Title	
Author(s)	,
Citation	
Issue Date	1998-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/1155
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Description	Supervisor: , ,

A Dialog Model with Cooperative Understanding of Intentions

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February 13, 1998

Keywords: cooperative dialog, conversational implicature, reference service, question-negotiation process.

In this thesis, we propose a formalization of the utterance model for cooperative answering considering speech act, which recognizes the speaker's intentions in a framework of constraint logic programming language. For this purpose, we out special focus on conversational implicature which is one of the various linguistic phenomena. For smooth human-computer interaction, cooperative conversation along with the recognition of each other's intentions is required for interactive commuication between human being and compufter. The cooperative conversation would enable more and more users to use computers in a better way.

Natural language has variable properties (i.e. conversational implicature, presupposition, illocational act, use of conversation, etc) which causes difficulties of formalizing the recognition of user's intentions by computers. Therefore, we need a pragmatic approach in which the properties of natural language usages are analized. Conversational implicature is that a speaker's utterance does not always correspond to the meaning of the utterance. There are some cases where the *yes-no question* is a request for providing information. Consider, for example: 'Do you know this person?' (=Who is this person?). This sentence is one of the *yes-no question* which cannot be answered simply "yes" or "no", which requires some information as the *wh question*. In addition, there are also some cases such a question indicates indirect requests: the speaker expects the hearer to do something. Fexample, consider: 'Can you pass me the salt ?'. Such a sentence is a request for actions that no verbal response is required. In usual cases, it would be inappropriate to answer the questions by "yes" or "no".

Conversational implicature is one of the most important ideas in linguistic phenomena, which makes it possible to mean more than what is literally expressed by the conventional

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sense of the linguistic expressions. In the human's utterance, there are speakers-meaning and sentence-meaning. The former is hidden information including a speaker's intentions. The interpretation of conversational implicature is also varied according to the common knowledge which includes the relations among humans and their contexts.

The purpose of this research is to explicate the relation between the utterance and their hidden meaning by using conversational implicature in the natural language, and formalize the mechanism of the recognition of a speaker's meaning from their utterance in a constraint logic programming language.

In this thesis, we first define the following three symbols p, q and C. The first two symbols p and q represent a speaker's utterance and a hidden meaning of the utterance respectively. The last symbol C indicates constraints treating background knowledge such as situation or presupposition. When the utterance the utterance p indicates q under the situations of C, it is formally described as follows:

$$p \ \Leftarrow \ q \ \| \ C$$

In various linguistic phenomena excepting conversational implicature, there are referring expression and metaphor, which have context-dependent-meaning. Referring expression is like a word of "architecture" whose meaning depends on the context. The word indicates the building in the context of the construction. On the other hands, it indicates the organization of computers in the context of the computer science. Also, in the sentence "Plato is on the top shelf.", the word 'Plato' represents a book written by Plato.

From the viewpoint to classify the linguistic phenomena, conversational implicature and metaphor are different problems. However, in our research, we can use the same formalization for them with the supplement of the utterance by using context information in a constraint logic programming language. By the formalization, we can model the recognition of user's intentions in the conversation by using the question-negotiation process of the reference service in the library. Reference librarians are required to understand their user's intentions accurately, and the users should tell their questions that they want to know in a clear way. However, in actual cases, users ask questions in a very irrelevant and incomplete way. There are many reasons for the incomplete questions. They become the invisible barriers for clear communication , and they make reference service very complicated. Users sometimes do not like to explicit their real intentions at first , or they cannot understand their own intentions by themselves. Thus, a framework of cooperative dialog for recognizing user's intentions from their utterance is required.

In our research, we use $\mathcal{Q}u\iota\chi o\tau\varepsilon$ which is a logic programming language to realize the dialog model, and we show some examples of the dialog in the reference service as examples of the conversational implicature and the inference. $\mathcal{Q}u\iota\chi o\tau\varepsilon$ is a hybrid language for accessing deductive object-oriented database(DOOD) and a constraint logic programming language. The language has the constraint-based formalism of a grammar and a description of situation-based semantics. Therefore, it is possible to represent complex phenomena in the natural language, and to treat various grammatical principles and an ambiguity in vocabulary. $\mathcal{Q}u\iota\chi o\tau\varepsilon$ is very useful in our research since it has an adductive

inference mechanism for complementing insufficient information by inferring with incomplete information at the question-negotiation process. In addition $\mathcal{Q}uix\sigma\tau\varepsilon$ can represent user's knowledges or librarians' knowledges as modules and some relations between submodule, It is possible to represent their hidden knowledges and to generate answers by the assumption based on the hidden knowledges. In addition, its flexible inference is very suitable to realizing cooperative dialog.

This thesis shows cooperative answering in reference service provided by libraries. In the approach, we represent answering about presupposition by preparing the knowledge for performing intentions, and answering with the additional information and the reasons by knowledges for solving problems. They did not appeared verbally since they are hidden in the knowledge of the speaker. We also show that the approach can be described in the same form of expression which depends on the representation of the conditional solution. However, our framework that represent the causal relationships among objects are represented in $\mathcal{Q}uix\sigma\tau\varepsilon$ may not be sufficient since we must show the dynamic sequence of an inference.

Lastly, we discuss linguistic phenomena that can be processed within a constraint logic programming language, and study how much it can be disposed of by deep chain of the inference and monitoring processes in a meta level.