THE DESIGN AND IMPLEMENTATION OF ONTOLOGY AND RULES BASED KNOWLEDGE BASE FOR TRANSPORTATION

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ABSTRACT: The traditional transportation information inquiry mainly uses key words based on the text, and the service the inquiry system provided is onefold and only aims at one transporting means. In addition, the inquiry system lacks the comprehensive transportation inquiry combining water, land and air traffic information; also it lacks semantic level inquiry, bringing users lots of inconvenience. In view of the above questions, we proposed establishing a knowledge base of transportation information based on the OWL ontologies and SWRL rules, which can express the rich semantic knowledge of three dimension transporting means (water, land and air) in formalization. Using the ontologies through kinds, properties, instances and classifications ontologies can express structure knowledge, support knowledge automatic sorting and the instance recognition, so as to provide formal semantics for the description of many concepts involved in the transportation domain and relations between these concepts. Using the SWRL rule can solve problem of insufficient expressivity of ontologies in properties association and operation to provide support for spatial relationships reasoning. In order to make use of these knowledge effectively, we have designed a reasoning system based on the ontologies and rules with the help of Protégé and its plug-ins. The system can eliminate ambiguity of the concepts and discover hidden information by reasoning, realizing knowledge and semantic level transportation information inquiry. The rich semantic knowledge and the powerful reasoning functions have made up the shortage of expert knowledge for non-GIS users, strength.

1. INTRODUCTION

Along with the rapid developments the technologies relevant to geographic information system (GIS) and rapid popularization of their applications, the GIS system gradually is moving towards the ordinary populace from the profession application, however how to let the non- specialized users to use them effectively is still in need of further research (Peachavanish R., Karimi H., 2007). At present, the effective use of the GIS technologies relies on project training or the specialized knowledge which gains from the practice; however this kind of training and practice needs to spend much time and energy, which has hindered the GIS popularization. The effective way to solve this question is to constructs the system which has the full domain knowledge and logical reasoning ability to surmount knowledge gap between the non-GIS users and experts. In this article, we use the technologies of both ontologies and rules to establish knowledge base in the transportation domain, which may have all kinds of entity and the relations in the transportation domain formally expressed in the semantic knowledge which machines can recognize and share, and we have designed the knowledge reasoning system based on this foundation, for the non-expert user to fill specialized knowledge vacancy, which avoids the ambiguity of concepts in inquiries based on text, realizing intellectualized reasoning and the inquiry in the knowledge and the semantic level.

2. KNOWLEDGE REPRESENTATION IN TRANSPORTATION DOMAINS

Generally speaking, the so-called knowledge representation is a group of agrees for the description of the world, is the symbolization or formalization of the knowledge (Xu B., Ye P., 2007.).Knowledge representation methods used at present are mainly: Predicate logics, production rules, frameworks, semantic network, object-oriented method , ontology and so on. These methods respectively have their advantages and disadvantages, this article use the method which combines ontology and the rules to describe the transportation knowledge. The ontologies which are taken as the explicit conceptual standard, can be shared, and is commonly used to describe the acknowledged structured knowledge. But at present it is yet imperfect, having problem like insufficiently expressivity and reasoning capabilities. The rule is different from the main body, stresses to the statement knowledge deduction, through logical program design based on rules (Mei J., 2007). The participation of rules can make up for insufficient expressivity of ontologies, enhances the practical application the operating efficiency.

2.1 Ontologies constructing

The main purpose of constructing ontologies is to capture the knowledge for transportations, e.g., all kinds of transporting modes in water, land and air, correlated administrative area, landmarks, meteorological information knowledge and so on. Each kind of entities and their relations possibly involved when one travels have been represented by formal language, provides in semantic and the knowledge level structured description for this domain, enables the machine to read them and reasoning base on them, lays foundations for the establishment of the rules.

2.1.1ontologies compositions: In this article according to need for knowledge expression as well as expression capability of the modeling tools, we use five elements to express ontologies in this domain: T-Ontology= (TC, TP, TI, TR, TA).T-Ontology is the ontology we are aiming at which describes correlated concepts and their relations gathered from each kind of transporting modes; TC is a series of concepts set; TP is a attribute set related to concepts; TI is the instances set that are instantiations for the concept s from TC;TR are relations including the basic semantic elations and the spatial relations; TA is the axiom collection, used for restraining each kind of attributes and the relations.

