

done to determine the best control strategy to use. The control issues that were tested were left to right processing through the sentence versus an "island driven" strategy, examining all the words that might be present in a given location at once versus taking them one at a time, doing time-consuming but accurate context checking as soon as possible versus delaying such checking, and focusing the processing on a single hypothesis versus skipping around to whatever hypothesis seemed best at the time. The average reader will probably be more interested in the results of the experiments than the details of them, however.

The third chapter explains the semantic component of the system, which was represented by the partitioned network scheme of Gary Hendrix. With many detailed examples, Hendrix shows how the partitioning scheme was used to encode quantifiers and logical connectives (conjunction, disjunction, negation, implication), to form associations between semantic objects and the syntactic units of the input, to distinguish between new and old information, to encode multiple hypotheses, to allow sharing of representations among competing hypotheses, and to define hierarchies for discourse analysis. The semantic component of the system used this formalism to filter out combinations of words that were acoustically and syntactically acceptable but semantically unacceptable; it also constructed a representation of the meaning of good interpretations for other components to use, and could make predictions of words or structures that were likely to occur in other parts of the utterance.

The next chapter is devoted to Barbara Grosz's work on discourse knowledge. After showing examples of how the focus of a dialogue affects the identification of definite noun phrases, word sense interpretation, pronominal reference, and ellipsis, she discusses (again, in more detail than some readers would wish) the analysis of actual problem solving and question answering dialogs which were examined to provide the basis for a representation of focus that would enable the SRI system to use focus in its semantic interpretations. The notion of focus spaces which was derived from these experiments was represented in Hendrix's partitioned network formalism and used for resolution of noun phrases, inferencing, reference resolution, and other high level aspects of sentential processing. The problems of shifting focus, reinvoking an old focus of attention, and dealing with ellipsis are also covered in detail.

The fifth chapter comprises three sections relating to the problem of responding to an utterance once it has been understood. This is unfortunately limited in scope, since the major emphasis of the project was on understanding rather than responding to spoken language. Gary Hendrix writes on the problem of interacting with the deduction component and an English generator to formulate a reply. Richard Fikes and

Gary Hendrix detail the deduction component, and Jonathan Slocum's section deals with generating an English description of a semantic structure. The conclusion, written by Ann Robinson, summarizes the work and points out issues relating to other areas of research.

One of the chief features of the book is the large number of illustrations and detailed examples, including as an appendix a short but well chosen example of the entire processing of a single utterance.

Someone already familiar with the ARPA speech project will gain little from this book, and someone interested in a general overview of the speech understanding problem and the ARPA project's results would do better to look elsewhere [1, 2]. What this book has to offer is something rare but not unimportant in the literature: a detailed description of a single large and complex system. One can get from it not only an understanding of how that system worked but also an excellent understanding of the important pieces of that work which have had a continuing influence in the field of computational linguistics since the termination of this particular project.

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References

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The Process of Question Answering - A Computer Simulation of Cognition

Wendy G. Lehnert

Lawrence Erlbaum Associates, Hillsdale, N.J., 1978.
278 pp., \$16.50, ISBN 0-470-26485-3.

This book can be reviewed from two perspectives: (1) as a general and technical introduction to the complexities and subtleties regarding human understanding of and response to questions and (2) as a much more comprehensive system, intended to produce not only humanlike interpretations of questions, but doing so in ways that model human thought processes. Lehnert appears to have both approaches in mind, emphasizing the second more, but it is with respect to only the first that the book is successful.

From this first perspective, then, there is no other single source that so completely and persuasively illustrates the many-faceted problems of translating a person's question (e.g., "Do you have a match?" vs. "Do you have a hangover?") into a valid interpretation of the questioner's desires or information requirements (e.g., "Give me a light" vs. "How is your physical state after last night?"). Lehnert provides abundant evidence for the necessity of utilizing a wide

variety of information in the analysis of questions. This information can lead to the transformation of the immediate naive understanding of the question into a drastically changed conceptualization.

