The Future of Expert Systems

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Abstract

We have witnessed in this decade another new technology integrated into mainstream computing. Expert systems technology has finally come out of universities and research labs and has become part of mainstream computing practices. In the next decade, how will this "old" technology evolve? Daniel Lee will share Inference's experiences and visions in the areas of tools, methodologies and future research directions. Deborah Finley will focus on new areas and designs of applications beyond the first generation of expert systems. Wouter Put will present a methodology to combine traditional information systems technology and expert systems technology. Theresa Szczurek will discuss the role of human elements in making expert system projects successful.

1. S. Daniel Lee

Inference has lead the evolution of expert system building tools by constantly introducing new products on new platforms. The ART family of expert system building tools has evolved from a research-oriented, Lisp-based tool to a commercially-oriented, C-based tool. In 1984, Inference released its first commercial expert system tool, ART (Automated Reasoning Tool), which was written in Lisp. In 1988, ART-IM (ART for Information Management), the C version of ART, was released. ART was first available only on Lisp machines, but it was subsequently ported to workstations. ART-IM was first available on PC's and IBM mainframes. It is now available on most popular platforms including the VAX/VMS family and numerous Unix workstations. Recently, an Ada version of ART called ART-Ada was released to satisfy the needs of government agencies. Inference's ART family of expert system tools are interfaced with all major computer languages and all major operating systems, which makes Inference's expert systems technology truly mainstream. Inference's tools are well known for its powerful knowledge representation features. Its development now focuses on the ease of use and integration. Inference is committed to provide innovative tools for building knowledge bases, user interfaces and database interfaces.

Inference's own professional services group and its customers have developed numerous applications, which are in daily use today [2], [4], [5], [6], [1], [7], [3]. From its experiences with various expert systems projects, Inference has developed a unique methodology and a model of expert system life cycle, which has evolved and has been validated through multiple projects over several years. It combines the traditional waterfall model and the newer spiral model, and it takes advantage of both traditional methodology of software engineering and rapid prototyping methodology of expert systems.

Inference has a research group within the professional services organization who conducts research under contracts. Some examples of current research topics are: knowledge-based software reuse assistant, real-time expert systems and case-based reasoning. As part of these projects, the integration of expert systems technology with neural networks and fuzzy logic is also being studied. The primary purpose of the research group is technology transfer from the
research group to the product development group. For example, ART-Ada was designed and developed under a research contract initially, but it was refined and productized by the product development group. This tradition of technology transfer will continue in the future.

2. Deborah A. Finley

Expert Systems are traditionally defined as sophisticated computer programs that manipulate knowledge to solve problems efficiently and effectively in a narrow problem area. These systems use symbolic logic and heuristics to find solutions. By linking the power of computers to the richness of human experience, expert systems enhance the value of expert knowledge by making it readily and widely available. This capability of expert systems has been demonstrated in the fields of medicine, law, education, finance, manufacturing, and operational military problems.

This discussion will focus on new areas and designs of applications beyond this first generation of expert systems. Parallels between advancing technologies such as network management, ISDN, and image processing will be made and viewed as future areas of consideration for expert systems development. Additionally, strategies for improved management of expert system projects and programs, which help insure successful use, will be reviewed.

The discussion of the future of expert systems will be significantly based on the increasing trend toward integration and interconnecting of information equipment with telecommunications to build networks. Advances made in this and other information technology-induced growth industries will also need the capabilities of *smart or intelligent* systems which will be engineered by expert systems. Thus, the future of expert systems will be focused on how we can better utilize the present hardware and allow it to *help* with the various database which are continually expanding.

If we look at expert systems as having a role at every level of existing technological production regimens (i.e., collection, manipulation, monitoring storing, sensing, counting, actuating and transmitting of data and/or information), we see numerous application possibilities.

Categorically, the areas of application can be paralleled with four information technology growth areas:

1. intermediate and final demand of industry
2. government purchases
3. private household demand
4. infrastructure investment

Industrial activities are coming under pressure to develop technologically advanced equipment, systems and services. This in itself facilitates increased productivity and flexibility to meet ever changing economic circumstances as well as consumer demand. For example, in the agriculture, forestry and fishery industries farm management aids will include the use of artificial intelligence/expert systems for achieving optimum yields. Simple robotics and automatic/remote control systems may also be coupled with expert systems which will allow for smart machines which, on one hand, enhance operations if tractor work, milking, poultry management, sheep shearing, picking and harvesting as well as determine procedural needs.

