above focus more on applying either semantic web or sensor network in tourism application, but little on the both (i.e., semantic sensor web).

This paper presents an architecture from the perspective of both semantic web and sensor data to support intelligent information management of tourist attractions.

## 3 Motivation

The motivation of our work is to design an architecture for integrating sensor data collecting from the specific spots of a tourist attraction, and link these sensor data to provide a view for users to browse and query status information in a semantical way. The main idea of our approach consists of the following three parts:

(1) Building an ontology-based semantic scenery model for tourist attractions to link tourist information, scenery information and sensor information.

(2) Transforming sensor data from raw format to semantic sensor data based on the scenery model.

(3) Developing a web-based application to browse and query sensor data such as tourist location, temperature and humidity of scenery. Furthermore, the system can be used to give warning information by reasoning over the sensor data.

## 4 Model and Architecture

In order to link sensor data with tourists information and scenery information, we have designed a semantic scenery model as an OWL ontology. As shown in Fig. 1, the main concepts in the semantic scenery model include scenery spot, tourist, sensor, RFID chip, temperature, humidity, wind, etc. Temperature sensor, humidity sensor and wind sensor are three types of sensors used in our information management of tourist attractions. The sensors deployed in a scenery spot will respectively collect environmental data of temperature, humidity and wind in a series of date and time. Each tourist will hold a RFID chip within a e-ticket, and in each culture relic, a RFID chip will also be deployed for safety's sake. Readers will be deployed in scenery spots to collect RFID data. The collected RFID data and sensor data will be sent to the server of the tourist attraction. A warning will be created if the environmental conditions satisfy the logic rule for detecting a specific warning, and the manager of the scenery should be informed of the warning.

For a scenery spot, we should define the maximal number of tourists in it. For every tourist, he/she has a unique ID and the register time will be recorded when he/she enters the gate of the whole tourist attraction. For a sensor, we would like to know the type of the sensor, and the value range of the collected information by the sensor (i.e., the maximal value and the minimal value). An item of collected information such as temperature and humidity will have a specific time and a corresponding value. The main part of the semantic scenery model is shown in Fig. 1.

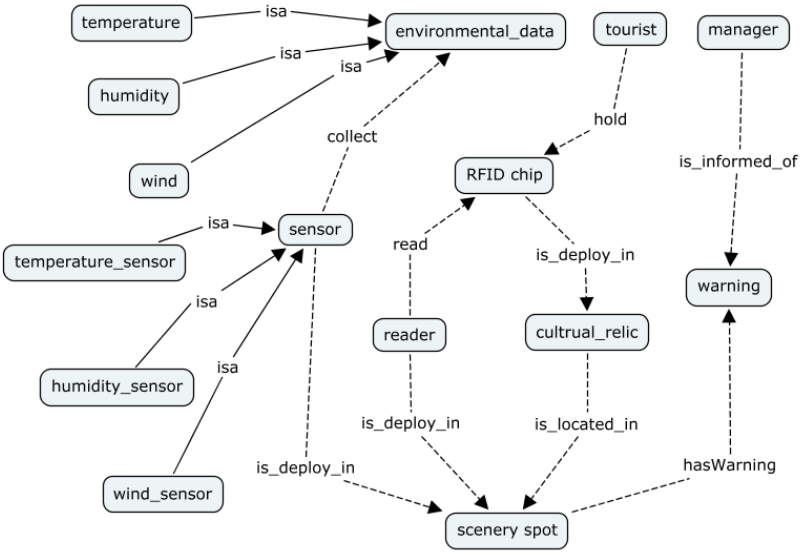


**Fig. 1.** Semantic scenery model

Based on the model presented above, we designed a four-layer architecture to implement intelligent information management of tourist attractions using Semantic Web technology and sensor data. The architecture is shown in Fig. 2.

The bottom of the architecture is raw data layer. Temperature sensors, humidity sensors and wind sensors are deployed in different scenery spots, and RFID tags are set in e-tickets and cultural relics. These sensors and RFID tags will generate sensor data progressively. However, these sensor data is in their raw formats which are different according to different types of sensors.

