Natural Language Query Interface in SMS/MMS-based Spatial Information Service

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Abstract— **To solve the problem of poor interface of SMS/MMS, we adopt natural language query interface as an optional approach for the user who does not know any command format. Since there is no service code in natural language query string, we have to evaluate what kind of service the user wants. In this paper, we propose an approach of mapping natural language query string to standard commands that servers understand. We also discuss the extraction process of spatial semantics from unstructured query string based on the spatial semantic roles. Meanwhile, the system framework of the prototype is given, and the potential problems and the future works are also discussed.**

Keywords- Spatial Information Service, Natural Language Interface, Multimedia Messaging Service (MMS), Semantic Extraction

I. Introduction

Currently there is a hot topic about providing Spatial Information Services to mobile users due to the huge potential market needs. As a typical application of distributed Geographic information System (GIS), Mobile Spatial Information Service (MSIS) aims to provide spatial information, such as cartographical maps, images and texts, to mobile user at any time and any place. It usually depends on Mobile GIS and Geographic information retrieval (GIR). Mobile GIS often responses for handling maps, images, and other visual geographic data with clearly defined boundaries or extents, while GIR responses for textual form geographic information. There are two popular solutions for MSIS. The one is based on Short Message Service (SMS)/Multimedia Message Service (MMS), the other is based on Wireless Application Protocol (WAP). This paper focuses on the first solution.

Compared to Web-based spatial information service, MSIS should pay more attentions to the human machine interactive mode and results form because of several bottlenecks such as the low-bandwidth of wireless network, the diversity of mobile devices, limited processing power and screen display limitation of mobile devices and the diversity of mobile system platform[1]. In SMS/MMS , if user wants the services, he has to know the special service command format, which is defined by the service provider. Otherwise, he can never get them. What's more, Web-based GIR is also unsuitable for MSIS, since the candidates of retrieval results are documents which are usually too large for mobile devices to display.

To solve the problems, we designed a semantic search based MSIS which looks like a Question Answering (QA) system. It accepts natural language as query input and returns not the related documents but "just the right information". As natural language is easy to use, it is an ideal interactive mode for mobile users. Meanwhile, since the system returns the right answer, it is much suitable for the screen-limited mobile devices to display. Besides texts, it also provides maps or images. So, it is distinct from traditional QA system in contents. theoretically speaking, it is an ideal MISS.

Unfortunately, natural language is difficult to understand for computer, and how to retrieval the right answer on the fly is also a challenge. In this paper, we introduce an approach of semantic extraction from Natural Language Questions (NLQ). It trys to understand user's spatial query semantics and returns corresponding geographic instances or maps to user.

The next parts are structured as follows. The MSIS system architecture is first presented in Section 2. Then the detail implementation methods such as spatial semantic extraction and question semantic mapping are described in Section 3. Finally, we give the conclusion and discuss the potential problems and future work.

II. System Architecture

Figure 1 shows an overview of MSIS system architecture. The mobile user's Natural Language query requests are transformed to spatial semantic parser through different wireless application platforms. The parser analyses the request and generates three kinds of structured query statements: RDF/OWL, keywords, GeoSQL, respectively. Then, the RDF/OWL request is sent to semantic web reasoner which can inference exact answer, keywords are submitted to traditional QA retrieval module which returns the most relevant answers, and the GeoSQL is submitted to GIS server which produces maps or images for mobile clients. The results are merged together to form suitable format for mobile clients displaying. To enhance the capability of spatial semantic inference, the exact spatial relationships among query geographic entities are computed in GIS server. In addition, all space-associated information such as geographic ontology instances and theme fragments (phrases, keywords, etc.) are extracted from web pages, they are stored in instance database and QA retrieval database respectively. As the whole system associates with many technologies, this paper only focuses on spatial semantic parser module.

