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ABSTRACT

Expert systems are computer programs that solve selected problems by modelling domain-specific behaviors of human experts. These computer programs typically consist of an input/output system that feeds data into the computer and retrieves advice, an inference system using the reasoning and heuristic processes of human experts, and a knowledge acquisition system that enters information into the system. Expert systems are used to solve problems associated with mundane or recurrent activities requiring high levels of relatively scarce expertise, usually in science or medicine. They can, however, be applied to human communication activities such as summarizing research, writing speeches, monitoring political campaigns, and evaluating instructional strategies. In pointing out that generalized methods of problem solving are inefficient and error prone, artificial intelligence (AI) research encourages speech communication specialists to examine the domain-specific nature of certain communication patterns. Four potential hazards in AI development are an over dependence on machines, a reduction of the knowledge base, a loss of attention to pressing educational issues and a reliance on easy solutions to complex issues, and a loss of privacy due to the surveillance capabilities of expert systems. (MM)

# RHETORICAL CONSEQUENCES OF THE COMPUTER SOCIETY: EXPERT SYSTEMS AND HUMAN COMMUNICATION

Presented by Eric Wm. Skopec* at the annual meeting of the Eastern Communication Association, March 1984.



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As many of you know, this is the second year ECA has sponsored a program concerned with the rhetorical implications of computer technology. Last year we noted the extent to which computers had become a part of our daily lives. Technological innovations coupled with aggressive marketing strategies had placed substantial amounts of computing power in the hands of many people at unheard of prices. These factors contributed to development of networks providing nearly instantaneous communication and direct access to incredible amounts of information through a variety of data bases.

As we review the same field a year later, I believe that techonology and market factors have run their course for the time being. The recent introduction of Apple's Macintosh computer built around a 32 bit processor capable of addressing a megabyte of memory signals a remarkable level of sophistication in microcomputer technology. Desktop computers are now capable of handling most of the tasks commonly assigned to individuals. In addition, market dominance by IBM and the demise of several smaller computer manufacturers indicates the computer prices are likely to remain stable or begin an upward climb for the near future. The introduction of relatively sophisticated Japanese microcomputers by Sony, Fujitso, and others may alter market price structures somewhat and the increasing number of colleges and universities requiring students to purchase microprocessors at discounted prices may make computers available to new segments of the population. However, neither development appears destined to affect computer usage and ownership to the extent of the technological and marketing efforts of the last five years.

Although technology and marketing influences appear to have stabilized, I believe we can now expect dramatic advances in computer software. In fact, technological advances of the last half decade promise to make the most sophisticated programming techniques available to home users and the stability of the hardware market is contributing to innovations in software. Current market trends indicate that exotic forms of software engineering products and techniques that are conventionally refered to as "artificial intelligence" will be readily transportable from mainframes to small, private microsystems. To date, some of the most sophisticated programming research and development efforts have concentrated on developing problem-solving programs that employ the heuristic techniques of human experts. Research on such "expert systems" began in the early 1960's and the progress of the research programs is evident in the fact that the first commercially marketed expert system generator is now available for use on systems available to the general public.[1]

In this paper, I will address five questions: (1) what are expert systems? (2) for what are they used? (3) can expert systems be applied to human communication activities? (4) what do we learn about our discipline in the process? and (5) what negative consequences should we anticipate?

The first question is **WHAT ARE EXPERT SYSTEMS?**

Expert systems are computer programs that solve selected problems by modelling domain-specific behaviors of human experts. To appreciate the significance of that definition, readers need to realize the departure from earlier approaches to artificial intelligence. The earliest approaches emphasized general inference processes that were not restricted to particular domains. The characteristic procedure employed by these inference mechanisms involved specifying all possible approaches to each step in a problem-solving process, evaluating each in turn, and selecting the most favorably evaluated path. This process is consistent with the popular image of computer reasoning but it produced two unanticipated consequences. First, an exhaustive evaluation of all possible approaches is unmanagable for all but the most simple problems. For example, the number of moves possible in a chess game approaches 10 to the 120th power and the most powerful computer operating today could not explore all of them before our sun burns out.[2] Second, reliance upon generalized reasoning processes produced humorous errors that resulted from violation of common-sense conditions. Such conditions are well known by mature and competent members of our society but failure to build them into computer programs resulted in logically correct analyses of socially unacceptable or physically impossible alternatives.

