

THE RESEARCH AND PRACTICE OF GEO-ONTOLOGY CONSTRUCTION

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ABSTRACT:

From the perspective of spatial information sharing and interoperation, the concept of geo-ontology has been proposed in this paper. At first, a brief introduction to the Geo-Ontology concept has been described and the hierarchical structure of geo-ontology has also been analyzed. Then, the traditional method of ontology construction has been discussed and the existing problems have also been summarized systematically. Based on the discussions above, a mixed method of geo-ontology construction combined top-to-bottom with bottom-to-top methods has been proposed in the paper. Combined with police information sharing and interoperation application requirements, a prototype crime case geo-ontology system has been developed which can be used for the construction, management, application of geo-ontology. The research practice has proved that the mixed method of geo-ontology construction is a feasible way for practical applications.

1. INTRODUCTION

With the development of GIS and its distributing application, GIS data share and interoperability have already become a problem which must be faced and has to be solved as soon as possible, especially in the scope of heterogeneous network and Grid [13]. Meanwhile, with the development of Semantic Web and Grid, semantic ontology mechanism supporting semantic web or knowledge Grid have been coming into view, which not only pay close attention to the interoperability of syntax, but also focus on semantic interoperability and is becoming one of cornerstones of the Semantic Web. Thus, as another promising approach to deal with the spatial information and service interoperability, spatial data share and spatial data mining besides the measure of standardization, the mechanism of geo-ontology consisted of spatial ontologies and relevant service ontologies is also increasingly explored, studied and recommended by some domestic and international organizations or scholars [12].

2. A GENERAL INTRODUCTION OF GEO-ONTOLOGY

2.1 A Brief Introduction of Geo-Ontology

Geo-Ontology is a definite formal specification of sharing concept model in the spatial information field [6]. The concept model here means the concept model within spatial information domain, which forms the spatial concept model through the

identification and abstraction about the geographic phenomena and indicate the type and rules of the concepts used explicitly as well as express it as computer readable form. Geo-ontology is the common knowledge within a specific domain, not the private ones and may be accepted and shared by a group [4]. Geo-Ontology has provided the spatial information sharing researchers with common terms.

2.2 The Hierarchy of Geo-Ontology

Breuker, Schreiber and wielinga, etc. [B.J.wielinga, G.Schreiber, J.Breuker,1986] have divided the expressing knowledge contents into two classes, which are domain knowledge and problem solving knowledge. The advantages of this classification are that the domain knowledge may be shared and the problem solving knowledge makes the application developers consider only the knowledge of the related domain knowledge [2]. F.Fonseca [F.Fonseca, M.Egenhofer, C.Davis, 2000] have also adopted this granular structure in their ontology driven geographic information systems structure, which are described by the Domain Ontology and Task Ontology [5]. Domain Ontology is the ontology of domain knowledge. Based on the achievements of the former researchers and the characteristics of GIS, the Geo-Ontology systems may be divided into three layers' structure, which are the Top Level Geo-ontology with the highest level abstraction, the Domain Geo-ontology used by specific application field and the Application Geo-ontology. Fig.1 has displayed the hierarchical structure of Geo-ontology.

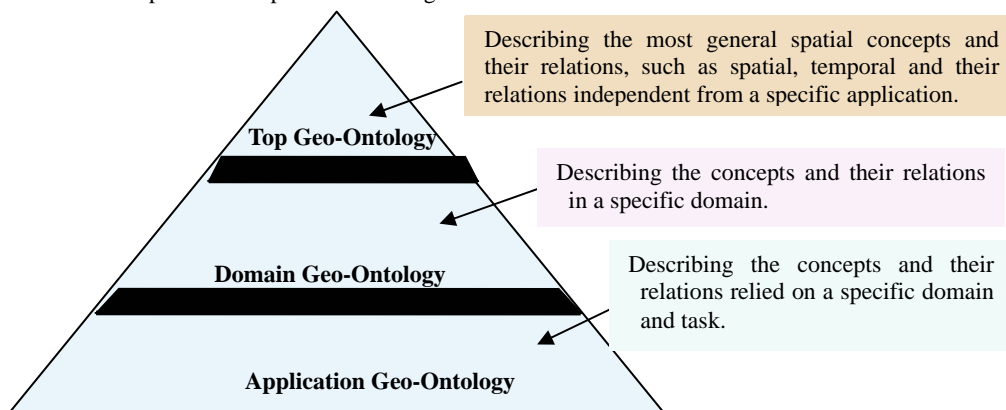


Fig.1 The Hierarchical Structure of Geo-Ontology

Application Geo-ontology is atomic geo-ontology with the smallest granularity and richest spatial information contents, as well as the least sharing and reusing facets. Domain Geo-ontology is a concept system, which contains the common sharing knowledge-base used in a spatial information domain. Top level Geo-ontology is a concept system which describes the most general spatial features and phenomena, and has the biggest sharing extent [3]. Meanwhile, Fig.1 shows that the extent and scope of information sharing, interoperation and generalization will be going up with the geo-ontology level going up. However, the semantic content of geo-ontology will become not so detail and the user will get less information content in the top level geo-ontology.