There are four major components to the question-analysis and answer-generation approach she describes: (1) different kinds of knowledge sources, (2) a variety of mapping and inferencing principles, (3) a parser which converts the surface text into one of a small number of conceptual representations (actually, Schank's system), and (4) a structured taxonomy of question types, one of which is assigned to the parsed representation. Among the most important knowledge sources are those involving "scripts" and contexts. The well established notion of "scripts" refers to the fact that many human activities have a stereotypical pattern of actions and events (e.g., eating at a restaurant: "look for table, go to table, ask for menu, get menu, be served," from Fig. 6.1, p. 141). Given that a script is judged to apply (e.g., cued by a verbal narrative beginning "John went into a restaurant"), Lehnert indicates how the details of the script can provide the basis for interpreting and responding to a wide variety of questions (e.g., "What did John do next?", "Did John eat?"). The importance of prior communication and the physical setting are also stressed as contextual sources of information for establishing topics or references that would otherwise be indeterminate. Two other knowledge sources, stressed as important but worked out in less detail, are general world-knowledge and personal memories.

Lehnert outlines as the second major system component a number of specific inferencing mechanisms for hypothesizing an initial question-type, for utilizing knowledge sources to translate this into a more valid representation, and for generating the answer. Indeed, she invokes, in one way or another, most of the important concepts involved in artificial intelligence. The use of inferencing principles and alternative knowledge sources can be governed by rather flexible search heuristics, but the power and accuracy of her approach depend critically on the use of a small number of conceptual-representation and question categories, the third and fourth system components. While a number of technical questions can be raised as to the adequacy of these categories, she does provide many examples in support of these, illustrating how fine distinctions among conceptualizations and question-types might be made.

Were Lehnert's goals only those described as the first review perspective, she would have achieved them rather remarkably: Many thorny problems in question-answering are presented, and she illustrates in some detail the processing algorithms that could be applied to provide a solution; she also indicates numerous areas where further work is needed. There is no question but that Lehnert provides an important and de-

tailed introduction to these problems as well as a significant challenge to both psychologists and computer scientists for testing or extending the theoretical ideas proposed.

Lehnert's goals were, however, much more ambitious, as indicated by the book's subtitle, and throughout. In the preface, having shortened the phrase "human information processing" to "information processing," she states that "this book describes question answering as a particular task in information processing" (p. viii). In the first paragraph, she says, "This thesis presents a process model of question answering as a theory of conceptual information processing" (p. 1). In her final sentence, she summarizes by saying that her system is "a theory of question answering that is founded on and extends theories of natural language and conceptual information processing" (p. 270).

On the basis of these very strong claims, the reader may justifiably expect to find supporting evidence of three kinds: (1) that the syntactic and semantic problems of question-interpretation identified and discussed extensively by linguists will be acknowledged and dealt with, (2) that existing psychological evidence on language and problem-solving behavior in general, and question-answering in particular, will be reviewed and related to the processing principles of the system, and (3) that performance statistics will be provided for a wide variety of test questions, with comparisons made of the system's interpretations and intermediate processing steps to those of humans.

In fact, none of these expectations is fulfilled. With respect to linguistic data, there is almost no reference at all to the enormous body of literature that exists on the interpretation of interrogatives (e.g., Aqvist's *A New Approach to the Logical Theory of Interrogatives*, 1975, and Hudson's *The Meaning of Questions*, 1975). Even without discussion of the particular views of linguists, there still are well-known technical linguistic problems which surely should be addressed by systems intended to implement computer processing of questions, such as whether noun phrases are to be understood referentially or attributively, determining qualifier scope, and interpreting quantification (see the *Syntax and Semantics* book series by Academic Press). The notable exception is her criticism, in a discussion of semantics, of Katz and Fodor's (1964) theory as being inadequate for semantically representing the equivalence of active-passive transformations (p. 249). She fails to report, however, that Katz's later book (*Semantic Theory*, 1972), which is an extension and modification of his earlier work, does in fact provide for exactly the type of representation for which she seemed to be arguing.

