4

The Use of Artificial Intelligence in Accounting

Daniel E. O'Leary

The purpose of this chapter is to review the work that has been done to date in the area of artificial intelligence and expert systems in accounting. Currently, there are few applications that have been implemented commercially and only a few prototype expert systems that have been developed. This chapter summarizes those systems, reviews the knowledge base and inference engine of those applications, and compares those systems to each other and to expert systems in medicine and mineral exploration. Finally, this chapter summarizes some limitations and provides some extensions of expert systems in accounting.

4.1 INTRODUCTION

The purpose of this chapter is to review and extend the use of artificial intelligence (AI) and expert systems (ES) in accounting. The primary focus of this chapter is on expert systems, although other uses of artificial intelligence also are discussed.

4.1.1 Previous Reviews of AI/ES in Accounting

There have been earlier reviews of some business expert systems (Michaelsen and Michie 1983) and auditing-based decision support systems (DSS) and expert systems (Messier and Hansen 1983; Bedard, Gray, and Mock 1984; and Dillard and Mutchler 1984). However, there has been substantial work in *accounting* expert systems since these reviews were written.

A theoretical framework for developing ESs in auditing is expected from Lewis and Dhar (1985). Finally, an analysis of the potential implications of expert systems on the accounting industry from the perspective of a public accounting firm is given in Elliot and Kielich (1985).

4.1.2 The Plan of This Chapter

Section 4.2 briefly reviews some characteristics of accounting and then relates accounting and ESs. In Section 4.3 characteristics of one of the best known and most discussed accounting ESs are examined. Section 4.4 summarizes various AI/ES accounting applications, and Section 4.5 analyzes those applications in terms of their knowledge bases and inference engines. Section 4.6 relates the accounting ESs to each other, and Section 4.7 compares the ESs in accounting to those in mineral exploration and medicine. A discussion of the limitations of ESs in accounting appears in Section 4.8. Section 4.9 reviews some related ESs from other disciplines and briefly discusses some extensions of ESs in accounting. A brief summary appears in Section 4.10.

4.2 WHY AI/ES IN ACCOUNTING?

Researchers have generated some ESs for analysis of accounting-based decision processes. This section addresses why management needs to know about AI/ES in accounting and analyzes the feasibility and desirability of AI/ES in accounting.

4.2.1 Why Does Management Need to Know about AI/ES in Accounting?

Management will be concerned about AI/ES in accounting for two primary reasons. First, the development of AI/ES affects management's allocation of resources. Second, AI/ES in accounting contains knowledge and reasoning about accounting-based decisions. Accordingly, the extent those decisions affect or are affected by management reflects the importance to management.

In the first situation, management's allocation of resources will be affected by the resources expended on AI/ES. The systems may reduce payroll costs or enhance decision making. However, the systems also will require an investment of time and dollar resources. As a result, management will be concerned that AI/ES in accounting is cost beneficial in the long run.

In the second situation, management's information and decisions are impacted by accounting information. The type of impact on management's decisions depends on the functional area.

Functional Areas of Accounting There are five functional areas of accounting: auditing, management accounting (planning and control systems), tax, accounting information systems, and financial accounting.

As noted by Arens and Loebbecke (1984),

> Auditing is the process by which a competent, independent person accumulates and evaluates evidence about quantifiable information related to a specific economic entity for the purpose of determining and reporting on the degree of correspondence between the quantifiable information and established criteria. (p. 1)

In the *auditing* process there are three branches of auditors: external auditors, internal auditors, and EDP auditors. External auditors are from outside the firm (certified public accountants), and internal auditors are from within the firm. *External auditors* issue an accounting opinion about the financial statements. The opinion directly impacts the credit of the firm and the ability of the firm to generate capital. Thus management is concerned with the decision process by which the external auditor generates the opinion. *Internal auditors* review the operations of the firm. As a result, management is concerned that the internal auditors have the appropriate tools to ensure an adequate review. *EDP auditors* are either external or internal auditors concerned with the audit of computer-based systems. Accordingly, management is concerned that EDP auditors have the appropriate tools and expertise to assess and develop the controls required for the computerized accounting system to minimize the loss of resources through improper controls.