The concept refers to a gather of entity or phenomenon which has the same attribute in the domain. In this article the concept mainly involves the routes like the track for flight, train and the public transportation vehicle; stops like highway exportation, airport, train station, public transportation stop, motor station and so on; road like highway, administrative division like Wuhan, Hongshan area and so on; landmarks like Wuhan University, Guangbutun and so on; Time concept like year, month, date, hour, minute and so on; Meteorological concept like thick fog, storm, typhoon and so on; Transportation situation like accident, traffic jam and so on. The properties are used to describe some facet of the concept or entity, like the price for airplane ticket, time for taking off, average speed of the train and so on.

The instances are equivalents in the concept space for entities in the real world, also instantiations of the concepts, like west

Beijing station, Wuchang train station, Hongqiao Airport, the city of Wuhan, 106 national road for Beijing to Guangzhou and so on.

In the ontology five elements the most important part is the relations description, we divide them into two kinds:

Basic semantic relations. Relations represent a type of interaction between concepts of the domain. There are four basic relations in this domain: part-of, kind-of, instance-of, and attribute-of. Part-of represents the relations between parts and the whole. Kind-of represents the Succession relations among concepts, similar to the subclass-superclass relation in the Object Oriented Design (OOD), for example, the railway station is a subclass of the Station. Instance-of represents the relations between instances and their concepts (e.g., Beijing is an instance of the concept of administrative area) just like the relations between objects and their classes in the OOD. Attribute-of represents refer to some instance taken as property of others, just like Guangbutun stop is an anchor point for the 519 bus route.

Point-Point	Point-Line	Surface-Surface
Overlap Adjacent Far away	On Adjacent, Far away	Contain（ed） Adjacent Far away
Line-Line	**Line-Surface**	**Point-Surface**
Connect Cross not Connect Not Cross	Connect Cross not Connect Far away	Contained Adjacent Far away

Table 1 the spatial relations implemented in our work

Spatial relations. According to the spatial entities' geometric characteristics and the need for knowledge expression, we category them into three kinds of concepts： the point, the line and the surface. In the following we will analyze the point-line, the point-surface, the line-surface, the point-point, the surface-surface, the line–line and so on (as table 1 shows). Spatial relations between the point and the line include: On (), Adjacent_To (), Off (), respectively presume that the point is on the line, that the point is in the buffer-area of the line within a certain threshold, and that the point is far away from the line. Spatial relations between the point and the surface mainly include: Contained (), Adjacent_To (), Off (), respectively presume that the point is in the surface, that the point is in the buffer-area of the surface within a certain threshold, and that the point is far away from the surface. The line and the surface relations are classified into two kinds, Cross () presumes that the line has the stops in or access to the surface, Off () presumes that the line and the surface do not have intersections physically, while Cross_Off() presumes that the two intersected physically but are not able to reach, for instance some highway passes through some province but there is neither entrance nor exit there, then we thought this line cannot directly arrive at this region. The spatial relations between the point and the point include: Overlap (), Adjacent_To (), Off (), respectively presumes that the two overlap, one is in the buffer-area of the other within some threshold and that the two are far away from each other. The surface and the surface spatial relations include five kinds, Contained () refers to the former is located in the latter, Contain () are contrary relation to Contained (), Adjacent_To () refers to the two has the common surface territory or the nearest distance in a certain threshold, Off () refers to the two are far away from each other and the nearest distance between the two outside the certain threshold. Spatial Relations between lines include three kinds of situations, Cross ()refer to the two intersect and connect, Off () refers to the two don't have a common point of intersection, Cross_Off () refers to the situation which the two intersect but don't connect（e.g., the road are cross, but there are no turns from one to the other）. Although some relations (e.g., Adjacent_To (), Off (),) may express relations between many kinds of instances, but there will be a difference in the semantic information among different kinds of objects. In the above relations the threshold value can be presumed dynamically according to context of the spatial scale. OWL is capable of describing the above relations, but the spatial relations reasoning merely depending upon ontology description language is unable to complete; therefore they must be described and reasoned with the help of the rules, filling the flaws that the description logic expressivity is insufficient.