With respect to psychological data, no reference is made to the sizable body of literature concerning the development of human question-asking (e.g., Davis,

"The form and function of children's questions," 1932), nor to work concerning adult question-answering (e.g., Wright, "Some observations on how people answer questions about sentences," 1972), nor even to work closely paralleling her own approach in the use of a question taxonomy (e.g., Kearsley, "Question and question asking in verbal discourse: A cross-disciplinary review," 1976). Even more distressing is the fact that the human problem-solving literature, larger by orders of magnitude than the specific work on question-answering, is not reviewed to provide a comparison for her system's detailed search and inferencing processes.

Finally, almost no performance data of any kind are provided, not even the complete details of the processing for a single example. In view of the incompleteness of presentation with respect to the exact details, one has no way of ascertaining the limitations

of her system. Since most of the examples given were trivial with respect to the syntactic complexity of questions for which other question-answering systems have been designed, and since the system appears to be very modest with respect to the size of its knowledge structures relative to more representative situations, there still remains considerable question whether or not her system is designed on sufficiently extendible principles to permit handling of these more realistic instances.

Despite Lehnert's failure to provide support for her more extravagant claims, the reader who adopts the less demanding perspective will be well rewarded.

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The Process of Question Answering - A Computer Simulation of Cognition

Wendy G. Lehnert

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This attractive and well-written book describes QUALM, a facility for question-answering developed by the author in conjunction with systems designed by Roger Schank and others at Yale. But it is a good deal more than a system description, and it will be read with interest and profit by logicians (particularly for its contributions to the logic of questions and answers), students of mind and of the philosophy of science (for its defense of the methods used in artificial intelligence research), and, in fact, all the readers of this polyglot newsletter [i.e. *CBT*]. Someone teaching a course that touched on AI techniques might use this as a concrete example, suitable for intensive study -- the writing is clear, full of intriguing examples, concerned with serious problems, and accessible to readers without any background at all in computer science.

The logic of questions and answers has developed only recently. (For an excellent introduction to this "erotetic logic," with an extensive bibliography, see Nuel D. Belnap, Jr. and Thomas B. Steel, Jr., *The Logic of Questions and Answers*, New Haven: Yale University Press, 1976.) Inspired by the need for realistic dialogue with users of a natural language system, it has attempted to identify the presuppositions that enter into questions and appropriate responses to them. To take one of the hoariest examples, "Is the present king of France bald?" presupposes that there is now a king of France (Belnap and Steel, p. 110). If we are going to build a system that responds helpfully to this question, it is going to have to have some way of identifying the presupposition.

But this is only one of the questions that Lehnert addresses, and not the most interesting or important one. The role of context, the appropriateness of the answer, the focus of the question, the memory representations that are required, the inferences that the answerer must make, search strategies -- these and many other problems are raised at the beginning of the book. The remaining chapters describe the way in which she solves them.

QUALM reflects the concepts and approaches that Schank and others have developed at Yale. (Cf. R.C. Schank and R.P. Abelson, *Scripts, Plans, Goals and Understanding*, Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977.) These notions, including the conceptual dependency approach, and the use of scripts to represent expected behavior in a situation, are described in sufficient detail to permit the reader to follow Lehnert's discussion without previous exposure to them.

I found that the book helped greatly to clarify the current status of natural language processing, documenting the tremendous strides that were taken during the 1970's. (The contrast between this book and Terry Winograd's pioneering *Understanding Natural Language*, New York: Academic Press, 1972, is quite overwhelming.) Equally interesting, I think, is the degree to which Lehnert gives us a sense of what AI research is doing, why it thinks that it is a science, and what counts as a successful experiment in AI.

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