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TEXT GENERATION FOR STRATEGIC COMPUTING

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OBJECTIVES

There are many information-rich computer intensive organizations. They need to have easy, understandable access to a wide variety of information. Currently, information is often in obscure computer notations that are only understood after extensive training and practice. Although easy discourse between the user and the machine is an important objective for any situation, this issue is especially critical in regards to automated management decision aids. A manager can not afford to miss important information nor is it reasonable to expect managers to undergo highly specialized training to understand obscure computer dialects which change from machine to machine.

A great deal of work has been done in the area of natural language understanding and this work is starting to pay off with the delivery of functional interfaces that interact naturally with the user. Comparatively little, however, has been done in the area of natural language generation. There is currently no effective technology for expressing complex computer notations in ordinary English. If there were, computer-based management information could be made more accessible and understandable in a way that was less subject to personnel changes.

This project is helping to create and demonstrate new technology to provide an English-in, English-out interface to computer data, called **Janus.** ISI is developing the English-out (text generation) portion of Janus, referred to as **Penman.** The initial organization served by Janus will be the US Navy, and the initial capability will be demonstrated on a naval data base. However, most of the techniques are more general and will be applicable to other management and military problems. The end result will be a new capability that produces answers to queries and commands in the form of text understandable to any user that understands English.

This project was put in place at the beginning of FY85 in order to develop the first natural language generation capability robust and capable enough to be used in DARPA's Strategic Computing Program. It is intended that this interface be coupled to the battle management system being developed under DARPA's Fleet Command Center Battle Management Program (FCCBMP). In the first 1.5 years of the effort, USC/ISI was able to demonstrate a uniquely expressive generation system producing English from output demands expressed in formal mathematical logic using a broad coverage grammar and an artificial intelligence knowledge base. We have developed the basic technology that will permit the realization of a full text generation system. In the next phase of the work, ISI will extend text generation from sentences to paragraphs, increase the power of the grammar, dictionary, and planner, expand the knowledge base, optimize and make robust the software, and tune the resulting system to the Navy problem. Finally, USC/ISI will deliver their generation system to Bolt, Beranek, and Newman Incorporated (BBN), which will combine it with an understanding system for delivery to DARPA and subsequent integration with FCCBMP.

This report details our approach to these problems, Penman's current status, and our plans for future work.

OUR APPROACH

Both understanding and generation components are necessary in an effective information system interface. It is also necessary that the technologies used by these two components be absolutely consistent. If they are not, the embarrassing situation of the interface failing to understand a piece of text it has just output can occur, leading to a loss of confidence in the system on the part of a user.

In order to alleviate this problem, we are developing Penman in close cooperation with a natural language understanding project at BBN. This cooperation extends to joint development of knowledge representation software, lexicon design, and work to insure compatibility between the RUS understanding grammar and the Nigel generation grammar.

The understanding/generation compatibility effort can be considered the first of our goals for the Penman system. Another is the ability to generate substantial amounts of English text, up to the multiparagraph level. A useful interface should not be restricted to short replies or comments.

A third goal is to make Penman as portable and domain independent as possible. There are many knowledge domains available for interface systems, and few specialists to create the interfaces. Thus, we are emphasizing domain independent capabilities over domain dependent ones.

Finally, there are many linguistically and computationally significant issues that must be addressed if high quality generation is to be achieved. For example, we are working on improved methods for knowledge representation, vocabulary development, and for using semantics and discourse context to guide the generation of text.

ACCOMPLISHMENTS

By the time of this report, the project had created and delivered a Master Lexicon facility, ML, for vocabulary acquisition and use (Cumming 1986a, 1986b; Cumming and Albano 1986). ML is unusual in that it is compatible with the two radically different grammars of English in Janus: the Nigel generation grammar and the RUS understanding grammar. The system features a multi-window bit mapped display manipulatable through the keyboard and a mouse. Online documentation is provided for all lexical choices. ML is built to allow for the extension of the Janus lexical system. It is also possible to use ML with other natural language processing systems by replacement of a single data structure.

