AI Magazine Volume 4 Number 4 (1983) (© AAAI)

Research at The University of Texas

Elaine Rich

Department of Computer Science
University of Texas
Austin, TX 78712

Research in artificial intelligence at the University of Texas at Austin is diverse. It is spread across many departments (Computer Sciences, Mathematics, the Institute for Computer Science and Computer Applications, and the Linguistics Research Center) and it covers most of the major subareas with AI (natural language, theorem proving, knowledge representation, languages for AI, and applications). Related work is also being done in several other departments, including EE (low-level vision), Psychology, Linguistics, and the Center for Cognitive Science.

Automatic Theorem Proving in Mathematics

The goal of this group is to explore the use of domain-specific knowledge and natural deduction-based reasoning techniques to construct theorem provers that operate in non-trivial mathematical domains. Two new provers, by Larry Hines and Tie-Cheng Wang, are very much like expert systems, since the prover takes its direction by trying to satisfy "higher level" goals, based on knowledge about theorem proving. These are stand-alone provers, not man-machine systems, which are attacking some fairly difficult theorems in mathematics. In addition to this mainline work on mathematical theorem provers, two auxiliary efforts rely heavily on knowledge-based deduction. Michael Starbird is developing a knowledge-based expert system for an area of geometric topology, particularly for three dimensions. One of the objectives is to develop methods for graphic represention (on the LISP machine) of the topological objects, and tools for allowing the computer to make geometric observations about specific examples. In addition, Don Simon is building a proof-checker that operates in the domain of number theory. This system must rely heavily on its domain knowledge because the proofs it must check are really more accurately described as proof sketches, into which many steps must be inserted to produce complete proofs.

Participants: Woody Bledsoe (contact), Larry Hines, Tie-Cheng Wang, Michael Starbird, and Don Simon.

Building and Querying a Text Knowledge Base

The goal of this project is to explore the design of text knowledge bases and their use in question answering systems. The current specific project is to define a consistent set of text representation conventions for organizing fifty pages of the AI Handbook as an inferential knowledge base that includes a system of general inference schemas for answering questions from it. Using the computer manuscript provided by Feigenbaum and Barr, several sections of Volume 1 have been selected as content for the knowledge base, 250 questions concerning sections B1 and B2 have been obtained from students in an AI course, and the SRI grammar provided by Jane Robinson and Jerry Hobbs has been studied as one basis for the syntactic organization of the the semantic system that will analyze the questions. The text knowledge forms a complex inter-related relational database composed of semantic relations derived from phrases, clauses, sentences, and multi-sentence units. Several pages of the text have been represented by hand as a rooted network of such semantic relations. Several case-relation questioning procedures have already been developed and run. The goal of these experiments is to understand and incorporate inheritance of conceptual properties as an integral part of the process of matching or unifying a question SR with a candidate answering relation. Procedural logic is used to augment the knowledge base with paraphrase rules which significantly improve the QA capabilities. Future work on this project includes the accumulation of a significant body of paraphrase rules, and the development of a discourse grammar to augment the current sentence grammar for automatically compiling English text into SRs.

Participants: Robert Simmons (contact), Michael Hess, Chin Chee, Sui-Su Tseng

GLISP

The goal of this project is the extension of GLISP, a programming language that is compiled into LISP. GLISP allows programs to be written in terms of objects and their properties and behavior; the GLISP compiler, in turn, converts such programs into efficient programs in terms of the implementations of objects in LISP. This allows programs written in object-centered form to be converted into efficient runtime code. The use of GLISP is facilitated by GEV, a window-based data-inspection program, which displays data according to its GLISP description. GLISP and GEV are available for the major dialects of LISP. GLISP is currently being used for the implementation of knowledge-based systems both here at the University of Texas and at other AI research centers. Current work on the system is focused on combining separate generic algorithms into unified programs.

Participant: Gordon Novak (contact)

Theorem Proving Using Recursion and Induction

The goal of this project is the construction of a mechanical theorem-prover that is a rule driven system with much expert knowledge of recursion and induction. The theorem prover is primarily used to prove theorems in the discrete, inductive mathematics associated with program verification tasks. The system is entirely automatic once it begins a proof, but its performance and behavior can be affected by its knowledge-base of rules. Unlike many rule driven systems, new rules cannot be added by the user until they have been proved by the system. By presenting the system with an appropriate sequence of lemmas—graduated from elementary to difficult as in a textbook—the user can lead the system to very deep results. For example, given no more input than published in the CACM, the machine constructed a formal proof of the invertibility of the public key encryption algorithm by Rivest, Shamir, and Adleman. Other deep number theory theorems proved include Fermat's Theorem, Wilson's Theorem, and the so-called "jewel of number theory" Gauss' Law of Quadratic Reciprocity. The machine has proved a variety of algorithms correct, including simple compilers, parsers, list processing functions, and simple real time control programs. In the theory of computation, the machine has proved such results as the soundness and completeness of a decision procedure for propositional calculus, the existence of nonprimitive recursive functions, the Turing completeness of Pure LISP, and the recursive unsolvability of the halting problem for Pure LISP. It appears that the last result cited represents the first time a machine has proved that a given problem is not solvable by machine.