3. THE CONSTRUCTION METHOD OF GEO-ONTOLOGY

3.1 The Traditional Method of Constructing Ontology

The construction of traditional non-spatial ontology is usually used in different problem solving domain and some specific engineering. Therefore, there are many different methods of constructing ontology based on different applications. At present, there are five representative methods of constructing ontology which are listed as follows: (1) Uschold and King Method used in enterprise modeling process; (2) Gruninger and Fox Method based on developing business process and is behavior model oriented; (3) Berneras Method based on the feasibility of knowledge reuse and ontology functions used in complex system research; (4) METHONTOLOGY Method used in constructing ontology based on knowledge layer; (5) SENSUS Method used in natural language processing. The methods above are used in specific problem solving and are non-spatial ontology oriented [14]. Hence, they are not suitable for geo-ontology construction.

3.2 The Existing Problems in Constructing Geo-Ontology with the Traditional Method

Now, the research and development of geo-ontology still lacks the complete methods and the valid technological routes. There are still a series of key problems need to be solved in the construction of geo-ontology until then, and some are as follows:

- The work of extracting the non-formal geo-ontology is still very difficult.
- The method of establishing formal geo-ontology is also very complex.
- The work of managing geo-ontology is complex and diversified.
- The tools for parsing geo-ontology need to be modified or customized frequently.

As an exploration, a solution has been offered here in this paper to deal with these problems to some extent.

3.3 A Mixed Method of Constructing Geo-Ontology

As described above, the structure of geo-ontology system is the popular three layer hierarchy. The application ontology layer is consisted of formal application sub-layer and specific application sub-layer. Any layer of the above may be empty layer. The construction of geo-ontology on each layer is empirically confirmed by domain expert or ontology engineer according to the features of the application project.

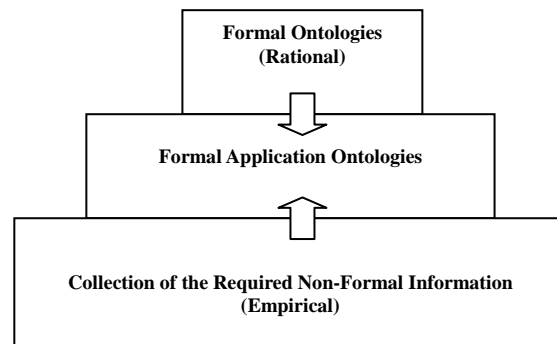


Fig.2 The Mixed Method of Constructing Application Ontology

Geo-ontology is different from non-spatial information ontology. However, the common methods of non-spatial information ontology engineering, such as Uschold and King Schema of Enterprise Process Modeling and the METHONTOLOGY schema of constructing ontology based on knowledge etc., are still useful for geo-ontology construction although they are focused on special business and application oriented. Based on the above hierarchy, the spatial information ontology can be constructed by the synthesizing method of “bottom-to-top” and “top-to-bottom”. As illustrated by the Fig.2 on the above, formal application ontologies may be constructed by two reciprocal activities from the perspectives of theory and experience.

Bottom-to-top construction of ontology is a process of extracting core concepts from the collection of required non-formal information and at the same time establishing the corresponding logic structure. By the way, the restricting information of the core concepts and corresponding logic structure must also be collected. It can be done by relevant experiences and difficult cognitive process. By using the methods described above, the core concept sets, the no-formal abstract logic relations among them and relevant attribute sets and attribute status can be acquired for spatial information application.

Meanwhile, the top-to-bottom construction process can be carrying out with the bottom-to-top process at the same time. It can be done by relevant logic methods and formalization process. Different formal results (i.e. formal ontologies in the lower level or layer) are generated with different formalization tools and terminology criterions (i.e. formal ontologies in the upper level or layer). In the process of acquiring formal results, the lower level formal ontologies in upper layers, typically domain ontologies, have to be constructed primarily and GML-ontology is one of them. Since GML can describe vector spatial information in the format of XML, and is based on a series of abstract models used to spatial information and established by ISO/TC211. So the interoperability GML is evident. In practice, GML-ontology is formed first by mapping GML to formal file of OWL. Then, as soon as the above bottom-to-top step has been finished, another top-to-bottom construction is triggered. Based on upper formal ontologies, a RDF diagram consisted of RDF tri-tuples and a set of schemata binded with corresponding attributes and consistent semantics can be acquired in special RDF/XML formats. By using Protégé, the ontology editing software package, the corresponding OWL format file can be produced. Thus the spatial ontology, a formal application ontology, is able to be constructed.