Management accounting (planning and control systems) develops information to meet the needs of decision makers. As a result, management is concerned with the expertise used in the development and maintenance of the planning and control systems.

Tax accounting relates the tax law to the needs of individuals and corporations. This branch of accounting is characterized by its relationship to the Internal Revenue Service (IRS). Tax accounting decisions have a direct impact on the cash flow of the firm. Accordingly, management is concerned with the expertise of the tax advice it receives.

Accounting information systems (AIS) refers to the computerized accounting information systems that are developed to meet management's and external users' requirements. Accordingly, management and external sources are concerned with the expert systems used to develop and implement the AIS.

Financial accounting deals with the general purpose accounting reports and financial statements (Kieso and Weygandt 1983). This branch of accounting is characterized by its link to requirements of accounting disclosure by the Security and Exchange Commission (SEC) and the Financial Accounting Standards Board (FASB). Accordingly, management will be concerned that the firm meets the legal requirements of disclosure.

4.2.2 ESs and Generic Tasks

Accountants are concerned with a number of ES generic tasks that have been the source of ESs from other disciplines: interpretation, diagnosis, monitoring, scheduling, planning, and design (Hayes-Roth, Waterman, and Lenat 1983).

These generic tasks generally differ across the functional areas in accounting. For example, an auditor's primary activity is the diagnosis and treatment domain. Internal auditors perform a number of monitoring activities. Accounting firms must schedule audits and audit personnel. Tax accountants face a configuration of tax laws and client activity for diagnosing the best plan. Management accountants (planning and control) design planning and control systems. This suggests that there is no one typical AI/ES application in accounting.

4.2.3 ES Characteristics and Accounting

Chapter 1 listed some characteristics of expert systems. Those characteristics included: (a) tasks can be decomposed into segments, (b) knowledge can be expressed in the form of rules and heuristic judgments, and (c) expertise is scarce and expensive.

The task characteristics vary across accounting functions; however, accounting tasks often are characterized by decomposability.

Accounting is characterized by knowledge in the form of rules and heuristic judgments. Large sets of accounting rules are provided by the IRS, SEC, FASB, and individual companies. Heuristic judgments are made in all functional areas of accounting (e.g., tax planning).

Accounting expertise often is in short supply and almost always expensive. The existence of certifications such as a certified public accountant (CPA) indicates the existence of a distinction between a neophyte and an expert.

The relationship of these characteristics to accounting suggests that accounting is a *feasible* domain for ESs.

4.2.4 Complex Accounting Problems

The accountant faces a broad base of complex problems. Hansen and Messier (1982) show that some audit problems are NP-complete (nondeterministic polynomial), which are effectively intractable for traditional optimization methods. The tax accountant and the auditor face compliance with a broad base of rules established by the IRS, SEC, and FASB. Management accountants (planning and control) face ill-structured systems design problems.

Accordingly, accountants have developed heuristic methods to analyze these problems. However, as the problems and the computer technology changes, accountants are faced with developing new tools to meet these changes. The complexity of accounting problems and the available set of responses to the problems indicate that accounting is also a *desirable* domain for the development of ESs.

4.3 A SAMPLE ACCOUNTING EXPERT SYSTEM

This section examines an accounting ES that probably has received more attention than any other accounting ES. TAXADVISOR (Michaelsen 1982a, 1982b, and 1984; and Michaelsen and Michie 1983) is a prototype tax ES. This system has at least four characteristics in common with other accounting ESs: designation of a highly specific problem, study of a human expert(s), translation of that process into a computer program, and performance of the activity at a human level. These characteristics also are used in the next section to discuss other accounting ESs.

