The 8th International Conference on e-Business (iNCEB2009)
October 28th-30th, 2009

GEO-ONTOLOGY FOR CULTURAL KNOWLEDGE

Ubonrat Phumisathan and Panjai Tantasanawong
Department of Computing, Faculty of Science, Silpakorn University, Thailand 73000
ubonrat@su.ac.th, panjai@su.ac.th

ABSTRACT

This paper presented the methodology that developed model of the information retrieval process for cultural knowledge using geo-ontology. It represented the relationship between cultural heritages site, period and location. The developed system consists of four parts as follows: 1) Extract information from Cultural Heritage textual documents and then create the geo-reference mapping from the knowledge base. 2) Design model and relation with Geo-ontology 3) Develop Inference engine. 4) Development of a Web based interface system for search, insert/edit templates.

Geo-ontology constructed cultural knowledge with OWL-DL for ontology description. Rules in Description Logic are defined to describe relation between concepts and properties with Pellet reasoner.

Index Terms— Geo-ontology, OWL-DL, Description Logic, Geo-Reference, Cultural Heritage

1. INTRODUCTION

At present, Geographic Information System (GIS) has more roles for information retrieval system on internet network such as searching location of tourism place, hotel and etc. In this research, GIS map was applied to show location of cultural heritage sites and integrated with related cultural knowledge. The information retrieval by users often specify the query with text string which are low precision and confusing because cultural information such as name of place or person are not unique and may have different names, moreover name may change or even disappear throughout time [1].

We use geo-ontology that constructed cultural knowledge system describes concepts roles relations and spatial data such as: geometry (point, line and polygon), geo-reference (Latitude, Longitude and alt) etc. that approach is based from graph.

The relationship in geo-ontology in this work include: ***Place (name), Location, Time, Activity*** and ***Person*** that extract knowledge from textual documents.

Geo-ontology was constructed in OWL-DL that is essentially based on description logics (DLs). Reasoners for OWL, such as Pellet, FaCT++ or RacerPro use tableau reasoner with good performance results, but even those successful systems are not applicable in all practical cases.

Overall, the research has the following contributions:

- Proposed methods for extracting relevant part of cultural heritage sites from textual documents on knowledge acquisition and create related geo-reference mapping.
- Develop the geo-ontology that specifies the concepts and their relationships in the domain of cultural heritage information via period and location (geo-reference).
- Develop a search engine to find locations of cultural heritage sites by, periods that are referred to in particular query.
- Special template for domain experts which support inserted and edited their knowledge and stored on ontology knowledge-based.

In this paper, we present a model of Geo-ontology for cultural knowledge that retrieves location of cultural heritage site via period. Using geo-ontology description represents the knowledge-based of relationship between cultural heritage sites, periods and location (geo-reference) information from auto extraction textural documents and other ways. Geo-ontology was constructed in Protégé (OWL-DL), with RacerPro reasoner in description logics.

2. RELATED WORKS

Different approaches for Geo-ontology have been proposed in literature.

Francisca Hernandez et al. [3] proposed the describe probably the largest initiative for the construction of an ontology that compiles the knowledge around the cultural heritage related to a specific region and choose CIDOC CRM [4] represent information concerning different domains.

Renata Viegas and Valéria Soares [5] proposed the use API Java to developed geographic ontology to support a common and shared understanding of a specific domain (the coral reefs) based on three points of view of different communities: the geologists, biologists and tourists.

Yandong Wang et al. [6] have built the Geo-ontology with Protégé and saved it as OWL (Web Ontology Language) document. When user query information in client, Jena first read the OWL document and parses the Geo-ontology, and then connects inference engine to Jena, the inference engine carry out reasoning according to the query condition. Finally result is sent to ArcIMS and ArcIMS retrieves the map and sends the result to client.

