Project I1-OntoSpace: Ontologies for Spatial Communication[1]

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Abstract

The poster describes the essential ingredients of project I1-OntoSpace of the "SFB/ TR8 on Spatial Cognition: Reasoning, Action, Interaction" (Bremen/ Freiburg). The SFB/TR8 is an interdisciplinary collaborative research center that has been financed by the DFG since January 2003. The poster highlights the empirical studies in linguistic human-robot interaction being carried out, including first results.

1 Project Outline

Natural language is an essential mode of interaction between users and sophisticated spatially-aware systems such as mobile assistance robots. Providing suitably sophisticated natural language capabilities for ever more complex interaction scenarios is a major problem. An important contributing factor is the lack of appropriate modularizations of the technical components involved in complete systems that combine spatial and linguistic capabilities. Such interaction needs to be as natural and non-intrusive as possible in order to support the widest possible range of potential users, and so sophisticated accounts are required. Most of the features that make interaction 'natural' still present substantial challenges for dialog systems and solutions are not to be found within single research areas.

One particularly effective strategy for modularization is the adoption of linguistically motivated ontologies that mediate between domain/application knowledge and Human Language Technology (HLT) components. But current strategies for ontology mediation exhibit a rigidity that is inappropriate for the relationships observed between domain and linguistic knowledge in real interactions. Here, a negotiation of mediation within 'conversational' interaction appears crucial both for ontology design and for achieving interoperability.

This project therefore has the primary goal of developing a toolbox of ontology-based methods suitable for supporting natural language interaction and technology re-use within a range of interaction scenarios involving spatially-aware systems. The methods developed will be motivated by detailed empirical investigations of the actual communicative strategies of negotiation employed by users of robotic systems. The results of these experiments will feed into a situation/scenario-parameterized formalization of inter-ontology mappings.

[1] The authors listed are the members of Project I1-OntoSpace. The poster is presented by Thora Tenbrink.

The project will contribute to the further development of emerging standards in ontological engineering, their application in the management of natural language, and the development of ontological modules involving spatial representations for mobile robots. It will also use the ontology mediation strategy to overcome a persistent lack of interaction between spatial system design, robotic interaction, etc. and HLT. This has limited both the wider re-usability of important research results concerning the natural language analysis and generation of spatial relations, including fine-grained semantics for spatial expressions, route description planning and understanding, resource-adaptive generation, etc.

2 Empirical Studies

This project is concerned with two primary ontology levels: the linguistic and the spatial; these are defined by importing existing research results and then refined by targeted empirical investigation of linguistic behavior in specially tuned spatial settings. For maximal re-usability of generic components, any language components employed must refer only to the linguistic ontology level. Contact with the spatial knowledge is achieved by inter-level mediation.

The particular mappings to be defined between the spatial and linguistic ontologies are derived from the communicative strategies revealed in the empirical investigations. The empirical problems we address are located in two problem areas: first, the complexity of the interpretation of spatial expressions based on the considerable variability of implicitly underlying reference systems and the associated negotiation processes between the interactants; second, the peculiarities pertaining to the choice of linguistic expressions in an unfamiliar interaction situation involving an artificial interlocutor. Both problem areas combine in linguistic interaction scenarios in which users are required to communicate with an unfamiliar robot about spatial surroundings.

We address the parameterization of ontology mappings related to spatial configurations by making the relationship between situational variables and linguistic properties transparent. For instance, the users' choices of spatial reference systems and of strategies for referring to landmarks are central parameters of linguistic variability in human-robot interaction. Users may (justifiably!) be uncertain about what the robot can perceive, and so the lack of mutual and reflexive common ground for the interactants regarding the spatial situation may lead to insecurity about which objects may serve as landmarks and how they can be referred to. This variability can be experimentally controlled. Closely related to this factor are the participants' linguistic and spatial choices concerning group-based reference – a kind of reference system often neglected in the literature – using further similar objects instead of a different object as a relatum to specify the target object's position. Such issues are addressed by confronting users with tasks involving different configurations of diverse (similar and differing) objects, the robot, and the user.

Results achieved so far suggest that in human-robot interaction, irrespective of the particular spatial configuration, human instructors reliably take the robot's point of view. This behavior differs from that found in human-human interaction and so needs to be considered in designing dialog interpretation strategies for such systems. Furthermore, the dialogue history demonstrably influences users' decisions about their choice of reference systems: With previous success using group-based reference, users tend to employ this format even in a scenario in which the robot only perceives *one* box, a situation where group-based reference does not standardly apply. Users attend to the robot's (linguistic and motional) reactions, relying on previous successful instruction formats as well as aligning to the robot's output on all linguistic levels: morphological, syntactic, semantic and conceptual. A further major area of results concerns the degree to which the spatial arrangement – including the robot's view direction – influences the users' instructions with regard to choice and applicability range of reference system, choice and direction of perspective, complexity of reference, vagueness or redundancy, etc. Functional aspects such as perceived distance and accessibility play a major role, for example in interpreting expressions like *front* and *back*.

Such findings can – and will in the project's future – be used for the parameterization of inter-ontology mappings in order to link abstract spatial representations with their possible linguistic expressions in a flexible manner.