Expert Systems in Accounting in a Personal Computer Environment

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Introduction

A recent survey by the AICPA [Frotman and Wixson, 1985] found that the use of the personal computer is rapidly growing. The software commonly available for the personal computer includes word processing, database programs, and spreadsheet programs.

Recently, expert systems and artificial intelligence tools have become available for the personal computer. Since accountants have just begun to use artificial intelligence and develop expert systems, there has been only limited analysis of the implications of these new tools for the profession. Accordingly, the purpose of this paper is to analyze the development of expert systems and the use of artificial intelligence technology in accounting in a personal computer environment.[1]

This article will discuss the following subjects:

- review of artificial intelligence and expert systems,
- analysis of artificial intelligence and expert systems in accounting,
- the impact of the personal computer environment on accountants,
- the impact of expert systems in accounting,
- the use of artificial intelligence and expert system shells for expert system development on a personal computer, and
- summary of expert systems developed for accountants.

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Artificial Intelligence and Expert Systems

Rich [1983, p. 1] defined artificial intelligence (AI) as ". . .the study of how to make computers do things which, for the moment, people are better." Barr and Feigenbaum [1981, p. 1] have defined AI as ". . . the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics associated with intelligence in human behavior. . . ." These definitions indicate that AI is the study of developing computer systems to perform tasks and do analysis that humans currently use knowledge and reasoning to carry-out.

The domains of AI include knowledge representation in computers, natural language use with computers, learning by computers, and other topics. Good surveys are included in Barr and Feigenbaum (1981) and Rich (1983).

Knowledge-based expert systems (ES) are also a branch of AI. ES's perform tasks normally done by knowledgeable human experts [Rich, 1983]. Accordingly, ES's are developed by programming the computer to make decisions using the processes and knowledge as the expert.

Typically, ES's perform intellectually demanding tasks, rather than mechanical tasks. In addition, ES's usually have the ability to explain their reasoning [Barr and Feigenbaum, 1981].

Structurally, ES's usually have four major components: Database, Knowledge Base, Inference Engine, and User Interface. The database includes the data used by the expert system. This is normally the same data that a human expert uses to solve the problem. The data may be a part of the program, it may be a part of the database, or it may be elicited from the user.

The knowledge base provides the set of knowledge that the expert indicates is used to process the data. The knowledge base contains the knowledge that the ES uses to process the data. Typically, this is the domain-specific knowledge that an expert would use to solve the problem. Knowledge can be represented in a number of ways. Two of the primary methods are rule-based and frame-based knowledge representation. Rule-based knowledge representation generally takes the form of "if . . . (condition) then . . . (consequence/subgoal/goal)." The rules may or may not include a numeric level of confidence or probability of occurrence. Frame-based knowledge representation uses a "frame" to capture the characteristics associated with a given entity. Characteristics define the knowledge that is of interest to the entity.

The inference engine provides the basis to use the knowledge base to process the database. In a rule-based system, the inference engine normally uses either a forward or backward chaining approach. Forward chaining reasons toward a goal. Backward chaining reasons backward from the goal to determine if or how the goal can be accomplished.

The user interface defines the relationship between the user and the system. Generally, the interface is user friendly, particularly in those situations where the data is generated from the user.

Expertise and Decision Characteristics

Researchers have identified some characteristics about successful expert systems. First, the expertise that is being modeled should be in short supply [Fox, 1984], an expensive resource or not readily available at a particular geographic location. Second, a difference should exist between the decisions of an expert and an amateur [McDermott, 1984]. Otherwise, there is no need for such an expert. Third, the knowledge base and the inference engine must not be easily acquired. Otherwise, the user could simple develop the knowledge base and the inference engine and operate independently of the expert. Fourth, Fox (1984) has suggested that the decision should require short reaction time or else the expertise may be developed by the user. Fifth, McDermott (1984) adds that the decision should be a high value decision. These conditions ensure that there is a high cost-benefit contribution of the ES.

Purpose of System

AI and ES have been used to develop programs that perform in an educational mode, an advisory mode, and a replacement mode.

Educational AI/ES are being used for modeling educational functions that previously would not have been placed in a computer model. STEAMER [Williams et al., 1981] is an example of a simulation program that uses concepts from AI to serve as a tutor, training students in the principles of propulsion engineering.

Advisory Most existing expert systems are designed to function in an advisory manner. These systems make a recommendation and a human expert reviews the decision and the logic behind the decision before the decision is executed.

Replacement There are some systems designed, however, to replace the decision maker. Glover et al. (1984) designed a system that they suggested should be called a "managerial robot" because it was designed to replace the decision maker. The system was designed to schedule employees in an environment of weekly fluctuations.

Although the system was designed to replace the manager, it does not have to be implemented in that manner. The system can be implemented to advise the user. (It is interesting to note that this system may be used for scheduling auditors.)

Implications of Expert Systems in Accounting

The expertise and decision characteristics of a successful expert systems suggest that accountants function in an environment where ES's can aid the user.