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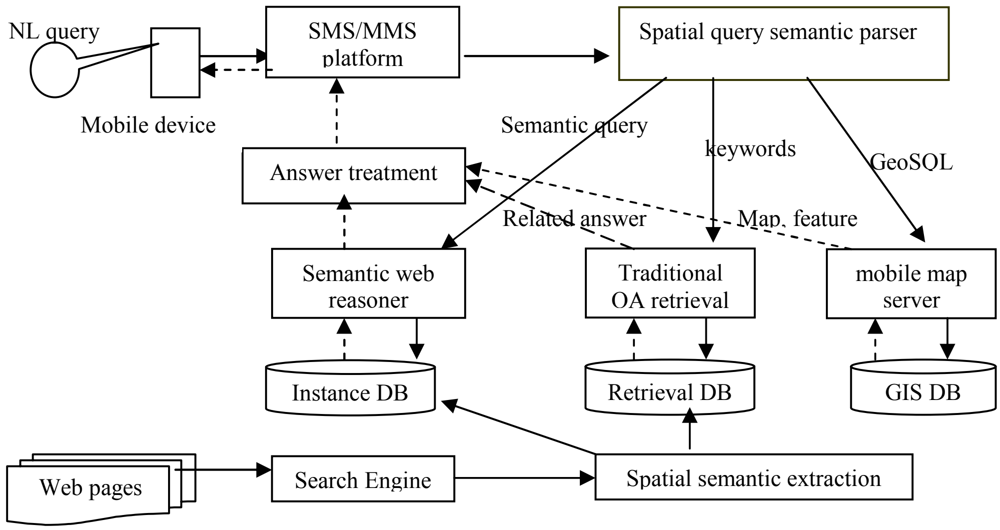

Figure 1. MSIS system architecture

(Note: Solid arrow line shows input flow, dashed arrow line shows output flow)

III. Implementation Methods

Briefly speaking, we make use of GeoOntologies to get spatial semantic roles. By annotating spatial semantic roles and making shallow parsing to sentences, we can get the spatial query semantics of user.

A. Spatial Semantic Extraction

Spatial semantic extraction is the premise of understanding natural language query and semantic instance extraction. Figure 2 shows the whole process. It can be roughly generalized as four steps: geographic ontology analysis on linguistics view, semantic roles annotation, phrase recognition and sentence recognition. We'll discuss them next.

