Understanding Ambiguous Language in Context-Aware Mobile Querying

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Abstract

In this paper we discuss a method for understanding ambiguous language in natural language interfaces for mobile devices. We approach the problem by modeling the user and system with semantic web ontologies that are informed by a context-aware computing platform. The semantic model is then used to interpret ambiguous language based on the user's real-world context.

1 Introduction

Understanding ambiguous language is one of the key problems faced in natural language processing, and mobile devices pose a unique set of problems and opportunities. Because of their small screen-size and often cumbersome input methods accessing and searching for information on mobile devices can be difficult and tedious. Natural language interfaces are one method that can provide intuitive access to the users.

Unfortunately NLIs frequently suffer from poor expressivity and highly restricted language. We feel that in order to develop more successful interfaces we must allow for more natural grammars, larger lexicons, and understanding of *context-dependent* terms. We consider context-dependent terms to be those that vary based on a user's real-world context (e.g. where they are at what they are doing).

The growing availability of GPS and sensor information on mobile devices, when combined with ever increasing computational power, allows us to utilize a wide range of information to address the problems related to NLIs. We use a unique combination of context aware computing and semantic web modeling to aid in understanding user queries.

This work takes place in the context of Intelligent Transportation Systems. The focus is on using computer science and information systems to solve transportation related problems. One of the key components to ITS is giving users access to the information they need in order to make intelligent travel decisions. One proposed approach to this is developing a Intelligent Traveller Assistant – a mobile device allowing access to transportation, commercial, and other social information (Dillenburg et al., 2002). The device acts as a platform and provides services such as GPS, semantic location, trip planning, activity planning, maps, etc. for applications. Our approach makes extensive use of these information services.

2 Approach

2.1 Overview

As show in figure 1, our approach is centered around two primary research components: a semantic model and a parser. The semantic model is described in great detail in section 2.2. The semantic model is used by the parser in order to interpret ambiguous queries (see section 2.3 for details). Additionally we must define a grammar for the voice recognition engine. The components drawn in a dashed line are considered to be largely black-boxes using off the shelf components.

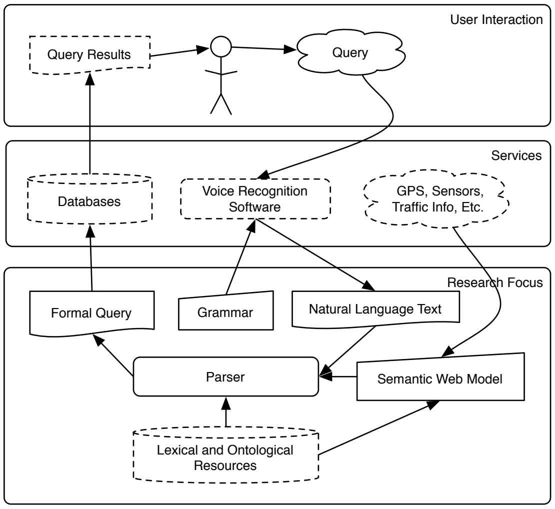

Figure 1: System Model

2.2 The Semantic Model

The OWL-based semantic model is the foundation for the natural language interface – it models the data, world, and context for the system. There are two primary sub-models of real-world concepts: the user model and an urban transportation model. A third "task" model conceptualizes the tasks a user would like to accomplish, which in turn correspond to potential query classes. We also model a number of linguistic phenomena.

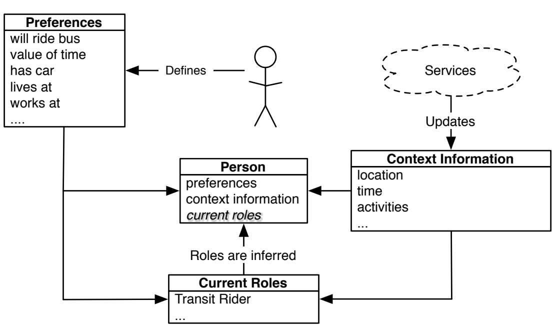

Figure 2: The User Model

The user model consists of their preferences, intrinsic properties, current context, and a set of current roles. Preferences and properties include their age, home, workplace, car ownership, willingness to ride forms of transportation, value of time, etc. Context information includes where the user is located, both physically and semantically[1], who the user is with, and activities the user is participating in. The user also assumes a set of "roles" based on their current context and properties (inspired in part by (Cirio et al., 2007)), which are inferred dynamically without intervention from the user. The roles (e.g. *pedestrian*) determine how the user interacts with the various concepts within the model.

We also build a detailed model of urban transportation that includes concepts related to driving (e.g. automobiles, roads, congestion, accidents), public transit (e.g. busses, trains, schedules, routes), weather, accidents, etc. and how they interact with each other and the user. Spatial and temporal concepts and relationships are included as well.

The next key component of the model is the incorporation of linguistic constructs. We provide explicit conceptualizations of deictics such as *here, there, near, close, best, soon*, etc. We annotate the concepts in the ontologies with their corresponding concepts in SUMO and OntoWordNet. Additionally, we provide annotation for colloquialisms for appropriate[2] concepts.