Expertise and Decision Characteristics

Much accounting expertise is in short supply and not always easily accessible. In order to mitigate the limited supply problem of expertise many of the larger public accounting firms have centrally located expertise (e.g., industry and function). Demand for an accountant's expertise can arise at the client's office where the desired expert may not be available, or the expert may receive multiple calls from the field simultaneously and thus not be available for each of the requests.

The knowledge of the accountant is not easily obtained. In order to pass the CPA exam a large body of knowledge must be assimilated. Becoming a partner in a public accounting firm requires additional knowledge. Accounting expertise is also expensive. Current billing rates of CPA's attest to the high cost of expertise.

Accounting decisions are frequently high value decisions. For example, the litigatory nature of some audit decisions associates a large potential cost with those decisions.

Uses of Expert Systems

Accountants can use ES's for education and advising. Accounting firms do substantial amounts of training of their personnel. It may be that ES's could be used in training accountants. As noted below, there have been a number of prototype expert systems developed for advising accountants on a variety of issues.

Personal Computer Environment

The personal computer (PC) environment arises from individual use of the personal computer. The personal computer environment is differentiated from either minicomputers or mainframe computer environments in at least four ways. First, the broad dissemination of PC's allows the user to use their own PC at their home office location and another's compatible PC at their work location (e.g., at the client's). Even if the alternate work location does not have a PC, portable PC's are available that allow the user to take the computer to the problem. This allows the user to have the same software at both locations and, accordingly, implement the power of the computer at both locations. Second, information storage is private (as opposed to publicly available) and under control of the user. The physical control of a diskette, for example, means that information and knowledge can be used at arbitrary locations in the privacy of the user's office. In addition, the user can physically protect the data from unauthorized use by controlling the diskettes. Third, the user has direct personal control over all stages of the activity [Keen and Hackathorn, 1979] ensuring control over quality and a necessary understanding of the use of the programs. In addition, the user can choose the tasks and allocate the resources for which software is developed or purchased. Accordingly, this can lead to the development or purchase of software in a timely manner. A computer department can no longer be used as a reference or an excuse. Fourth, the software and programs that have been developed for the PC are normally very user friendly and inexpensive when compared to mainframe software and programs. User friendliness allows the use of the system for training, limits the time required for training, increases the scope of use, and allows the user to be familiar with a larger base of software. Inexpensive software leads to the user being familiar with a broader base of programs because of affordability.

ES in Accounting in a PC Environment

Four primary implications for accountants derive from the use of ES's in the PC environment. First, the dissemination of PC's and the portability of PC's allow the accountant (e.g., auditor or consultant) to have computer capabilities at virtually all locations (e.g., at the client's). Thus, the accountant can bring ES capabilities on-site. To the extent that AI or expert knowledge can be captured in a computer program, that intelligence and expertise can be used in virtually all locations. Consequently, high value or high cost decisions can be made in consultation with an expert system at virtually any location. Second, the storage of private information allows the accountant to carry the expertise of a number of tasks to the site of the activity and still ensure privacy of the expertise. This leads to mobile and available expertise. Privacy also allows the use of arbitrary AI-based or ES training tools. Third, the personal control of the activity allows the accountant to choose the areas of ES application to meet the user's needs and suggests that the accountant may develop the applications. Fourth, the user friendly and the inexpensive aspects of the PC environment make the AI/ES tools usable and economically feasible.

AI/ES Capabilities on PC's

Artificial intelligence techniques are implimented and expert systems are developed using three primary approaches: procedural languages, artificial intelligence languages, and expert system "shells." Only recently have the last two methods been available for use on a PC.

Procedural Languages

Procedural languages, such as BASIC, allow the user to define a sequenced set of operations to solve a specific problem. Some expert system shells and some expert systems have been developed using procedural languages. Fortran and Pascal are the two most frequently used procedural languages in the development of AI applications or expert systems. Both Fortran and Pascal are available on the PC [e.g., Borland, 1985].

Artificial Intelligence Languages

Two primary artificial intelligence languages are in use: Prolog [Clocksin and Mellish, 1984] and LISP [Whinston and Horn, 1984]. Prolog has been chosen by the Japanese for their fifth generation computer project. Whereas, the primary AI programming language applications in the United States have used LISP. Both these languages are used on personal computers [e.g., Clark and McCabe, 1984 and Steele, 1984, respectively].

AI languages differ from procedural languages in three primary ways. First, in contrast to other computer languages that are designed to process specific numeric information, an AI language is designed to process language-based and abstract symbol information. Second, the procedural languages are dependent on the order of the statements, whereas LISP does not have the same procedural constraints [Sheil, 198]. Third, unlike procedural languages, Prolog is a natural and easy-to-analyze language.

In some cases the designer may use both AI and other languages. Some versions of Prolog and LISP allow the user to access procedural languages. The advantages and limitations of Prolog and LISP have been summarized by Williamson (1984).