Recognizing the limitations inherent in such generalized reasoning processes, researchers headed by Edward Feigenbaum began developing knowledge-based programs that relied upon the domain-specific knowledge and reasoning processes employed by human experts. The distinction between general reasoning processes and domain-specific inferences is one with which most members of this audience should feel comfortable because it parallels Aristotle's distinction between topoi and eida and

Toulmin's classification of inference warrents.

Employing a format demonstrated by Feigenbaum in project DENDRAL, expert systems generally consist of the units displayed in Figure I.

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FIGURE I

BASIC STRUCTURE OF AN EXPERT SYSTEM[3]

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Expert(s)                                                   User(s)
    |                                                          |
    |                                                          |
    |                                                          |
    |                                                          |
knowledge                                              Input/output
acquisition                                               system
facility                                                   |
    |                                                      |
    |                                                      |
Knowledge_____________________________________________Inference
base                                                    system
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The human components of this system are the expert(s) on whose experience and expertise the system depends and the user for whom the system has been constructed. The input/output system allows the user to communicate with the system. In typical systems, input consists of specific facts and data about the problem to be solved while output consists of advice from the system and, upon request, explanations about the inference processes and heurisitc rules employed. The inference system represents the reasoning and heuristic processes employed by human experts. Testing procedures used to find solutions are known to economists as "satisficing." Rather than evaluating all possible alternatives, expert systems select the first satisfactory solution encountered even though unexplored alternatives might be superior. The most difficult programming problems arise from representing the "fuzzy" or "soft" reasoning processes employed by experts to resolve cases involving uncertain data or inferences. The knowledge base consists of the domain specific information including relationships between and attributes of elements involved in the problem.

The final element, the knowledge acquisition system, consists of the means whereby information is acquired from human experts and entered into the system. This process is the principal limitation on current systems because information solicited through extended interviews and observations must be hand-coded into machine-readable form. The number and variety of expert systems is expected to expand dramatically once this limitation is overcome.

The second question is WHAT ARE EXPERT SYSTEMS USED FOR?

Figure II lists some of the better-known expert systems that have been described in the public domain. The qualification, "in the public domain," is important because expert systems may have considerable commercial value and it is probable that some of the most powerful systems are proprietary. Reviewing the table shows that .cp 8

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Insert Figure II

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most systems have been developed in areas related to science and medicine. This distribution is not a necessary consequence of either the systems nor the disciplines. Instead, this locus of activity results from several incidental features including (1) the sources of funds for research, (2) personal interests of the people involved in the programming activities, and (3) the desire to simplify initial efforts by avoiding areas requiring attention to behavioral variables. Aside from these transitory factors, a relatively clear pattern emerges: **Expert systems are used to solve problems associated with mundane or recurrent activities requiring high levels of relatively scarce expertise.**

In validation tests, some expert systems perform better than human experts but most perform at about 80% of the level of human experts. Even when they perform less well than the human experts on whose experience and knowledge they are based, expert systems have two advantages: (1) they are relatively less expensive and therefore more readily available, and (2) they are not subject to fatique or boredom and are more reliable over large numbers of repetitive tests.

The third question is, **CAN EXPERT SYSTEMS BE APPLIED TO HUMAN COMMUNICATION ACTIVITIES?**

My answer is an emphatic "yes" and I note there are already several systems functioning in areas closely related to our concerns. Speech recognition, natural language processing, and image identification involve processes intimately associated with human communication, but the motivation underlying construction of systems in these areas is only tangentially related to human communication as we customarily understand the concept.* However, a quick glance at the kinds of problems to which expert systems are normally applied suggests a variety of uses.