4. GEO-ONTOLOGY ENGINEERING IN CRIME CASE INFORMATION FIELD

4.1 The Crime Case Geo-Ontology

Crime Case Geo-Ontology is constructed for the sharing and interoperation of spatial crime case database among different police divisions based on the spatially processing of crime case data which are the core contents of police work. There is still not a specific standard for describing the contents of ontology in the present spatial information domain. But as a higher level metadata, ontology should cover the contents of all aspects of metadata. The present main international standard for spatial information metadata is the Content Standard of Digital Geographic Metadata (CSDGM) compiled by the Federal Geographic Metadata Committee (FGDC) of the United States of

America [10]. Therefore the core concepts of police crime case geo-ontology should contain 7 main element sections which are listed as: identifying information, data quality information, spatial data organization information, spatial entity and attribute information etc. as well as 3 aiding element sections which are listed as: citation information, time period information and primitive data referencing information according to the standard of CSDGM.

4.2 The Constructing Method of Crime Case Geo-Ontology

According to the mixed method of bottom to top and top to bottom described above, the technical route of constructing crime case geo-ontology may be displayed as that showed in Fig.3.

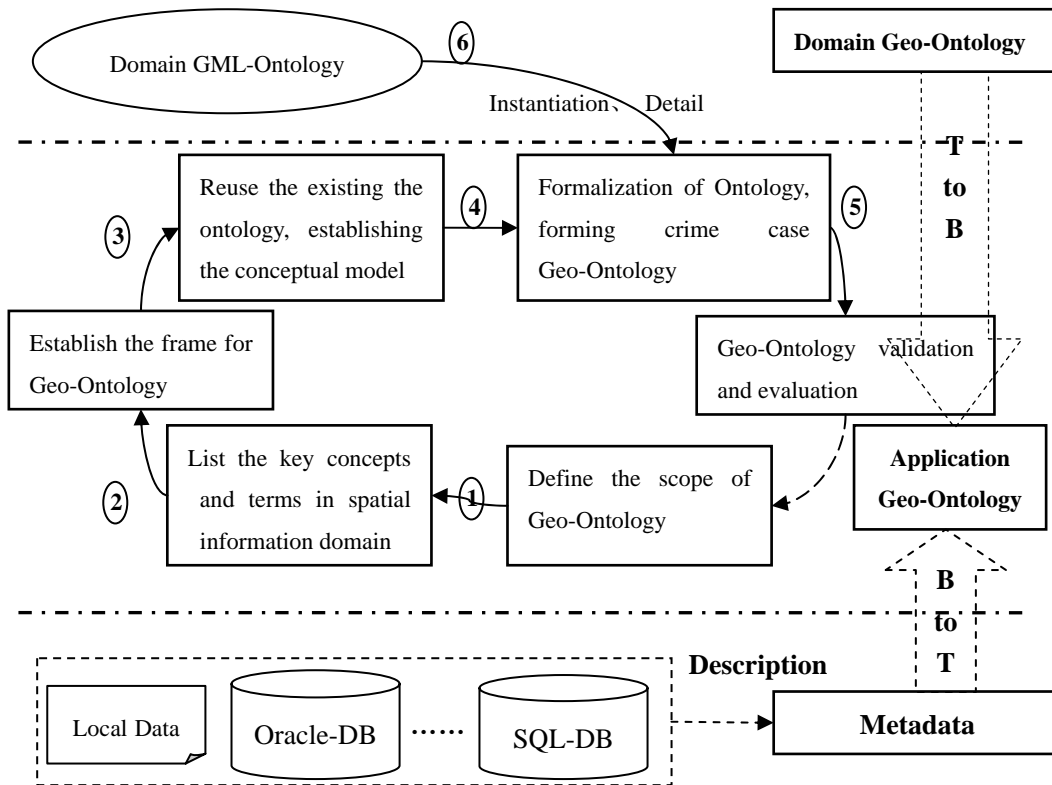


Fig.3 The Flow Chart of Crime Case Geo-Ontology

As showed in Fig.3 above, the construction of crime case geo-ontology may be completed through 6 steps. The first to 4th step may acquire the geo-ontology used for crime cases by the bottom to top method. The 5th step is mainly for testing the correctness, validity and feasibility of the constructed geo-ontology in order to improve it through evaluation. Finally, the geo-ontology still need to be instantiated and detailed and the construction of geo-ontology will be completed by the method of top-to-bottom.

The construction of Geo-Ontology is a reciprocal process. After the establishment of first version geo-ontology, it is still needed to be used in the practical systems or communicate with domain experts repeatedly to evaluate and correct it until it has been completed satisfactorily. The reciprocal process of geo-ontology construction will last to the whole life cycle.

4.3 The Construction of Crime Case Geo-Ontology

According to the method described above and the practical requirements of police information sharing, a prototype crime case geo-ontology has been constructed by using ontology developing tool Protégé on the Windows Platform. Protégé has provided some methods for creating classes, relations, functions, axioms and instances and made developers care nothing about realization details [7]. Class is the core concept of the whole concept model in Geo-Ontology. Here in the prototype geo-ontology, the class has described the core concept of crime case information. After the construction of geo-ontology through Protégé, a class hierarchy map will be created as Fig.4.

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