The axiom are usually first order predicate logic expression. Axioms are used to model sentences that are always true for instance the Hongqiao Airport will belong to the concept "the airport". We may use the axiom to constrain the information, to testify correctness and infer the new information. Joining the axiom in the ontology means it may express richer relations among concept, and may describe all r the real fact in the domain.

2.1.2 Ontology representation language: The ontology may be described by natural language, framework, the semantic network and the logical language. OWL (OWL Web Ontology Language)(Smith et al. 2004) is recommended by W3C ontology description language for ontology in the Semantic Web, it takes RDF and RDF-S as the foundation, further strengthened expression and the reasoning ability for domain knowledge. Through the Boolean operator (conjunction, disjunction, negation), OWL may recursively construct the complex kind, the language elements have also considered the existential restrictions, value restrictions and number restriction, functional restrictions and so on. At the same time, OWL can describe the attribute's characteristics such as transmission, the symmetry, the function and so on, stating equivalence or disjointness between concepts, attributes and individuals. Based on the above characteristics of OWL, in this article we adopt OWL as the ontology description language

2.1.3 Ontologies OWL descriptions: Take Protégé-OWL as the ontology editor. Protégé is a free, open-source platform that provides a growing user community with a suite of tools to construct domain models and knowledge-based applications with ontologies. The Protégé-OWL editor is an extension of Protégé that supports the Web Ontology Language (OWL) (Knublauch et al., 2004). The Protégé-OWL editor enables users to: load and save OWL and RDF ontologies, edit and visualize classes, properties, and SWRL rules, define logical class characteristics as OWL expressions, execute reasoners such as description logic classifiers, edit OWL individuals for Semantic Web markup.

In the following we take the spatial relations description as an example to explain the OWL expression the ontology. Excerpt below described the Wuchang railway station and Zhongshan Road's geometry shape as well as neighboring relations between them(Figure1):

```
<?xml version="1.0"?>
<rdf:RDF
  ……
 <owl:Ontology rdf:about="Traffic Knowledge">
   <owl:imports
rdf:resource="http://protege.stanford.edu/plugins/owl/protege"
/>
 </owl:Ontology>
 <owl:Class rdf:ID=" GeoDescription "/><!—Geomety
Description-->
 <owl:Class rdf:about="#Point"><!—Point -->
   <rdfs:subClassOf rdf:resource="#GeoDescription"/>
 </owl:Class>
 <owl:Class rdf:ID="Polyline"><!--Polyline-->
   <rdfs:subClassOf rdf:resource="#GeoDescription"/>
 </owl:Class>
 <owl:Class rdf:ID="Station"><!--Station-->
   <rdfs:subClassOf rdf:resource="#Point"/>
 </owl:Class>
 <owl:Class rdf:ID="Road"><!--Road-->
   <rdfs:subClassOf rdf:resource="#Polyline"/>
 </owl:Class>
 <owl:SymmetricProperty rdf:ID="Adjacent-To"><!—the
symmetry Adjacent_To relationship-->
   <rdfs:range rdf:resource="#GeoDescription"/>
   <rdf:type
rdf:resource="http://www.w3.org/2002/07/owl#ObjectPropert
y"/>
   <owl:inverseOf rdf:resource="#Adjacent-To"/>
   <rdfs:domain rdf:resource="#GeoDescription"/>
 </owl:SymmetricProperty>
 <Station rdf:ID="WuChang_Station"><!—WuChang
Trailstation is adjacent to Zhongshan Road-->
   <Adjacent-To>
     <Street rdf:ID="ZhongShan_Road"/>
   </Adjacent-To>
 </Station>
</rdf:RDF>
<!-- Created with Protege (with OWL Plugin 3.4, Build 108)
http://protege.stanford.edu -->
```

Figure 1. Except of spatial relations description

2.2 Rules' Construction

Although ontology is organized through semantic means such as vertical classification, transverse attributes and relations and so on, it is far from enough by OWL for attributes operation such as rules of relations among attributes. While spatial relations reasoning is involved in the operation of space attributes (Wang H., Cao H. ,2007).

SWRL (Semantic Web Rule Language) (Horrocks et al., 2004) is developed in order to make up for the OWL language that is imperfect in the ability of expression, which is based on a combination of the OWL DL and OWL Lite sublanguages of the OWL Web Ontology Language with the Unary/Binary Datalog RuleML sublanguages of the Rule Markup Language. SWRL described the knowledge of OWL ontology by highly abstract syntax expression, which realized the combination between the Horn-like rules and OWL Knowledge Base. We take SWRL to express formally spatial reasoning rules. And we can use SWRL Editor in figure 2 that is integrated by Protégé – OWL to edit SWRL.