In the extractive sector, expert systems will be feasible for prospecting and extraction management. In the manufacturing domain, expanded uses of expert systems will include applications for integrated, intersite communications automated testing and quality control, automated handling and manipulation, automated packaging and dispatch, and computer-aided planning, scheduling and management. With reference to service sector applications, expert system functions will allow for intelligent-based database search and retrieval systems, thereby providing new forms of library-type services.

Fifth generation computers are expected to use artificial intelligence techniques to allow for effective interaction with people, and to facilitate reasoning about information. Several levels are gleaned here with regard to the type of information technology-based equipment of the next decade:

- Remote controlled (e.g., infrared switches, leading to multicontrol remote (multiple devices operated by the same controller),
and distance or telecontrol (e.g., controllable by telephone instructions, as are telephone answering machines now);

- User-friendly (voice control; menu-type displays for control; more informative output displays, voice synthesized messages);

- Programmable (offering increased options to fit current user requirements, and automatic control which takes into account energy tariffs);

- Informed (memory to recall previous programming and data inputs - e.g., weights of dieters on successive days - and ability to interface with other devices to optimize performance, and with external information sources to achieve desired outcomes);

- Portable (smaller, more personal, devices; devices permitting greater mobility; devices for cooking, washing, etc.; cordless devices for convenience of use);

- Safety featured (warning indicators, automatic fail-safe controls);

- Breakdown featured (diagnostic and easy repair);

- Power conserving (more energy-efficient devices, ability to take account of environmental temperatures and energy tariffs);

- Integrating different items of equipment around common monitoring and control systems (moving toward information handling services (IHS) for the home).

The major tactics for use of this equipment will be to improve the person/computer interface, to simulate real and fantasy worlds, and to encode expertise for use by others. The major software will be expert systems which will accomplish auto-programming for many of these activities.

Inherent to these technological developments for the factory, home and office is the communications infrastructural. The integration of information technologies may be best assisted by an embedded expert system or systems which bring together many of the divergent technologies. Thus expert systems with learning capability show promise for the management of future networks.

This need is based on the fact that the high tech communication user of the future, often referred to as a knowledge worker, will have a basic job of making decisions. Since the decision-making process is one of an input-output function, the knowledge worker will need to have many facts and opinions available. Traditionally, access to this information is via databanks or direct contact with people. Expert system tools which allow for conversion, enhancement combination or correlation of graphics or animated presentations, will increase information movement and management. Thus, the implication for integrated services digital networks (ISDN) is the parallel development of higher-level languages for application specific functions.

In the area of image processing, expert systems have the potential for enhanced management of large optical disk systems - particularly in reference to "jukeboxes" which hold and manipulate large numbers of optical disk platters. Since the device must physically move platters from a storage to a disk drive, information retrieval is delayed. Use of expert system software that could "learn" how the optical disks are being used could result in the user not realizing the optical disks are being switched because it was anticipated and performed beforehand.

Based on the specific capability of expert systems to assist in analyzing problems and decision-making, their future is virtually established if, indeed, increased productivity is an overriding objective of the factory, office and home. Attention toward the specific application still requires determining how they best accomplish this function. As information technology is fueled in general by supply and demand, integrating expert systems will facilitate bridging the gap.

3. Wouter Put

During the 1980's Knowledge-Based System and Expert System design has been troubled by the persistent knowledge engineering gap. The fact that no formal...
acquisition and knowledge modeling existed, hampered effective KBS and ES development.

Since 1985, the new Structural Knowledge Engineering (SKE) methodology has been applied to KBS and ES projects. SKE, which is based on academic research, provides the knowledge engineer with the techniques and methods to reliably recognize and thus categorize generic business problem types: SKE is referred to as a model-driven, domain-independent methodology.

During the KBS/ES development life cycle, SKE addresses and resolves issues such as knowledge acquisition and knowledge modeling, verification of completeness of the domain knowledge, validation of the knowledge, engineering and documenting the knowledge model, up-front feasibility assessment, up-front economic justification and effective prototyping aspects.

Not all data handling processes can be captured and made operational by Information Technology. In various applications, the system analyst (i.e. information engineer) will conclude that a particular process cannot be formalized. If such processes cause problems in the client organization, a knowledge engineer would need to formalize these "different" processes.