First, TAXADVISOR was developed to resolve a specific problem in tax accounting—in particular, to make recommendations concerning estate planning. Second, TAXADVISOR models the decision processes of a tax expert. In particular, it (a) performs a screening process to determine if it can help the client, (b) gathers information for making recommendations, and (c) finds a solution that reflects the objectives and situation of the client. Third, the system translates the process using a series of IF-THEN rules as modeled using an ES shell. Fourth, the system produces results similar to those of human experts.

4.4 PREVIOUS RESEARCH*

The systems that have been developed in accounting using AI/ES fall into three categories: systems in use, prototype systems, and conceptual design/systems in process. *Systems in use* refers to those systems that are or will be in use. *Prototype systems* refer to those systems that have been

*This paper examines previous research from a number of different sources: the *Peat Marwick (1985) Interim Report* of research grants for auditing, Miller's *1984 Inventory of Expert Systems*, the new *Expert Systems* journal, the *Accountant's Index*, accounting Ph.D. dissertations, major accounting journals (few artificial intelligence publications to date), and unpublished working papers and presentations at major conferences known to the author.

designed to understand the particular processes and are not necessarily for use in the commercial world. *Conceptual design/systems in process* refers to those applications for which the system has been planned but not implemented.

4.4.1 Systems in Use

There apparently is only one artificial intelligence–based system that will be in use in accounting (Willingham and Wright 1985). Peat, Marwick, Mitchell and Company have developed an ES that is a loan evaluation system for use in the audit of banks. The system examines the collectability of term and collateral loans. The system was built using an expert system shell/kit (Insight 2) and has over 1000 rules.

Peat, Marwick, Mitchell and Company apparently has future plans for the use of other systems (Elliot and Kielich 1985). Some expert system shell vendors have indicated that other accounting firms have purchased their product for developing expert systems. In addition, an expert system for capital budgeting (Reitman 1985) is scheduled to be in commercial use in the near future.

4.4.2 Prototype Systems

The largest category of work completed to date using artificial intelligence in accounting is the prototype. These systems are summarized in Table 4.1.

AUDITOR AUDITOR (Dungan 1983 and 1985; and Dungan and Chandler 1983) was developed to make diagnostic judgments concerning the adequacy of a firm's allowance for bad debts. The system modeled the judgment of an auditor using an ES shell (AL/X). The system performed on a level similar to an expert.

EDP AUDITOR EDP AUDITOR (Hansen and Messier 1982, 1985a, and 1985b) was developed to assist in the audit of computerized accounting systems. The system modeled the diagnostic judgments of an auditor using an ES shell (AL/X).

AGGREGATE AGGREGATE (Munakata and O'Leary 1985) was developed to aid in the design of accounting information systems by developing aggregated financial statements from a set of accounts in order to improve management decision making. The system modeled the aggregation judgments of a management consultant using Prolog.

ICE ICE (Kelly 1984) is a prototype expert system designed to aid in internal control evaluation. Unlike other accounting-based ESs, ICE in-

TABLE 4.1
A SUMMARY OF AI/ES PROTOTYPE SYSTEMS IN ACCOUNTING

System Name	Function	Subject	Language/Shell	Type
AUDITOR—Dungan (1983)	Audit	Auditing allowance for bad debts	AL/X	ES
EDP AUDITOR—Hansen and Messier (1985a, 1985b)	EDP audit	Auditing advanced EDP systems	AL/X	ES
AGGREGATE—Munakata and O'Leary (1985)	Accounting information systems	System design of aggregated financial statements	Prolog	ES
ICE—Kelly (1984)	Audit	Audit planning process	INTERLISP	ES
TICOM—Bailey et al. (1985)	Audit	Internal control evaluation	PASCAL	AI*
TAXMAN—McCarty (1977)	Tax planning	Corporate reorganizations	MicroPLANNER/LISP	AI**
TAX ADVISOR—Michaelsen (1982a, 1982b)	Tax planning	Estate tax planning	EMYCIN	ES

*They suggest an interface with an ES.
**TAXMAN II is being developed (Miller 1984).

cludes knowledge about the clients of an audit firm, including information about their management, the industry, and the economy. The system modeled diagnostic judgments of auditors using LISP.