Above the raw data layer, it is the layer of semantic sensor wrapper. In this layer, the input is the raw sensor data in different format, and the output is the sensor data in Semantic Web format. Therefore, the semantic sensor wrapper is designed to transform sensor data into RDF (OWL instance) by annotating the received raw sensor data using the semantic scenery model.

The third layer is the layer of knowledge base for semantic sensor data. In this layer, the storage of semantic sensor data in RDF should be considered to improve the query efficiency. On the other hand, to take advantages of the reasoning feature of Semantic Web, we also add some specified logic rules to make the sensor information management more intelligent by reasoning over the semantic sensor data. Furthermore, the semantics in semantic scenery model is limited in a small domain, so we can extend the semantic expressing by linking the semantic scenery model with other domain ontology, and the linking between them can also be expressed by logic rules.

The top layer is the application layer. The three layers below this layer can provide sensor data in a unified view. In the tourist attraction domain, the applications can be divided into two types. One is real-time applications (e.g., dangers warning, tourist location), and the other is data analysis applications (e.g., tourist path tracking, trend analysis).

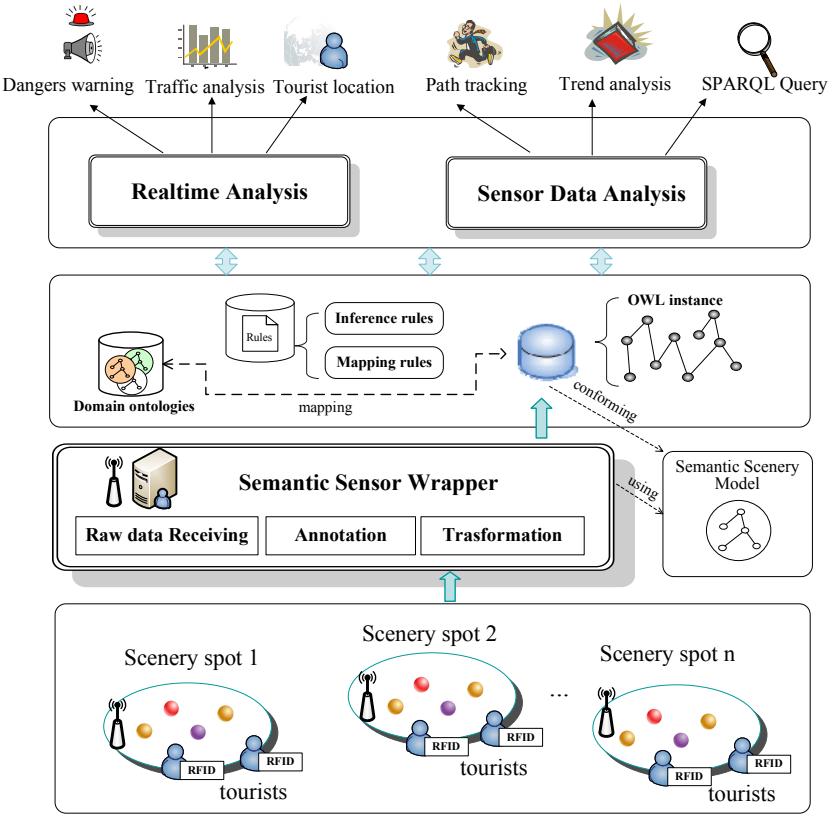


**Fig. 2.** The proposed architecture

## 5 Experimental Prototype

In order to evaluate the presented approach, we have developed a Web-based prototype for intelligent information management of tourist attractions. We use Java Server Faces (JSF) as the main development technology. Primefaces [12] components are used to facilitate the development of the graphic user interface (GUI) of the prototype. We also use Jena [13] API to manipulate the data in Semantic Web format.

As shown in Fig. 3, the main user interface of the prototype is separated in two parts. The left part has two accordion panels. One is to show scenery information such as scenery spots, tourists, and sensors, and the other lists the possible warning types. The right part is a display area where the display content will change according to the select item from the left panel.