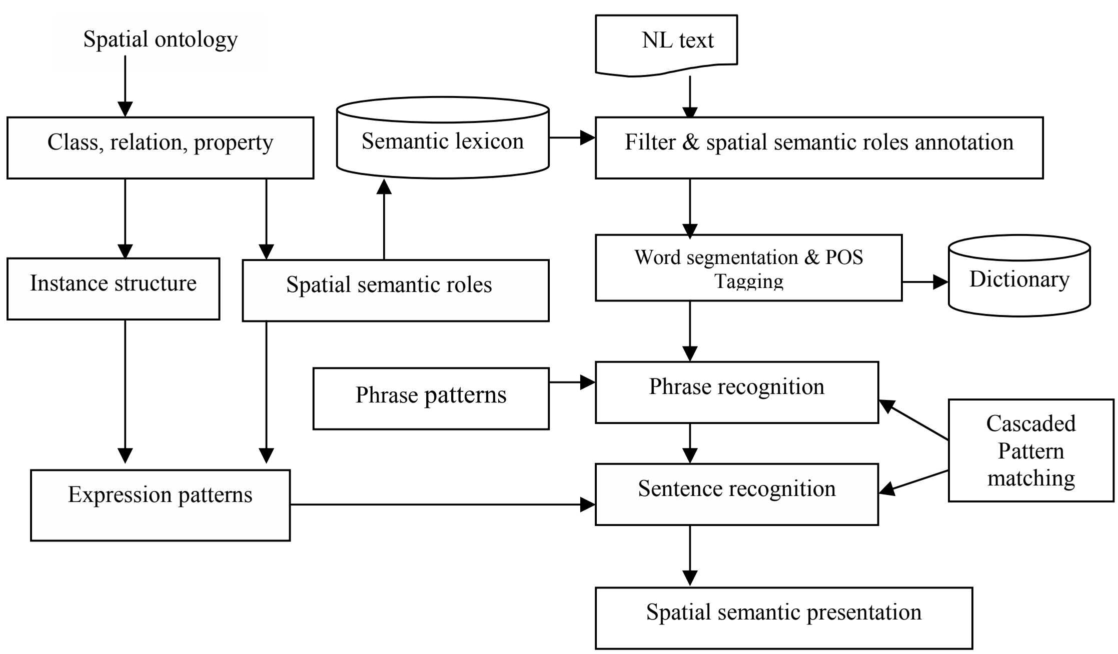

Figure2. Spatial semantic extraction process

1) Linguistics Analysis of Geographic Ontology

Ontologies are often defined as shared conceptualizations of a domain and consist of concepts, relations and instance information held as entity-relation-entity triples [2]. They are often created by experts and described in structured languages (e.g. XML/RDF/OWL). An intuition tells us if we could find the expression regulations of natural language for a domain's ontology, the semantics described in ontology would be easily extracted from unstructured text.

According to this clue, we present an approach to analyses geographic ontology. The geographic ontology is taken from [3]. It includes typical geographic feature classes and geographic relations (e.g. topological, distance, and direction relationships) and is written in OWL. With this ontology, we constructed a spatial semantic lexicon by defining spatial semantic roles. In the lexicon, semantic items can be described as follows.

1. En, the spatial entity, is used to identify geographic feature classes.

2. SR, the spatial relation, is used to identify geographic relations in ontology. It includes three types: SRT (topological relationship), SRD (direction relationship), SRM (measure relationship). SRT represents the following eight relations: equals, disjoint, intersects, touches, crosses, within, contains, and overlaps. SRD represents the cardinal directions like isEastof,, isSouthof,, isWestof, ,isNorthof, SouthEastof, NorthEastof, SouthWest, NorthWest and reference directions like isBeforeof, isBehindof, isLeftOf, isRightOf, isUpOf and isDownOf. SRM represents space distance and time distance, e.g. withinMetersOf, withinMinutesOf.

3. AR, the attribute of spatial entity, expresses the properties of geographic feature classes

4. POS (part of speech). The definition is as same as general lexicon.

The first three semantic items are associated with spatial semantic roles. Each of them has many instances. During the lexicon collection we need collect large quantities of Chinese lexis, which is used to express these semantic roles.

2) Semantic Annotation

Unlike English, Chinese has no separate space between words. Chinese semantic annotation generally includes word segmentation and roles recognition. As the annotation only cares the spatial area, we adopt the strategy of filter, roles recognition and POS annotation. We use Maximum Matching Algorithm (MMA) to recognize spatial semantic roles with the semantic lexicon. The algorithm is widely used in Chinese information processing and was proved a good performance. Chinese POS annotation is also a complex procedure. we adopt Hidden Markov Model (HMM) to implement it. The specific algorithm is described in [4].

The whole semantic annotation procession can be described as follows. Sentences irrespective of spatial concept are filtered first, and those having spatial lexicon are store to buffer, then they are fetched respectively and are treated with MMA using the spatial semantic lexicon, as a result, the spatial semantic roles are tagged. The non-tagged parts are deal with HMM to make POS annotating.

3) Semantic Extraction

Although semantic annotation recognized spatial semantic roles and POS, they are still atomic fragments which are isolated from each other. If we directly extract spatial semantics from these fragments, it would be hard to process because of the complexity of NL. In NLP there are many approaches to analyses sentence semantics. We select cascade shallow parsing method to extract spatial semantics, since the method is relatively practical and its performance is also acceptable. So we define series of spatial semantic role phrases, such as SE_P (spatial entity phrase), SRT_P (topological relation phrase), SRD_P (direction relation phrase), SRM_P (measure relation phrase), AR_P (attribute relation phrase) and other relevant phrases, to establish associations among fragments. To recognize these phrases, we collected phrase rules from Chinese. These rules composite of spatial semantic roles and POS, and are expressed in regular expressions. Similarly, the upper level recognition patterns for the whole sentence can also be created. Therefore, step by step, spatial semantics of sentence are gradually recognized in three levels: word, phrase, and sentence. Figure 3 illustrates the extraction process of the example sentence: 桌子上有三个红色的苹果 (there are three red apples on the table).