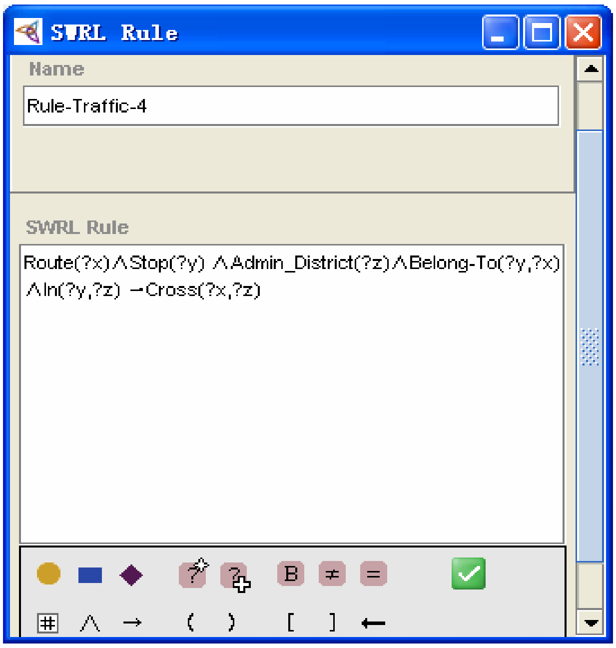

Figure 2. SWRL editor in protégé-owl

A few simple examples as follows:

Route(?x)∧Stop(?y)∧Admin_District(?z)∧Belong-To(?y,?x)∧In(?y,?z)→Cross(?x,?z)

Notes: If a certain route has a stop within the scope of the administrative regions, the route passes through the administrative region.

Route(?x) ∧ Stop(?y) ∧ LandMark(?z) ∧ Belong-To(?y,?x) ∧ Adjacent_To(?y,?z)→Adjacent_To(?z,?x)。

Notes: If a landmark has a closer distance to a stop of some route, it may be considered that the route can reach the landmark through the stop.

Route(?x) ∧ Route (?y) ∧ Stop(?z) ∧ Belong-To(?z,?x) ∧ Belong-To(?z,?y)→Transfer(?x,?y)

Notes: If a stop belongs to two lines at the same time, we can transfer through the stop.

Route(?x) ∧ Admin_District(?y) ∧ Admin_District(?z) ∧ Cross(?x,?z)∧Cross(?x,?z)→Direct(?y,?z)

Notes: If a certain route has a cross relationship respectively with the two administrative regions Cross, the two regions can be reached directly through the line.

Admin_District(?x) ∧ Thick_Fog(?y) ∧ Highway_Gate(?z) ∧ In(?z,?x)∧Has_Weather(?x,?y) →Disable(?z)

Notes: If there is heavy fog weather in some administrative region, highway entrances and exits in there need to be closed.

Through spatial relations and the formal rules of expression, we can realize the computer-readable and automatic processing of spatial relationships.

3. INFERENCE SYSTEM BASED ON THE OWL AND SWRL

Based on ontology and Basic rules, the SWRL leaps the limitations of the inherent ability of expression for both ontology and rules. SWRL and OWL can play advantages of both them: on the one hand, the rules are good at pluralistic relations with deductive knowledge, and Ontology focus on the description of the unary concept; on the other hand, the rules do not support the concept of existence, while ontology provide complex definition of the concept, including the concepts such as existence and so on (Mei J., 2004). The inference task for ontologies and rules based knowledge base mainly divided into two parts: ontology-based reasoning and rule-based reasoning.

3.1 Ontology-Based Inference

We can use Racer (Haarslev V. and M¨oller R., 2001)-description logic inference engine, to complete the ontology consistency, concept based classification and other Ontology-based Inference tasks. Racer is a kind of inference engine based on Description Logic, which is developed by V. Haarslev and R. Moller. It uses SHIQ (Horrocks I, Sattler U., and Tobies S., 1999) as its Description Logic basis, so racer can be used in the inference behavior of OWL DL which is based on this logic. In this system it is mainly used for the following tasks:

Firstly, it is used to test the consistency in the ontology. If there are inconsistencies in the ontology, as a modeling and semantic description tool, it will produce formal and semantic contradictions, making ambiguity in specific work.