Generic tasks to which expert systems are suited have been described in a variety of texts. While some applications require rigid control structures and fall outside our domain, other applications are directly relevant to social processes. Table III lists some common tasks and possible applications to human communication.

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TABLE III

EXPERT SYSTEM APPLICATIONS

| Generic Tasks | Potential Applications to Human Communication |
|---|---|
| Interpretation and Diagnosis | Infering social and cultural patterns from qualitative data; identifying disfunctional patterns in groups and organizations and prescribing intervention strategies; summarizing and interpreting results of prior research |
| Planning and Design | Speech writing; public relations and political campaigns; social intervention activities; research programs |
| Prediction and Monitoring | Training and development activities; public relations and political campaigns; social intervention and group development activities; faculty, staff, and student performance |
| Training and Instruction | Selecting and evaluating instructional strategies; managing instructional medial including intelligent libraries, newspapers, journals, textbooks; regulating computer aided instruction programs and self-development activities; preserving experiences of distinguished scholars, administrators, and teachers |

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The fourth question is, **WHAT DO WE LEARN ABOUT OUR DISCIPLINE BY EXAMINING THE POTENTIAL FOR EXPERT SYSTEM APPLICATIONS?**

At the very least, I believe development of expert systems will force us to face economic reality in a way we have not in the past. The primary motivation for development of expert systems results from the relative scaricity of highly valued expertise. As systems move into areas related to human communication we may find that much of what we do is neither highly valued nor in scarce supply. While we could spend a good deal of time debating that point, I believe we can use our time more profitably by reconceptualizing the nature of Speech Communication.

Ever since Aristotle rescued rhetoric from the mire created by Gorgias' inability to define rhetoric, we have been taught that communication is an art of method, not substance. As the "rationale of informative and suasory discourse," rhetoric is a generalized method of solving problems for which there are no adequate domain-specific procedures. Unfortunately, the lesson of artificial intelligence research is that such generalized methods are (1) inefficient and (2) error prone. Thus the development of expert systems may force us to concentrate on domain-specific elements in an attempt to answer the platonic question, "what is rhetoric?" Aside from any philosophic interest the question may raise, answering it will direct attention to the specific kinds of expertise necessary to engage in communication. The commonplace assumption is that communication requires knowledge of a language but speech recognition systems have demonstrated that knowledge of a language alone is insufficient.

Speech recognition systems relying on phonetic discrimination are limited by the diversity of meanings associated with individual words and have achieved modest success only when preselected speakers use limited vocabularies. More sophisticated speech recognition systems such as Hearsay II at Carnegie-Mellon use expert system methods requiring knowledge of social contexts and intentions, but are still limited to vocabularies of under 10,000 words.

Moreover, development of expert system approaches to speech recognition has emphasized the domain-specific nature of certain communication patterns. In at least some cases, the domains do not correspond to traditional academic disciplines. As a result, we are likely to find ourselve reevaluating traditional disciplinary boundaries and participating in the formation of "metadisciplines."

The final question is **WHAT NEGATIVE CONSEQUENCES SHOULD WE ANTICIPATE?**

The question is not an idle one and the potential of knowledge-based, reasoning systems like those I've described gives greater reason to fear an Orwellian future that the hardware and marketing innovations discussed last year. The issues extend beyond disciplinary boundaries and in June, 1983 the Institute of Electrical and Electronics Engineers assembled a round-table discussion at Carnegie-Mellon University to explore social consequences of continued development. The participants noted four potential hazards:[7]

First, expert systems pose the danger of intellectual stagnation if we become slavishly dependent on machines.

Second, we fact the danger of "homogenized knowledge" as the codification of existing knowledge reduces diversity reducing the knowledge base required to adapt to unforeseen circumstances.

Third, expert systems may have enormous value in instructional programs but they may reduce attention to pressing educational issues and present easy solutions to complex issues.

Finally, expert systems employing speech recognition may facilitate surveillance resulting in loss of privacy producing a society functioning like the Panopticon envisioned by Benhtham.