2.3 Applications of the Model

2.3.1 Simple disambiguation of terms

The SW model represents the concepts in our transportation system and has been annotated with their semantic meaning in language. This means that a user can use a term not in the model or database itself, and still be matched to the appropriate concept.

For example, if a user poses the query, *What is the shortest **way** to the zoo?*, the term *way* is not present anywhere in the database or model. We are able to automatically determine that *way* corresponds to the `route` concept in the model because it has been annotated with the appropriate WordNet label. Another class of ambiguities arise from implicit personal references. You could have queries *What is the fastest way **home**?* or *How much is a cab to **work**?* These terms are easily matched to the `livesAt` and `worksAt` properties, which refer to specific places, in the user's personal model.

[1] A physical location would be an address or GPS position whereas the semantic location would refer to the fact that the user is in a grocery store.

[2] At this time our model focusses on the Chicago are and the colloquialisms reflect that.

2.3.2 Proximity

Terms such as *near* and *far* are highly context dependent. While humans are good at understanding their implicit meaning, computers require explicit semantics. Let us consider two potential queries: *Is there a Thai restaurant in **the area**?* and *Show **nearby** ATMs.* *The area* can mean very different things depending on the mode of transportation available, the resource sought, etc. If a user is a pedestrian *the area* may be no more than a few blocks, while for someone with an automobile is could be an entire neighborhood or region of town. If the user is on an El train *nearby* may refer to within a given distance from the stops rather than a simple radius from their current position. The type of resource will also influence the meaning – a close parking space is significantly more local than a close hospital.

2.3.3 Other Deictics

Here, *there*, *now*, *soon*, and similar terms are another source of ambiguity in natural language. *Here* is easy to handle as it refers to the current position of the user, but even then there is some ambiguity on scope. It may refer to the given point, room, building, block, neighborhood, etc. *Are there any parking spaces **here**?* may require searching a block whereas *How do I get to Millennium Park from **here**?* would refer to the current position. Other deictics are represented to some extent.

2.3.4 Ranking Terms

In a query like *What is the **best** way to get to Wrigley Field?* we are looking for a route that is judged to be optimal based on some criteria. Does *best* refer to cost, distance, time, amount of walking, etc.? The appropriate metric may vary with context in accordance to personal preferences. By reasoning over where the user is, what they are doing, and their personal preferences we could determine the most likely interpretation of such terms.

3 Related Works

3.1 Deictic Believability

We are not the first to work on understanding deictics in natural language interfaces. There is an active community doing such work, but it primarily focuses on the domains of human-robot interaction and other multimodal systems (Lester et al., 1999).

3.2 Integration of Language Information and Ontologies

The field of natural language processing possesses a rich set of tools and lexicons for capturing language semantics. One of the best known of these lexica is WordNet (Fellbaum, 1998). This resource is not a well defined ontology, but there are a number of projects that have started to integrate it within the framework of formal ontologies. OntoWordNet (Aldo Gangemi, 2003) and DOLCE (Gangemi et al., 2003) impose external rules in order to transform WordNet into a well-defined ontology.

SUMO (Suggested Upper Merged Ontology) (Pease et al., 2002) is an upper level ontology designed to capture high level concepts such as physical vsåbstract concepts, processes, attributes, collection, quantities, etc. and their relationships. Below that are more detailed mid-level and a small number of domain specific ontologies. SUMO and WordNet have been completely mapped to one another (Niles and Pease, 2003). Additionally, work has been done to link FrameNet to SUMO in (Scheffczyk et al., 2006).

3.3 Natural Language Interfaces

Natural language interfaces to databases provide users a method to query formal databases using natural language. A comprehensive study of many of the techniques used can be found in (Androutsopoulos et al., 1995). Most of the work has dealt with SQL-based languages, but in recent years there has been some work on querying XML (Li et al., 2005) and RDF (Kaufmann et al., 2007; Wang et al., 2007) resources. There have been NLIs for mobile systems like (Johnston et al., 2002), but they don't utilize context like our approach.

3.4 Databases and Query Languages

Because the final target for user queries is a database of some sort it is important to consider what the underlying data model and query language is. The formal languages act as an impedance between the idealized user query and what can actually be expressed. Due to the nature of the transportation domain we are looking specifically at Moving Objects and Spatial-Temporal databases, such as those from (Sistla et al., 1998) and (Erwig and Schneider, 2002) respectively.

3.5 Semantic Web and Context Awareness

The semantic web is becoming a popular tool in context aware computing. One of the reasons for this popularity is that ontologies can be used to model the different aspects of context and the elements within the system and leverage the reasoning power inherent in the systems to allow for adaptation based on the context. For example, (Sheshagiri et al., 2004) uses models to automatically discover relevant resources based on a user's current location and activity. The semantic web has also been used to monitor and manage context information in systems such as (Perich et al., 2004) and (Chen et al., 2003).

4 Future Work

Currently we are performing a detailed study of available query languages. Once the appropriate language has been chosen we will begin the design, testing, and implementation of the parser. The final step will be to implement the entire system on the mobile ITA platform and perform testing via user studies.

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