Second it is used to test the subsumption relation. Concepts can be classified into different levels through the test.

Third, the instance detection can determine the corresponding concept description for certain individuals, and then classify individuals belonging to some concept.

Fourth, some auxiliary inference functions are important tools for specific applications, such as retrieval of the concept names and individual names in the knowledge base, the retrieval of individual pairs related to their roles and the retrieval of role-level search which means the role of parent and son level.

3.2 rule-based reasoning

With respect to rule-based reasoning, we make use of Jess (Java Expert System Shell) to complete. The tool use Lisp-like syntax to describe the rules and facts, and can, through rules to inference facts. We make format conversions from knowledge base based on both ontologies and rules to Jess with help of SWRLTab plug-in. The SWRLTab has four main software components:(1) a graphical editor; (2) a Java API for working with SWRL rules; (3) a rule engine bridge that interoperates with rule engines to execute SWRL rules; and (4) a built-in bridge for defining and executing implementations of SWRL built-ins.

The SWRL Rule Engine Bridge is a subcomponent of the SWRLTab that provides a bridge between an OWL model with SWRL rules and a rule engine. Its goal is to provide the infrastructure necessary to incorporate rule engines into Protégé-OWL to execute SWRL rules.The bridge provides mechanisms to (1) import SWRL rules and relevant OWL classes, individuals, properties and restrictions from an OWL model; (2) write that knowledge to a rule engine; (3) allow the rule engine to perform inference and to assert its new knowledge back to the bridge; and (4) insert that asserted knowledge into an OWL model. The bridge also provides mechanisms to dynamically add graphical user interfaces to the SWRLTab to allow interaction between a particular rule engine implementation and a user.

A bridge for the Jess rule engine called the SWRLJessTab is provided in the Protégé-OWL distribution. Through this component SWRL Jess Bridge, we can have OWL / SWRL automatically converted into Jess Rule and implemented, which will avoid a tedious work of manual conversion from SWRL rules to Jess Rule rules. We can reason on various SWRL rules by using Jess inference engine, get kinds of hidden knowledge.

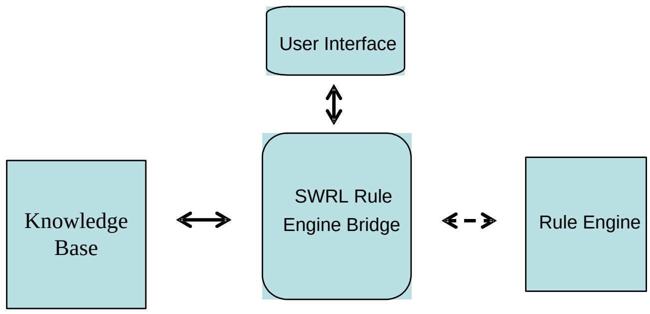

Figure 2 rule based inference framework

4. CONCLUSIONS

Through the methods ontologies and rules, this article established the transportation information knowledge base, and constructed a homogeneous reasoning system based both on semantic and spatial relations inference. The ontologies have given the full expression to domain concepts and their relations, laying the foundation for the inquiry based on the level of semantic and knowledge, have solved the inefficient inquiry problem which was brought based on the text inquiry, enhanced the inquiry accuracy and ratios. Since the rules can relate properties with each other, we describe the possible spatial relations inference rules with the help of SWRL, make up the flaw which the ontologies expression ability was insufficient. We used the rules to discover the implicit rich semantics knowledge, which optimize the inquiry algorithm and enhance the inquiry efficiency. The reasoning system divides tasks of reasoning into two parts (based on the ontologies and the rules) respectively handled by the ontologies reasoning engine and the rules engine. In brief, the knowledge base and the establishment of reasoning system will fill up the knowledge gap between the non- exporter users and the GIS experts, provide the more convenient inquiry way for the users. The prototype system is at the experimental stage at present, the integrated knowledge base also needs expert's carefully looking through to achieve better performance. In the future we will study the unifications about the reasoning system based on the knowledge and numerical value computation, bring the two advantages of both into play to provide services more continently.

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