Research and Application of Geographic Ontology
Modeling Method Based on OWL

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Abstract: We studied characteristics of geographic ontology which are different from the traditional ontology in detail. Based on detailed analysis of the basic theory, ontology construction method and the basic principles, we discussed the method of the basic attributes of geographic ontology in the expression of geographical objects with complex spatial relationship. We researched on the ontology modeling language based on OWL in the expression of geographic ontology, we introduced the part-whole theory, topology and location theory into OWL modeling primitives to solve geographic object expression between spatial relationships, and we create a geographic ontology based on the existing spatial data which are verified based on the improved OWL.

Introduction

Ontology is originally a basic problem of philosophy, mainly investigates the origin or matrix of the world, have deep roots in the history of Greek philosophy. Ontology from the category of philosophy is to explain or illustrate a system of objective existence, it is concerned with the nature \cite{1}, ontology development as the essential existence after a research entity and the existence of a universal theory, from being introduced into the information science, ontology is beyond the category of philosophy, has attracted much attention in the engineering and natural science. At present, academic circles think that “ontology” has four characteristics \cite{2} of no ambiguity, conceptual, formal, sharing, and is made up of the concept, relation, function, axioms and example five tuple \cite{3}. According to the research of ontology, ontology can be divided into the top level ontology, domain ontology, ontology, ontology application four categories \cite{4}. The most important usage of ontology is communication, which is between the computer and the computer, including human and computer and communication between people. As the ontology of solid, it refers to a kind of engineering design, is to share a clear, formal concept model specification, which can be used for knowledge sharing, interoperability, reuse tool; as the information organization ontology, which is a kind of knowledge representation method.

At present, the research of geographic ontology are mostly from the specific form of expression of sharing geographic concepts are defined, and applied to the geographic information sharing and interoperability, semantic integration of geographic information
retrieval and service, etc. based on the. The shape, position, size and geometric features of spatial relationship between them is peculiar in geographical information system, so the location relationship between the topological, geometric relations and objects in geo ontology design plays a key role, at the same time, which is the essence of geographic ontology information ontology in general.

The Description Method of Ontology

Commonly used ontology description language OWL is developed on the basis of DAML+OIL and, according to the XML language format is recommended by W3C, the Semantic Web Ontology Language standard. The design goal of OWL is to deal with relationship between the information in the application, to clearly describe the domain concepts and relations between them. It follows the object-oriented thought, structure according to the class and attributes form to describe domain knowledge contained. The OWL language has more semantic expression mechanism, but also has a certain logic description, inference and calculation.

OWL provides three sub set of language, semantic expression ability of incremental, respectively: OWL Lite, OWL DL and OWL Full. OWL Lite only provides a classification hierarchy and simple attribute constraint function, OWL DL in reasoning provides the greatest degree of reasoning skills, while ensuring integrity of computing all conclusions and calculation can be decisive, OWL Full can be viewed as an extension of RDF in function, expression ability in the aspects of semantics provides the strongest support, can be very good to meet the free RDF syntax users who in computability theory without too much demand. You can see that the three languages, every language is an extension to the front of language.

OWL Lite totally has 10 categories and 43 elements including the header information, version information, data types, property description, notes RDFS characteristics, equivalent/not equivalent characteristic attribute type constraints, intersection, properties, cardinality constraints, and class.

The Method of Establishing Geographic Ontology

For general information, ontology OWL is an ideal description language, part OWL provides (part-of), (kind-of), subordination relationship instances (instance-of) and property relations in general information in ontology can basically represent the semantic relationships of all. However, in the geographic ontology, besides the attribute information processing representation of geographical concept, more important is the spatial expression of geographic concepts, especially the space relationship. When OWL space is in the processing of geographic ontology it has many limitations, especially in the position relationship and geographic ontology topology it is insufficient [5]. But in the geographic ontology should be considered in spatial location, the boundary and the part whole relation, so the spatial properties of geographic ontology formalization expression must be based on the new theory.

General Ontology Extension Method

According to the defect of the OWL language in the spatial relationship of geographic ontology, some scholars put forward the part whole learning (Mereology) [6], (Location Theory) [7] position theory, and topology (Topology) into the three theory to ontology modeling, spatial relation of ontology concept, the formal expression of spatial editing and
spatial relations, and the establishment of geographic ontology on the basis of these theories. We take these axioms as modeling primitive into the OWL language system, so that spatial features and spatial relationships can be clearly and expressed in the OWL language’s building geographic ontology.