For example, if the user selects scenery spot 010 from the left panel, the temperature, humidity and wind information will be shown as line charts on the right area. And the cultural relics in or near the scenery will also be listed for users to navigate.

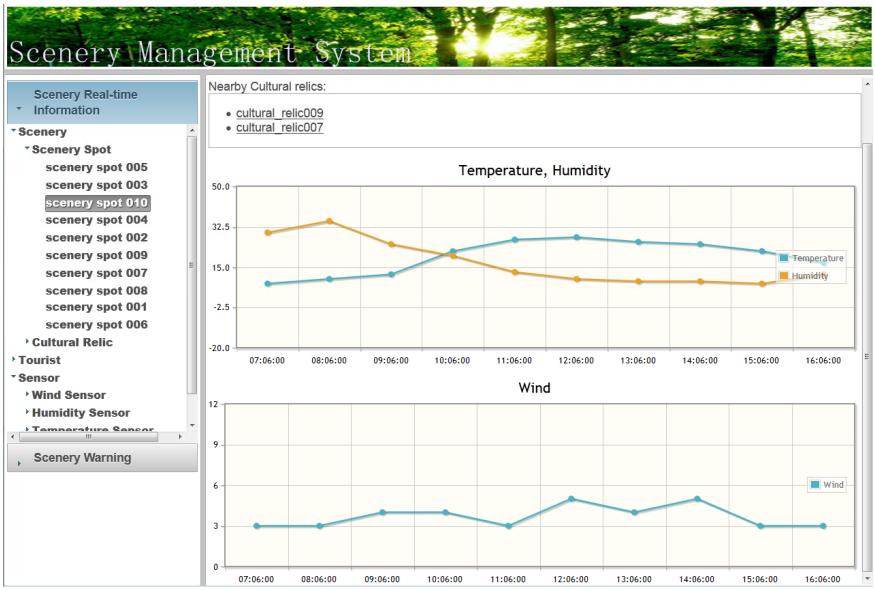


**Fig. 3.** Scenery information in experimental prototype

As shown in Fig. 4, If the user selects one of the tourist from the tourist list, the tourist's detailed information will show on the right area, and the tourist's touring path can be listed owing to the RFID tag held by the tourist. According the latest scenery spot and visit time, we can infer the approximate location of the tourist.

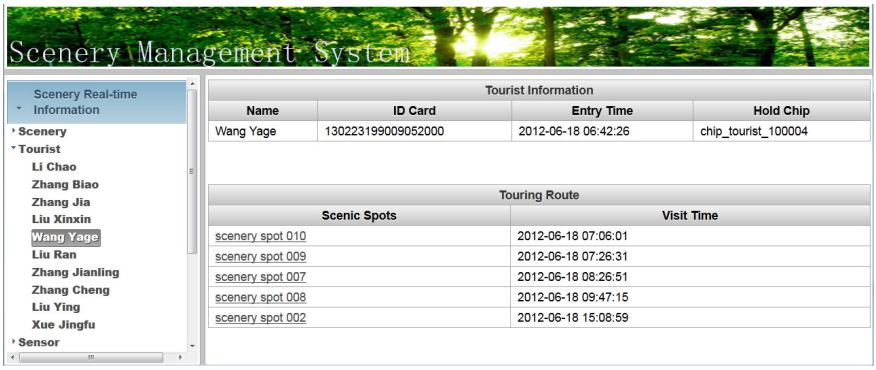


**Fig. 4.** Tourist information in experimental prototype

Furthermore, the prototype also can list warnings such as fog warning, ice warning, and crowd warning by reasoning with the logic rules defined in scenery sensor knowledge base.

## 6 Conclusions

In this paper, we have presented an approach to implement intelligent information management of tourist attractions based on Semantic Web and sensor information. An ontology-based semantic scenery model is designed to describe the relationships between sceneries, tourists and sensors. A four-layer architecture is proposed to support decision making by utilizing sensor information semantically in this domain. An experimental prototype has been developed, and has preliminarily demonstrated the effectiveness of the proposed approach.

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