In addition, work has been done on bringing the Nigel and RUS grammars into compatibility.

We have as a general goal the development of natural language generation capabilities. Our vehicle for these capabilities will be a reusable module designed to meet all of a system's needs for generated sentences. The generation module must have an input notation in which demands for expression are represented. The notation should be of *general* applicability. For example, a good notation ought to be generally useful in a reasoning system. The notation should have a *well-defined* semantics. In addition, the generator has to have some way of *interpreting* the demands. This interpretation has to be *efficient.*

In our research, we have chosen to use **formal logic** as a demand language. **Network knowledge bases** are used to define the domain of discourse in order to help the generator interpret the logical forms. And a **restricted, hybrid knowledge representation** is utilized to analyze demands for expression using the knowledge base (Sondheimer & Nebel 1986). We have:

1. Developed a demand language, Penman Logical Form (PLF), based on first order logic (USC/ISI 1985),
2. Structured a NIKL (New Implementation of KL-ONE) network (Kaczmarek 1986) to reflect conceptual distinctions observed by functional systemic linguists.
3. Developed a method for translation of demands for expression into a propositional logic database,
4. Employed KL-TWO (Vilain 1985) to analyze the translated demands, and
5. Used the results of the analyses to provide directions to the Nigel English sentence generation system (Mann and Matthiessen 1983).

To first order logic, PLF adds restricted quantification, i.e., the ability to restrict the set quantified over. In addition, we allow for equality and some related quantifiers and operators, such as the quantifier for "there exists exactly one ..." , the operator for "the one thing that ...". We permit the formation and manipulation of sets, including a predicate for set membership (ELEMENT-OF). And we have some quantifiers and operators based on Habel's (1982) eta operator.

The system's knowledge has been organized in a new way in order to facilitate English expression. Abstract concepts corresponding to the major conceptual categories of English have been defined in NIKL (a KL-ONE dialect) and used to organize the conceptual hierarchy of the domain. By defining concepts such as process, event, quality, relationship and object in this way, fluent English expression is facilitated.

KL-ONE is a hybrid knowledge representation system that uses NIKL's formal semantics. KL-TWO links another reasoner, PENNI, to NIKL. For our purposes, PENNI, can be viewed as restricted to reasoning using propositional logic.

We translate a logical form into an equivalent KL-TWO structure. All predications appearing in the logical form are put into the PENNI data base as assertions. A separate tree is created that reflects the variable scoping. Separate scopes are kept for the range restriction of a quantification and its predication.

The Nigel grammar and generator realizes the functional systemic framework at the level of sentence generation. Within this framework, language is viewed as offering a set of grammatical choices to its speakers. Speakers make their choices based on the information they wish to convey and the discourse context they find themselves in. Nigel captures the first of these notions by organizing minimal sets of choices into **systems.** The grammar is actually just a collection of these systems. The factors the speaker considers in evaluating his communicative goal are shown by questions called **inquiries** inside of the **chooser** that is associated with each system. A choice alternative in a system is chosen according to the responses to one or more of these inquiries. It is these inquiries we have implemented.

Our implementation of Nigel's inquiries using the connection and scope structures with the NIKL upper structure is fairly straightforward to describe. Since the logical forms reflecting the world view are in the highest level of the NIKL model, the information decomposition inquiries use these structures to do search and retrieval. With all of the predicates in the domain specializing concepts in the functional systemic level of the NIKL model, information characterization inquiries that consider aspects of the connection structure can test for the truth of appropriate PENNI propositions. The inquiries that relate to information presented in the quantification structure of the logical form will search the scope structure. Finally, to supply lexical entries, we associate lexical entries with NIKL concepts as attached data and use the

retrieval methods of PENNI and NIKL to retrieve the appropriate terms.