Participants: Robert Boyer and J. Strother Moore

Intelligent Interactive Systems

The goal of this group is to explore the use of AI techniques in the construction of interactive programs in a variety of domains. These programs should provide significant assistance to people operating within those domains. The basis for this significant assistance resides in the programs' use of both domain-specific knowledge and heuristic search. The specific problem areas that are now being investigated include:

- An intelligent help facility for the document formatting system Scribe. Aaron Temin is building this system, which reasons from the code of Scribe (rewritten in a carefully designed language for program representation, called HLAMBDA) to form answers to user questions that are beyond the scope of conventional help systems.
- A translator from LISP into HLAMBDA. John Hartman is building this system, which analyzes conventional LISP programs, and, using a database of standard programming knowledge in the form of cliches, converts those programs into HLAMBDA programs. These HLAMBDA programs differ from their LISP counterparts in having important aspects of their control and data explicit in the static program representations.
- A programming tutor for LISP. Bill Murray is building this system, which analyzes student programs, compares them to programs that the system itself generates from high-level plans, finds bugs, and isolates student misconceptions that are responsible for those bugs.
- An operating system interface that corresponds to TOPS20. This system, being built by Kim Korner, uses knowledge about both the system and its users (as individuals and as a group) to help users to issue commands that actually cause their goals to be satisfied.
- A graph-oriented data retrieval system. This system, being built by Bob Levinson, currently works in the

domain of organic synthesis, but can be applied to any domain in which the objects of concern can be characterized as graphs. The goal of this system is to use knowledge-based parsing to speed up database search by restricting search to only that part of the database that contains structures that are similar to the structures of interest.

The philosophy behind all of these efforts is that AI can encroach gradually on domains that are not well enough understood to lend themselves to stand-alone systems. Instead, these systems are designed to work interactively with people. As the issues become better and better understood, more and more of the problem solving burden can be transfered from the human users to the machines.

Participants: Elaine Rich (contact), John Hartman, Kim Korner, Bob Levinson, Bill Murray, and Aaron Temin.

Using Knowledge with Uncertainty

The goal of this project is to explore the ways in which uncertain knowledge can be represented and used. The approach that is being used is to assign to each assertion a certainty factor between 0 and 1. This contrasts with logic-based systems in which the only certainty factors that are allowed are 0 or 1. This approach is being investigated both in common sense reasoning, including property inheritance, as well as in specific application domains, such as the construction of the user models that are used in the interactive systems described in the last section.

Participant· Elaine Rich (contact)

Machine Translation

The Linguistics Research Center is now engaged in an R & D project whose goal is the production of an operational Machine Translation system to serve as a vehicle for both application (in a commercial setting) and continued research (in one of the widest, most challenging settings possible). Applying state-of-the-art Computational Linguistics techniques, the LRC will soon deliver to the project sponsor a large-scale, production-quality prototype for translating German technical texts into English. Extensions to other languages are getting underway. The LRC Machine Translation system will continue to act as a testbed for newly developed CL techniques, and promises to serve a significant role in the further development of AI in general, and Natural Language Processing in particular.

Participants: Jonathan Slocum (contact), Scott Bennett, Becky Root, Carl Weir, Martha Morgan, John Bear, and Glen Downing.

References

Boyer, R. S. & J. S. Moore. (1979) *A Computational Logic* New York: Academic Press.

Novak, G. S., Jr. (1983a) GLISP: A Lisp-based Programming System with Data Abstrction. *AI Magazine*, Vol. 4, No. 3., 37-49.

Novak, G. S., Jr. (1983b) "Data Abstraction in GLISP." *Proceedings of SIGPLAN'83 Symposium on Programming Language Issues in Software Systems*

Novak, G. S., Jr. (1982a) "GLISP: A high-level language for AI programming." *Proceedings of the AAAI-82 National Conference on Artificial Intelligence.* Pittsburgh, Pa., 238-241.

Novak, G. S., Jr. (1982b) "GLISP User's Manual". Memo HPP-82-1, Heuristic Programming Project, Department of Computer Science, Stanford University.

Rich, E. A. (1982) *"Programs as Data for their Help Systems." Proceedings NCC.*

Rich, E. A. (1983a) "The Gradual Encroachment of Artificial Intelligence." Technical Report, Department of Computer Sciences, The Univ. of Texas at Austin.

Rich, E. A. & A. Temin (1983b) "Representing Programs for Reasoning." Technical Report, Department of Computer Sciences, The Univ. of Texas at Austin.

Rich, E. A. (1983c) "Default Reasoning as Likelihood Reasoning." *Proceedings of the AAAI-83 National Conference on Artificial Intelligence, Washington,D C.*, 348-351.

Simmons, R. F. (1983a) "Some Considerations of the Cost of Inheritance Paths in Using Large Text-knowledge Systems." Technical Report, Department of Computer Science, Univ. of Texas at Austin.

Simmons, R. F. (1983b) *"Computations from the English "* New York: Prentice-Hall.

Simmons, R. F. & D.L. Chester (1982) "Relating Sentences and Semantic Networks with Procedureal Logic." *Communications of the ACM.* vol. 25, no. 8.