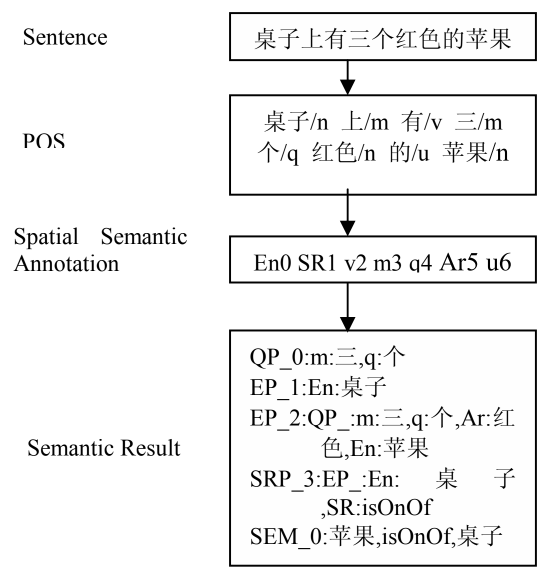

Figure 3 Examples of Spatial Semantic Extraction

B. *Question Semantic Mapping*

To understand exact meaning of user, the semantics of Natural Language Query should be extracted and mapped to service commands to get answers. We use the method introduced in former section to implement the function. As spatial NL query is domain concerned, we confined our application to spatial area. To begin with, we should collect phrase patterns and question pattern of questions. As geographic ontologies contains most of the properties and relations of spatial entity, we think questions to geographic ontology elements can cover most users' requirements. So we construct several question sets for each geographic ontology elements and extract relevant expression patterns. For example, in [3] there is a Class defined as "South" like "<owl:Class rdf:ID="South">…</owl:Class>",We construct a question set of the Class and take it as a predicate with unary relation and binary relation to spatial entities:

Q01: En 的南面是什么? (what' s in south of En?)

Q02: 什么在 En 的南面? (what' s in south of En?)

Q03: En1 是在 En2 以南吗? (Is En1 in south of En2?)

…

Phrase patterns:

EP: (QP_[0-9]+)?(Ar[0-9]+ (u[0-9]+)?)*(En[0-9]+ (u[0-9]+)?)+

SRP: (p[0-9]+)?(EP_[0-9]+)+(u[0-9]+)?SR[0-9]+ ?

…

Sentence patterns:

P01:SRP_[0-9]+ v[0-9]+ QP_[0-9]+ ?

P02: QP_[0-9]+(v[0-9]+)? SRP_[0-9]+ QP_[0-9]+ ?

…

By means of these patterns, most of spatial query semantics can be successfully extracted. They are mapped into the forms that servers understand. Taking Q01 for instance, if a mobile device sends a query string like"天安门的南面是什么？(what' s in south of TianAnMen square?)", the system can get the semantic form like"SEM_0:what, isSouthof, 天安门". Then it is mapped to the form of triple like "isSouthof (天安门,?) "and GeoSQL respectively to submit to Semantic Web Reasoner and Mobile Map Server.

However, pattern matching can not solve all the problems. Sentences failing to meet pattern matching are hard to obtain their meanings. So we make use of key words retrieval to get the answers. In this example, if the system fails to get semantics it would submit key words "天安门" & "南面" to retrieval server.

IV. Conclusion and Future Work

Natural language interface is an ideal approach for mobile user to query spatial information service. To make it practical, We tried an approach to extract spatial query semantics by making use of Geographic Ontologies, and mapped the query semantics into three forms to Semantic Web Reasoner, retrieval server and Mobile Map Server. As question sets considered each elements of Geographic ontology, most of the spatial query semantics can be recognized correctly. Moreover, since the system uses Semantic Web Reasoner, user can get more exact results from the Reasoner's capability of inference.

By now, the whole system is still in developing. So it is need to do more experiments further. In addition, during unit tests we found the most difficult thing is to collect spatial semantic expression patterns, since it is completely depends on manual induction. How to automatically create expression patterns is also needed to research further.

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