In real business situations, the information supply at large is provided through collaboration and interaction between the relevant processes (i.e. both information-based and knowledge based processes). In the ideal set-up, IT and KT engineers ought to cooperate to ensure an optimal information supply. This presentation discusses in more detail why IT and KT engineers should collaborate in order to deliver better solutions to the information supply problem.

The presentation discusses a combined methodology addressing both the IT and KT aspects of an integrated project.

4. Theresa M. Szczurek

Despite millions of dollars spent annually on the introduction of technological innovations, a large percentage fail. Fierce competition, large investment, and high risk are readily apparent reasons for failure in high technology industries. Less apparent, and less adequately researched, however are the human elements.

This research seeks to understand successful implementation of radical innovations by investigating interactions between key vending and buying players. The user is an important buying organization member because user satisfaction, this study's measure of successful implementation, is a prerequisite before the innovation delivers full benefits. Change agents, or champions, in the buying (BO's) and vending organizations (VO's) influence successful technological change. This study focuses on how interactions between users and change agents affect user satisfaction with the innovation. High level Artificial Intelligence (AI) software tools such as Knowledge Craft, KEE and ART are the radical innovations studied in this research.

A "Player Interaction Framework," built from interaction, social change, and agency theories, illustrates how interactions among players such as change agents and users affect user satisfaction. User's satisfaction is determined by positive and negative forces exerted on the user concerning the innovation's implementation. Interactions among vending change agents (VCA), buying change agents (BCA), and users stimulate the exchange process that realigns users' forces. Exchange of information, rewards, and products act to unfreeze, alter, and refreeze user's forces to greater satisfaction levels.

The proposed theoretical framework is empirically evaluated from both BO and VO perspectives using a hybrid methodology; data are collected via interviews and surveys and analyzed using hierarchical regressions and content analyses. Although BO and VO players have different opinions of what affects successful implementation, the following findings surfaced:

1. Change agents, who exist at many management levels of the BO and VO, play an important role in affecting user satisfaction with the innovation. Successful implementations often are supported by a network of change agents throughout the BO and VO who work together to nurture and support users. The VCA does not play as critical role in successful implementation as often as the BCA.
2. Forces, both positive and negative, exerted on users affect a user's level of satisfaction. When positive forces are greater than negative forces, users are more satisfied. Change agents can realign the forces. AI tool users are influenced by the following positive forces: technical system features; management, corporate, or financial support; need to solve a real problem; user interface; and benefits to the firm and individual. Negative forces affecting AI tool users include: technical system features; costs; education/training; lack of management, corporate, or financial support; and user attitudes.

3. Information and reward exchanges between BCA's and users bring greater user satisfaction. Only VO players perceive that VCA/user exchange of information and rewards bring greater user satisfaction. Information should be exchanged among various BO players including management, users, advocates, and resisters. Information should address: real problems to be solved, how the innovation works, benefits from the innovation, and how the technology fits overall corporate vision. The information should best be exchanged through hands-on demonstrations that use rapid prototyping and interaction. Such demonstrations should be conducted in small groups or informal one-on-one sessions.

4. Financial rewards such as raises and social rewards such as recognition from using the innovation help stimulate user satisfaction. Often BO's lack reward structures associated with use of the innovation. BCA's are often not rewarded for taking on this "risky" change agent role.

5. Intensity of change agent interactions with users affects level of exchange and ultimately user satisfaction. Frequency of interaction positively affects exchange, while length of interaction negatively affects exchange. The content of the interaction and the choice of participants are important to the outcome. The purpose of BCA's interactions with BO players is to raise awareness, internally sell the technology, nurture people who are interested in successfully implementing the technology, get funding for the project, and resolve any interpersonal or organizational concerns.

Building from the above findings, the following managerial recommendations should stimulate user satisfaction with the innovation:

1. The Player Interaction Framework should be used to guide VO and BO behaviors which will result in more successful technology implementations.

2. VO and BO change agents from many levels of management should be assigned (formally or informally) their roles.

3. Change agents should conduct a force field analysis for each potential user to understand the positive and negative forces affecting users. They should try to reduce negative forces hindering satisfaction.

4. VCA's should strive for increased visibility and effectiveness.

5. VO's and BO's should improve reward structures available to users and change agents.

6. Change agents should stimulate active information, reward, and product exchanges with users.

7. Change agents should frequently interact with BO players from many departments, functional areas, and management levels. Frequently of interaction is more important than the length of time change agents interact with users.

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