**Expression of Common Spatial Relationship of Ontology**

The part whole theory, location theory and topology expression of these three tools combined, can in the geographic ontology squadron spatial position, spatial topological relationship, part whole relations and geographical object boundary of formal description.

The part whole learning theory is the main part and the whole relationship is described between entities, the relationship can be expressed as "X is a part of" Y with part-of (X, Y) to represent. Associated with the overlap (Overlap) can be defined as follows:

$$0(x,y) := \exists z (\text{part - of}(z,x) \land \text{part - of}(z,y))$$

The whole part relationship ha anti symmetry and reflexivity, transitivity, extensibility.

Location theory is the relation between space position occupied geographic object and geographical target, basic relational theory is "is located in the" (Exact Location), denoted by L, L (A, B) means "object A is located in the region B". The basic definition is as follows:

Exactly located in:

$$FL(x,y) := \exists z (\text{part - of}(z,y) \land L(x,y))$$

Partly located in:

$$PL(x,y) := \exists z (\text{part - of}(z,x) \land L(x,y))$$

Combination:

$$x \sim y := \exists z (L(x,z) \land L(y,z))$$

F (x, y) is an extension to the L "is located in the" definition, FL (x, y) interpreted as "object x is completely on the object Y"; PL (x, y) interpreted as "object x in Y"; X \sim y defines two geographical objects "consistent" relationship.

Topology is a discipline between geography objects are used to describe the relative position relationship. Connectivity is often used to describe the relationship between the relative position of the geographic objects, and connectivity can be used to define the boundary theory. The boundary relation can be defined as follows:

The real closure:

$$C(x) := x + \forall y B(y,x)$$

Real connection:

$$TC(x,y); 0(C(x),y) \lor 0(C(y),x)$$

Internal parts:

$$IP(x,y) := \text{part - of}(x,y) \land \forall z B(z,y) \rightarrow 0(z,x)$$

**The Method of Establishing Geographic Ontology**

Based on an OpenGIS data model, the geographic ontology as a five byte GeoOntology = {C, R, H, Rel, A}, the concepts defined based on geographical elements, i.e. C = {GeographicObject, GeoRef, Geometry, Point, Line}; R said relations between geographical element set, that is R = \{has_georef, is_at, has_geometry\}, as shown in Fig. 1 the relationship between objects in geo ontology and geographic factors:
Through abstract spatial relations are abstracted as follows:

Has_georef (GeographicObject, GeoRef). A has_georef B said the geographical coordinates of geographical object A is B.

Is_at (GeographicObject, GeographicObject). A is_at B said that if the A has_georef B, A has and _georef C, then the geographic object A is same as B coordinates.

Has_geometry (GeometryObject, Geometry). A has_geometry B B A is the geographic object geometry type.

Through the above method can achieve effective description of geographical objects and their spatial relationships.

Process of Geographic Ontology

The geographic ontology building no universal method, either semi-automatic or automatic methods are not mature, the most reliable method is to use the manual method combining domain knowledge using a common ontology construction tools to build geographic objects and their relations. Based on the campus of Liaoning Technical University based spatial data and attribute data, on the basis of geographic ontology thought, establish the relationship between the concept and the concept of campus in the range between buildings, roads, established the basic structure and the spatial relationships and knowledge system, the basic flow as shown in Fig. 2:
Figure 2. Geographic-Ontology Modeling Process.

Geographic types get the geographic ontology model through modeling and adding space constraints, as shown in Fig. 3:
Summary

This article from the concept of ontology, function and classification method in this paper, focuses on the analysis of the geographic ontology and traditional ontological difference in concept, in order to solve the problems in the process of geographical ontology modeling, the part whole theory, location theory, and topology of these three theories into the geographic ontology concepts and relations of abstract description, the use of OWL defines the common spatial relationship, and the geographic ontology is interpreted as a five tuple, complete description of geographical objects and their spatial relationships, finally, through an example to verify the above theory. The geographic ontology construction at present there is no general way, manually or semi automatically based on the domain knowledge of spatial object relation is described, and the introduction of spatial relationship constraints proves that the model can effectively complete the field of geographic ontology.

References