3. GEO-ONTOLOGY

3.1 Geo-ontology

Geo-0ntology [2] results from analysis and modeling of ontology in geo-spatial application that is concepts and the relationships between concepts which is abstract from real-geographic space. A geo-ontology can be defined as this: Geo-ontology is the formalization of concepts sharing among GIS fields. Sharing concepts refers to the concept models of geographic information, which are the abstract models generalized from cognition of geographic phenomenon added on the type of concept being used as well as some restrictions explicitly. After formalization geo-ontology can be readable both to human and computer.

Geographic science is dedicated to explain geo-spatial reality precisely and ontology is a quite abstract methodology which is centered on the concept. The common ground between them is to represent the reality in a systemic way, even though geographic is dedicated to describe the physical structure of reality and ontology the concept structure. Therefore, geo-ontology is used to describe the characteristic of data and resource and data acquiring mode, and thus to provide a uniform expression for data integration and sharing.

Geographic studies the relationships between nature factor and human activity. So the spatial entity can be divided into nature geo-entity and artificially entity naturally as well as some spatial relationships between them.

In this paper, Geo-ontology used knowledge within a specific domain map phases to relationship between concepts and inserts model terms using Geo-ontological constructs. Specific domain is cultural knowledge such as place (cultural heritage site), time (period) to build place, human who built place in each period and location of place. Geo-ontology is designed as follows.

3.2 The design of Geo-ontology

Geo-ontology constructed using frame-based, such as concepts, subclasses, values, attributes (slots), and axioms. Geo-ontology referred to the conceptual model of geographic information and was constructed by OWL-DL that supports Description Logic (DL). DL used to create rules to define the mapping between concepts and properties.

Main concepts of Geo-ontology consists three categories: Location, Person and Time, as shown in Figure 1.

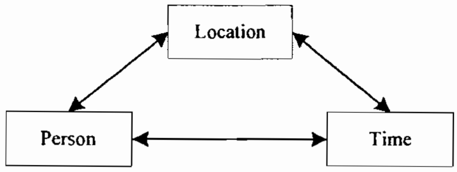

Figure 1. Concept of Geo-ontology

- *Time (period)*: temporal entity class that comprises all phenomena, such as the instance of period, event and state which happen over a limited extent in time.
- *Location (cultural heritage site and geo-reference)*: this class comprises extents in space, in particular on the surface to the position of the earth, in the pure sense of physics: independent from temporal phenomena and matter, such as geo-reference (Latitude, Longitude).
- *Person*: this class comprises all persistent physical items that are purposely created by human activity.

The Relation Patterns have design two parts: is-A and has-A.

- is-A is a relationship where one class D is a subclass of another class B (and so B is a superclass of D). For instance, "Building Place" is a generalization of "Ancient Remain", "Museum" and many others. One says that Ancient Remain is a Building Place.
- has-A is a relationship where one object (often called the composited object) "belongs" to (is a part or member of) another object (called the composite type), and behaves according to the rules of ownership. For instance, Ancient Remain is a place and has a building structure. Thus Ancient Remain has-A relationship Building Place.

In this section, relation between three categories and their properties in specific domain as shown in Figure 2.

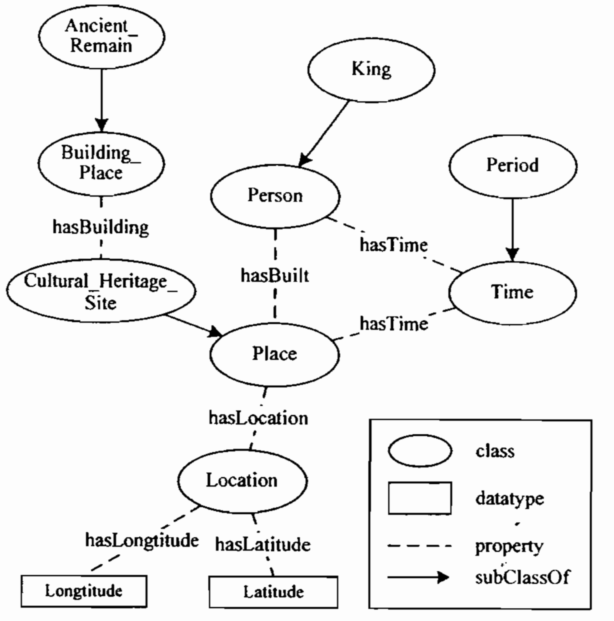

Figure 2. A simplified geo-ontology for cultural knowledge

4. CONCEPTUAL ARCHITECTURE OF GEO-ONTOLOGY

Geo-ontology is divided into four modules as presented in Figure 3: Query Engine, Expert Engine and Inference Engine.