1. Prolog's main advantage is its natural way of expressing ideas. The coded knowledge can be analyzed by the non-programming expert for its accuracy and completeness. LISP is more difficult to follow.
2. The order of the knowledge is important in Prolog but not in LISP. As a result, LISP programs are easier to maintain.
3. Prolog's development times are usually shorter than LISP's. Thus, it may be less expensive to develop a Prolog application.

Expert System Shells

Expert system shells simplify the development of an expert system by providing many user friendly features [e.g., Turpin, 1985]. The inference engine can be specified and does not need to be developed. The knowledge base usually is easy to program (not necessarily easy to elicit from the expert). The shells also may allow the user to access existing databases such as dBase III and other

AI languages. Some shells (e.g., M.1) are designed for programmers, while others (e.g., Insight) are easier to use [Williamson, 1985]. The cost of the shells ranges from around $100 (e.g., Insight) to over $10,000 (e.g., M.1). A number of these shells are listed in the appendix.

Which Approach Should Be Used?

The most basic (and generally the most difficult) approach to the development of an expert system or other artificial intelligence application is to program the system using a procedural programming language. The difficulty arises because these languages were not developed primarily to process symbolic information and do not have the unique features that specialization brings. A second approach is the AI language. However, these languages do not have the user friendly features of the shells. Accordingly, to the extent that a shell can be used to develop the system, that option may be executed. In either case, the AI/ES system developer should choose that approach that best meets the developer's needs in a cost effective manner.

Accounting Applications of AI/ES[2]

There have been few applications of AI and ES in accounting. However, those applications that have been developed provide evidence of the use of a range of computer languages and shells in the development of AI and ES in accounting. These systems also indicate a broad potential scope of applications. Each of these applications could be useful to the accountant both in the accountant's and the client's offices. This paper treats the applications as falling into one of two categories: systems in use or prototype systems. Most of the systems to date are prototype systems. Currently, ES's in particular and AI in general are not widely used.

Prototype Applications

The primary analysis of expert systems in accounting to date, has been preliminary in nature. The previous research has concentrated on the feasibility of developing accounting-based expert systems.

Taxadvisor Taxadvisor is a prototype expert system developed by Michaelsen (1982, 1984) for estate planning. Taxadvisor was developed using the shell Emycin [Buchanon and Shortliffe, 1984].

Auditor Auditor is a prototype expert system developed by Dungan (1983) and Dungan and Chandler (1983) for the evaluation of the adequacy of the allowance for bad debts decision. Auditor was developed using the shell AL/X [Reiter, 1980].

EDP Auditor EDP Auditor is a prototype expert system developed by Hansen and Messier (1982, 1985). EDP Auditor is an expert system for auditing computer-based accounting systems. EDP Auditor was developed using a shell AL/X [Reiter, 1980].

ICE ICE is a prototype expert system developed by Kelly (1985) for internal control evaluation. ICE was developed using a dialect of LISP.

TICOM TICOM is a prototype, computer-based tool based on some AI concepts developed by Bailey et al. (1984a and 1984b). TICOM is used to aid the auditor in the analysis of the internal control system. TICOM was developed using Pascal. The developers of that system suggest that it be interfaced with an expert system.

Conclusion

This paper suggests that using AI techniques and ES's in accounting in a PC environment capitalizes on the strengths of the PC and matches the characteristics of accounting expertise and knowledge. The PC allows the user to use AI/ES training capabilities. It makes the location of the training independent of the expert and increases the scope of potential training activities. The PC also allows the user to model a variety of advisory expertise where the expertise is expensive and not accessible. The PC environment allows the user to take the expertise to off-site environments.

APPENDIX

The purpose of this appendix is to provide a list of some of the available shells for personal computers. This list derives from

Miller (1984), Harmon and King (1985), Williamson (1985) and direct contact with some of the vendors. The addresses of these vendors are in those references. There new packages being released all the time so this is not a complete list.

Shell	Company
AL/X	University of Edinburgh
ES/P Advisor	Expert Stems International
Expert Ease	Expert Software International
Expert Edge	Human Edge Software
EXSYS	Essays Inc.
Insight	Level Five Research
Insight2	Level Five Research
KAS	SRI
KDA	KDS Corp.
KES	Software A & E
KES II	Software A & E
M.1	Teknowledge
Pesonal Consultant	Texas Instruments
TIMM	General Research
Series-PC	SRI
RuleMaster	Radian Corp.
XSYS	California Intelligence

NOTES

[1] This analysis is oriented toward personal computers such as the IBM PC, AT&T PC, IT&T PC, COMPAQ, and the Apple PC's, but it does not include the so called "LISP" machines such as the XEROX 1100.

[2] The expert systems evaluated in this article were found by examining four sources, including Peat, Marwick, Mitchell & Co.'s *Research Opportunities in Auditing* (1985), Miller's *1984 Inventory of Expert Systems* (1984), Ph.D. Dissertations through calendar year 1984 (because of the lag with their being listed in University Microfilms) and from the author's awareness of particular papers and presentations.

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