TICOM TICOM (Bailey et al. 1985) is an analytic query tool that incorporates AI concepts such as knowledge representation and graph simplification in the design, analysis, and evaluation of internal controls.

TAXMAN TAXMAN (McCarty 1977; and Miller 1984) was a model of the facts of certain corporate cases and some concepts from the IRS that produced the tax consequences of corporate reorganizations. The system used AI concepts in knowledge representation. The model was built using the judgment of a tax attorney using LISP.

4.4.3 Conceptual Design/Systems in Process

A number of systems have been developed to the conceptual design stage or are in the process of being built. These systems are summarized in Table 4.2. Because these systems have not been completed at the time this chapter was written they are not discussed in further detail.

TABLE 4.2
A SUMMARY OF REPORTED AI/ES CONCEPTUAL DESIGNS IN ACCOUNTING

Application	Description
Analytic Review—Braun (1983)	A problem of concern to the external auditor/CPA. Emulates auditor decision used in determining the relative importance of analytic review information compared to other audit evidence.
Price Analysis—Ramakrishna et al. (1983) and Dillard, Ramakrishna, and Chandrasekaran (1983)	Primarily a concern of the internal auditor. The system would analyze prices for fairness and reasonableness. Developed for the U.S. government. A design only.
Accountant's Opinion Formulation—Dillard and Mutchler (1984)	A problem of concern to the external auditor/CPA. Reviews the question of how auditors form an opinion of the financial statements. Addresses the issue of going concern. A design only.
Internal Controls—Meservy (1984)	Designed to help auditors evaluate the quality of the internal control systems.
Going Concern—Biggs (1985)	Addresses the issue of going concern judgment.
Capital Budgeting—Reitman (1985)	Designed for use by corporate management in the analysis of capital budgeting problems. Currently developing a prototype system in LISP.

4.5 ES COMPONENTS AND ACCOUNTING-BASED ESs

The knowledge base and the inference engine generally differ across functional applications of accounting-based ESs. If an expert system shell is used, then the shell defines the available set of knowledge representation schemes and inference engines.

4.5.1 Knowledge Base

ES applications in accounting have made use of two different knowledge base structures: rules and frames.

Rules Rules are structured as "if . . . then . . . ." The majority of the applications of ESs in accounting have used a rule-based approach. Typical of the rule-based approach is the rule in Hansen and Messier (1985a):

If:
1) Message control software is complete and sufficient, and
2) Recovery measures are adequate, and
3) Adequate documentation is generated to form a complete audit trail

Then: There is strong suggestive evidence (.8) that controls over data loss are adequate.

Another example of the rule-based approach is given in Michaelsen (1984). An example rule (in abbreviated form) is as follows.

If: 1) The client and/or spouse does wish to shift property income to another (not for support), etc. for at least ten years or until the death of the beneficiary, . . .,

Then: It is definite (1.) that client should transfer assets to a short-term trust.

Frames The use of a frames representation of knowledge has received only limited attention in accounting systems. A frames representation uses a networking approach to summarize a number of attributes associated with accounting concepts. Typically the knowledge is networked together using multiple frames to summarize the knowledge of the expert.

In Munakata and O'Leary (1985) a frame-based knowledge representation was used by attributing a set of characteristics to accounting titles. One frame was used to determine the "importance" of various words in an accounting title. For example, the system analyzes "net electric plant in service" to find that "plant" is the most "important" word, in that the characteristics in the next frame are a function of this word. The next frame assigns attributes to accounting titles according to the time dimension and the liquidity dimension of the most important word. For example, cash is a short-run asset and the most liquid asset.