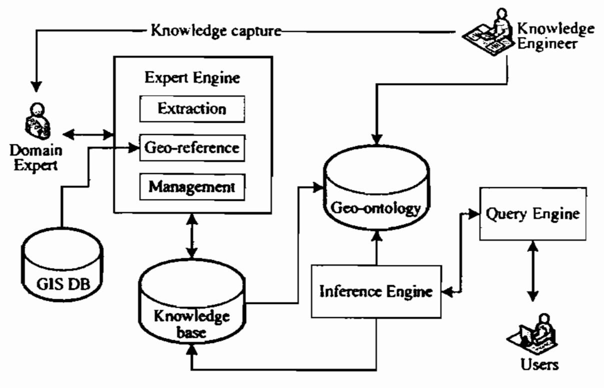

Figure 3. Conceptual Architecture of geo-ontology

The Expert Engine Module is the method for domain expert management knowledge including:

- Extraction: extract knowledge from textural document into phrase noun for cultural knowledge.
- Geo-reference: create location of place (cultural heritage site) using geo-reference (latitude and longitude) that create from extraction module and GIS Database (GIS cultural database and Google Map)
- Management: insert other information i.e. cultural image, and edit incorrect knowledge.

The Inference Engine Module combines facts with description logic rule in order to assert new facts or to identify specific cultural knowledge.

The Query Engine Module connection allows user's information access to the system and display result from inference engine.

5. IMPLEMENTATION

5.1 Expert Engine

This method extracted knowledge from textural document, created location (geo-reference) of place and verified the knowledge before stored them into knowledge base (KB) with XML.

Domain Experts accessed to the system and input textural document to Extraction module that extract knowledge in domain with Natural Language Processing (NLP). If results of Extraction module didn't have geo-reference then geo-reference was created from GIS Database: Cultural GIS Database or Google Map (created by domain expert). Finally the knowledge results were verified and stored in KB. If results were invalid, data were modified by domain experts.

The special template was created for domain expert for: insert knowledge, create geo-reference using Google map.

5.2 Inference Engine

The inference engine can be described as a form of finite state machine with a cycle consisting of three action states: match rules, select rules and execute rules.

In the first state, *match rules*, the inference engine finds all of the rules that are satisfied by the current content of the data store. When rules are in typical condition-action form, this means testing the conditions against. The rules matching that are found all candidates for execution: they are collectively referred to as the conflict set. The same rule may appear several times in the conflict set if it matches difference subsets of data items. The pair of a rule and a subset of matching data items is called and instantiation of the rule.

The second state, *select rules*, the inference engine applies some selection strategy to determine which rules will actually be executed.

The third state, *execute rules*, the inference engine executes or fires the selected rules, with the instantiation's data items as parameters. Usually the actions in the right-hand side of a rule change the data store, but they may also trigger further processing outside of the inference engine (interacting with users through a graphical user interface or calling local or remote programs, for instance). Since the data store is usually updated by firing rules, a different set of rules will match during the next cycle after these actions are performed.

5.3 Example of Geo-ontology

In this section the example of geo-ontology was presented for cultural knowledge in the development of the cultural knowledge retrieval system in Figure 4.