NOTES

[1]"Expert-Ease creates expert systems on IBM PC," InfoWorld (March 19, 1984), p. 11.

[2]Edward A. Feigenbaum and Pamela McCorduck, The Fifth Generation (Reading, Massachusetts: Addison-Wesley Publishing Company, 1983), pp. 67-68.

[3]Adapted from Feigenbaum and McCorduck, p. 76.

[4]Adapted from Robert Michaelsen and Donald Michie, "Expert Systems in Business," Datamation, November 1983, 243; and Frederick Hayes-Roth, Donald A. Waterman, and Douglas B. Lenat, eds., Building Expert Systems (Reading, Massachusetts: Addison-Wesley Publishing Company, Inc., 1983), passim.

[5]Described in Feigenbaum and McCorduck, p. 70.

[6]Discussions of these activities include Larry R. Harris, "Fifth Generation Foundations," Datamation, July 1983, pp. 148-156; David L.Waltz, "Helping Computers Understand Natural Languages," IEEE Spectrum, November 1983, pp. 81-84; and Raj Reddy and Victor Zue, "Recognizing Continusous Speech Remains an Elusive Goal," IEEE Spectrum, November 1983, pp. 84-87.

[7]Participants included Frederick Hayes-Roth, executive vice president for technology, Teknowledge Inc.; M. Granger Morgan, professor and head, Department of Engineering and Public Policy, Carnegie-Mellon University; Allen Newell, professor of Computer Science, Carnegie-Mellon University; Raj Reddy, director of the Rogotics Institute, Carnegie-Mellon University; Marvin Sirbu, principle research associate, Center for Policy Alternatives, Massachusetts Institute of Technology; Fred Weingarten, project director, Office of Technology Assessment, U.S. Congress; Joseph Weizenbaum, professor of computer science, Massichusetts Institute of Technology; and Langdon Winner, visiting associate professor of politics and technology, University of California at Santa Cruz. Their discussion is summarized in "Next Generation Impacts," IEEE Spectrum, November 1983, pp. 111-117.

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FIGURE II

REPRESENTATIVE EXPERT SYSTEMS*

| SYSTEM | DOMAIN | DESCRIPTION |
|---|---|---|
| Auditor | Business | Experimental system to select procedures for use by an independent auditor. |
| Crib | Computers | Diagnoses faults in computer hardware and software. |
| Dendral | Chemistry | Infers chemical structures of unidentified organic compounds from mass spectrograms and other data. |
| Macsyma | Mathematics | Performs differential and integral calculus; simplifies complex symbolic expressions. |
| Sophie | Electronics | Laboratory instructor that assists students attempting to debug malfunctioning equipment. |
| Caduceus | Medicine | Aids diagnosis in internal medicine by identifying deseases associated with particular symptom patterns. |
| Mycin | Medicine | Diagnoses infectious blood diseases and recommends appropriate drugs for treatment. |
| Teiresias | Computers | Aids in construction of knowledge bases for expert systems by permitting experts to interact in a subset of natural language. |
| Rosie | Computers | General purpose utility used in generating expert systems. |
| Prospector | Geology | Aids geologists in evaluating potential sites for mineral deposits. |
| Puff | Medicine | Analyzes results of pulmonary function tests for evidence of disorders. |
| R1 | Computers | Proposes hardware configurations for instillations of Vax-11/780 computer systems. |
| Raffles | Computers | Diagnoses faults in computer hardware and software. |

| | | |
|---|---|---|
| Sacon | Engineering | Advises structural engineers in using the structural analysis program, MARC. |
| Taxadvisor | Business | Provides estate planning recommendations for clients. |
| VM | Medicine | Provides care suggestions for patients needing breathing assistance. |
| Hearsay-II | Computers | Speech recognition system that may permit interacting with computers in natural language. |
| Mathlab | Mathematics | Assists in the integration of rational functions. |
| Drilling Advisor | Geology | Propriety system developed for Elf Aquitaine to diagnose problems encountered in drilling for oil and recommends ways of preventing further difficulties.[9] |

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