Although we have done some generation off of the BBN naval knowledge base, our most extensive experience comes from the Consul knowledge domain of computer mail and calendars (Kaczmarek, Mark, and Sondheimer 1983). Using the developments above, translation from first-order logic to English organized by NIKL has been demonstrated for a wide variety of sentence types.

Table 1 shows a series of independent sentences that Penman is now able to generate. We have arranged and labeled them to show how they might enter into computer database dialogue.

Table 1. Sentences from Penman

1. User: What is the read status of the message which was sent by Jones?
2. System: Message 40 is unread.
3. User: Are any messages which were sent by Jones in the tape file?
4. User: Are any messages which were sent by Jones in the old ISI tape file which Smith has?
5. System: Yes.
6. System: Do you want me to display the read status of the messages?
7. User: No.
8. System: There are messages which were sent by Jones.
9. System: However, the tape is in use.
10. User: Show me Message 40.
11. User: Did Smith send any messages?
12. System: Message 45 was sent by Smith.
13. User: Did Smith schedule his meeting with me in New York?
14. System: Yes.
15. User: What does the window show?
16. System: The window shows a message which was sent by Jones.
17. System: The window shows a request by Jones.
18. User: Did I create the window?
19. System: The window was created when you asked me to display Message 50.
20. System: You deleted the message, then you asked me to display it.

Besides the technology described above, work has been done on aspects of discourse modeling. This included a study of object description and an initial noun phrase planner.

In order to produce the sorts of larger texts that are needed in a User Assistance facility, work is under way to apply Rhetorical Structure Theory to text planning. A procedure has been developed that can design structures for paragraph-length texts given information about the text goal and communication situation.

FUTURE EFFORT

In the next phase of our effort, Penman will be delivered to BBN, integrated into Janus, and demonstrated in an extensive series of laboratory exercises. This version of Penman will support coordinated English input and output, paraphrasing, and user assistance, as well as constructive rhetorical structure theory to create descriptive texts (Mann 1984).

For a machine to create fluent English texts, several problems of text organization and presentation must be solved. ISI will design, implement, and demonstrate two kinds of new text planning processes. One will be a planner for gross organization of text based on rhetorical structure theory, and the other a low level planner for sentence configurations. In addition, ISI will examine the expert system explanation functionality necessary within FCCBMP, and will design a text planner to meet those needs.

Enhancements to the basic interface to Penman will also be developed. As part of Janus, BBN plans to develop methods for translating English inputs into a higher order predicate calculus form. In addition the logical form will be manipulated inside the BBN understanding component to reflect database organization, expressions in this form are expected to be much more complex than the direct expressions of the corresponding English, requiring multiple sentence expression. Penman will be extended so that it can express these complex forms in English.

Following successful completion of laboratory testing, Penman will be delivered to Naval Ocean Systems Center for knowledge base development and testing. This Penman capability is a basic text generation capability with only limited capability for responding to the knowledge of the user and the state of the user-machine interaction. In subsequent years, these basic capabilities will be extensively expanded to provide a much more useful interface, with particular development in the areas of user assistance, ability of the system to understand the user's knowledge and expectations, and meeting needs for expert system explanation and user dialogue, as described below.

Development of extensions is required in the area of user assistance functionality. Text generation can assist the user by explaining system actions and objects, and by clarifying its interpretation of incoming English. These capabilities must be integrated into the Janus interface in a natural, easy-to-use form. We expect to demonstrate increased user assistance functionality as time goes on.

Development of extensions is also required in the area of responsiveness to users' knowledge and expectations. This includes making the system aware of the ongoing topics and issues, what the user has already been told, and what he can be expected to know without being told. This in turn involves more extensive use of inference. It also requires implementing a notion of the state of the dialogue – what things are in attention, what interactions

are in process, and what has been interrupted and suspended.

Penman is scheduled for use in an expert-system explanation context whose details are yet to be determined. We will study what functionality is required in FCCBMP. The study will lead to a design of code for this use of Penman. Implementation and demonstration of full functionality are expected following the user assistance work.

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