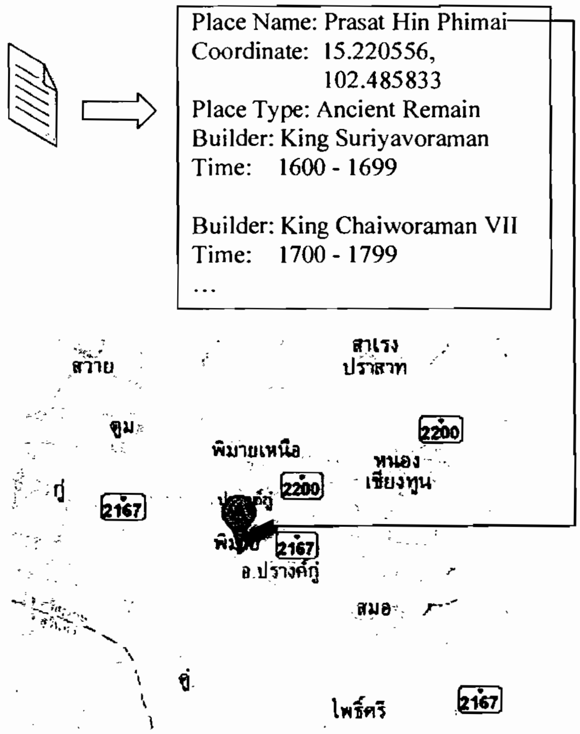

Figure 4. The example of Geo-ontology for cultural knowledge.

5.4 Evaluation

The results of this works are evaluated by domain expert, recall and precision measuring as in the following.

5.4.1 Evaluate by Domain Expert

Domain expert evaluates prototype model which display all possible result from knowledge and rules which design by knowledge engineering. The incorrect results have two cases: knowledge and rules. If knowledge is incorrect, domain expert will edit knowledge from expert management module. If the rules are incorrect, knowledge engineer will edit the rules, test and validate the edited model.

5.4.2 Recall and Precision Measuring

Recall and precision measuring used to evaluate all results from model.

- Recall is a measure of completeness.

$$\text{Recall} = \frac{|\{\text{relevant documents}\} \cap \{\text{retrieved documents}\}|}{|\{\text{relevant documents}\}|}$$

- Precision can be seen as a measure of exactness or fidelity.

$$\text{Precision} = \frac{|\{\text{relevant documents}\} \cap \{\text{retrieved documents}\}|}{|\{\text{retrieved documents}\}|}$$

6. CONCLUSIONS

This paper proposed the study of methodology which developed Geo-ontology model for culture knowledge and information retrieval cultural knowledge. Geo-ontology was developed for cultural domain, based on three categories: Location (geo-reference), Time and Person. Developed interface for domain expert to manage knowledge base, construct model of Geo-ontology and develop the query engine for user's who retrieved information from the developed system.

This research can be applied to study in history, archaeology and local cultural information. Furthermore it can promote historical and cultural travels.

7. REFERENCES

[1] Christopher B. Jones, Harith Alani and Douglas Tudhope, "Geographical Information Retrieval with Ontology of Place," *In Proceedings of the International Conference on Spatial Information Theory: Foundations of Geographic Information Science*, Springer, pp. 322-335, 2001.

[2] Jiang Ling, Gong Jianya, Li Bin and Min Min, "GeoReferencing the Semantic Web Based on Geo-ontology," *In Proceedings of IEEE International Conference on Geoscience and Remote Sensing Symposium (IGARSS) 2006*, pp. 1545-1548, 2006.

[3] Francisca Hernandez, Luis Rodrigo, Jesus Contreras and Francesco Carbone, "Building a Cultural Heritage Ontology for Cantabria," *In Proceedings of 2008 Annual Conference of International Document Committee of the International Council of Museums Athens*, pp. 2008.

[4] Nick Crofts et al. (editor), *Definition of the CIDOC Conceptual Reference Model*, 2009.

[5] Renata Viegas and Valéria Soares, "Querying a Geographic Database using an Ontology-Based Methodology," *In Proceedings of the 7th Brazilian Symposium on GeoInformatics*, pp. 141-156, 2006.

[6] Yandong Wand et al., "Geo-ontology design and its logic reasoning," *In Proceedings of Geospatial Information Science on GeoInformatics*, 2007.