Knowledge Representation and Semantics in a Complex Domain:  
The UNIX Natural Language Help System GOETHE  
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1 Abstract  
Natural language help systems for complex domains require, in our view, an integration of semantic representation and knowledge base in order to adequately and efficiently deal with cognitively misconceived user input. We present such an integration by way of the notion of a frame-semantics that has been implemented for the purposes of a natural language help system for UNIX.

2 Introduction  
It is commonly agreed that natural language systems for semantically rich domains require a level of semantic representation in order to provide for a sufficiently deep processing of the natural language input. The level of semantic representation is sometimes called a representation of linguistic knowledge. In addition, a natural language help system also requires a knowledge base of the application domain in order to answer the requests for domain specific help. The level of knowledge representation is sometimes called a representation of world knowledge. Most present day natural language processing systems, including, amongst others, SRI’s Core Language Engine (Alshawi et al. 1986), ESPRIT I project ACORD (Bez et al. 1990), and the UNIX natural language help systems UNIX-Consultant (Wilenysky et al. 1988), SINIX-Consultant (Wahlster et al. 1988), and AQUA (Ouilihi et al. 1986), keep the two levels of representation distinct. In addition, there usually is no feed-back of information between the semantic representation and the knowledge base. Thus, parsing is supposed to result in a complete semantic representation of the user input which then is passed on to the knowledge base manager for further processing. This kind of architecture follows a strategy that can be called stepwise processing. We claim that for complex domains this kind of approach is inadequate because it ignores the user’s cognitive misconceptions about the particular application. Instead, we wish to argue that at least with respect to semantics and knowledge representation in natural language help systems an integrated approach should be preferred. In the approach we advocate, semantics and knowledge representation interact to correct (or complete) a possibly incorrect (or incomplete) semantic representation. The mechanism by which this is achieved is based on the notion of a frame-semantics (cf. Heyer et al. 1988, Hausser 1989). We demonstrate our integrated approach with examples from GOETHE, a natural language help system for UNIX as a complex domain.

GOETHE (cf. Kese/ Oenig, 1989) has been developed together with OLIVETTI AI Center, Ivrea, and Tecsiel AI Lab, Rome, for UNIX V on the OLIVETTI L5X 30xxComputer Series. The present prototype includes a protocol for monitoring user’s actions and has the natural language mode of interaction fully integrated into a graphical Desktop under InterViews (based on a cooperation with Fraunhofer Society, Stuttgart), thus allowing also for deictic natural language and graphical interactions. It covers all of UNIX file handling, containing a static knowledge base of more than 70 UNIX programs. It is written in Quintus-PROLOG and C, and takes by average less than 10 seconds for generating an answer to a user’s request.
3 Requirements on Knowledge Representation and Semantics for a UNIX natural language help system

It is the task of the knowledge base in a UNIX natural language help system to serve as a basis for correctly and adequately answering a user's questions in one of the following situations: (1) the user needs to know a UNIX command, or series of commands, in order to carry out a certain task, (2) he has sent off a UNIX command and the system has resulted in a different outcome than he expected, or (3) he wants to get information about a UNIX command. In general, this will require two knowledge sources: static knowledge about UNIX as a collection of possible man-machine interactions, and dynamic knowledge about the respective UNIX state (in particular, i-nodes and the associated files with their permissions), the user's actions, and the system's reactions (in particular, error messages). It is the task of the semantic representation to provide such knowledge for the knowledge base manager with a correct and adequate semantic representation of the user's input (in a specific situation). There basically are two strategies available at this point. On the one hand, adhering to the idea that co-occurrence restrictions (also for missing elements) need to be treated as real restrictions, possibly even as syntactic restrictions (Chomsky 1965), we can insist that if there is a semantic representation of an input sentence at all, it will be correct and complete (with respect to the domain of application). Hence, the system will fail to provide an answer to a user's request unless he phrases his question in a correct and complete way. On the other hand, co-occurrence restrictions may not be taken as real restrictions but rather as semantic defaults which may be overwritten by additional knowledge base information. This allows for a much more user-friendly and cooperative natural language processing, but requires that the semantic representation is closely tied to the knowledge base.

For the purposes of the GOETHE system, we have opted for the second alternative, because the cognitive misconceptions a user may have about UNIX not only cause him to invoke the help system, but also cause him in most cases to phrase his questions in the way he does: If the system is presented with a semantically incorrect question, this is to be taken as an indication that the user needs help, and a reminder that he better rephrase his question in a correct way will not be of much use to him. Of course, it would have also been possible to relax the syntactic co-occurrence restrictions. In effect, however, this would have resulted in a duplication of knowledge base information in the lexicon. The second alternative, therefore, not only appears to be the more adequate, but also the more efficient solution.

4 Frame Semantics

Output of the parser in GOETHE is a possibly incorrect, or incomplete, semantic representation where the meaning of the individual- and predicate-constants of the logical representation are represented as frame-theoretic icons (Heyer et.al. 1988). We call this kind of semantic representation frame-semantics, or database-semantics (Haussler 1989). Taking the frame representation of UNIX (including attached procedures and, additionally, the protocolled history) as the context-model relative to which a user's input is interpreted, this frame-semantics allows for a simple and efficient processing of a semantic representation for correction, completion, or the retrieval of the requested information via the knowledge base manager. As an illustration, consider the following examples:

1) "How can I edit a text named 'test'?"

[qword(how),
 [action(edit),
 [mo(file),attr(name,test)]]]
2) "Why didn't you list dir 'testdir' sorted by date!"

[ qword(why-not),
  action(show),
  [ so(directory), attr(name, testdir)],
  [ mo(file), quant(all)],
  attr(name, _),
  app(descending, attr(date, _)) ]

(Note that "list directory" = "show all files"; "so" = source object, "mo" = main object, "attr" = attribute).

Why: search for a frame representing a program in the history and compare the used commands with the intended goal with respect to identities

Why-not: search for a frame representing a program in the history and compare the used commands with the intended goal with respect to differences.

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