In Kelly (1984) three levels of frames were used to characterize knowledge in the audit process. The first level of frames provided knowledge about global concerns for the audit planning process (e.g., management background and audit history). The second level of frames gives knowledge about the specific client environment (e.g., organization and manuals). The third level of frames summarized information on internal control functions (e.g., purchasing). Kelly also made use of rules in the IF-THEN form.

Representing Uncertainty Three of the expert systems developed in accounting use an uncertainty factor. Dungan (1983) and Hansen and Messier (1985a), in the context of AL/X, use an estimate of uncertainty in each rule. Michaelsen (1984) circumvents the uncertainty factor in EMYCIN by using a factor of 1.0 with each rule.

4.5.2 Inference Engine

If an expert system shell is used, then the inference engine generally is either backward chaining or forward chaining. In accounting ESs the goal normally is known and a backward-chaining approach is used to solve the problem. Dungan (1983) and Hansen and Messier (1985a) use the backward-chaining methodology embedded in AL/X. Michaelsen (1984) uses the backward-chaining inference engine in EMYCIN.

If a computer programming language is used, then the language can be used to define a general inference engine approach. For example, in Munakata and O'Leary (1985), the inference engine is the execution of a sequence of Prolog procedures. Kelly uses both forward- and backward-chaining rules.

4.6 RELATIONSHIP OF THE ACCOUNTING ESs TO EACH OTHER

Judging the extent of similarity of the accounting ESs to each other or to ESs in other disciplines has received little or no attention in the accounting literature. However, there are at least three dimensions on which to examine the similarity of the ESs: generic tasks, functional areas, and language/shell.

Some of the systems are related to each other based on the generic task they perform. For example, AUDITOR, EDP AUDITOR, and TAXADVISOR are diagnosis systems. Accordingly, these systems will use similar knowledge bases and inference engines.

Some of the systems are related to each other based on their functional similarity. For example, AUDITOR and EDP AUDITOR are auditing problems and thus are similar in terms of knowledge base and inference engine.

Another basis of similarity is the language or shell used to program the problem. To a certain extent this is a function of the functional area of application. For example, the audit ESs (AUDITOR and EDP AUDITOR) were written using AL/X. As noted, both audit ESs were based on diagnosis problems. As a result, it is not surprising that the same shell could be used in each system. Since they use the same shell, the inference engine and knowledge base are likely to be similar.

4.7 RELATIONSHIP OF THE ACCOUNTING ESs TO OTHER ESs

Two of the best known ESs are the mineral exploration system PROSPECTOR (Duda and Gaschnig 1981) and the medical system MYCIN (Buchanan and Shortliffe 1984). PROSPECTOR was developed to diagnose sites for potential mineral deposits. AL/X is based on PROSPECTOR and was developed to diagnose the underlying causes of oil platform shutdowns. MYCIN was developed to diagnose human illness. EMYCIN has evolved from MYCIN into an ES shell for general diagnosis purposes.

Two of the audit ESs used AL/X, and a tax accounting ES used EMY-

CIN to diagnose the appropriate tax plan. The ability of the accounting ES developers to design these accounting systems using these ES shells suggests that these accounting problems have a structure somewhat similar to the mineral exploration and medical diagnosis problems. In particular, it is likely that diagnostic-based problems such as those encountered in auditing are very similar to diagnostic-based problems from other disciplines.

However, this does not mean that all accounting problems are directly analogous to mineral exploration and medical diagnosis problems. For example, not all generic tasks of scheduling or design-based problems are accommodated as easily by using these shells. This is partially verified by the lack of use of EMYCIN and AL/X in these other types of generic tasks in the accounting ESs developed to date.

4.8 LIMITATIONS OF ES IN ACCOUNTING

There are a number of limitations associated with ESs in accounting. These limitations derive from ESs in general as applied to accounting and ESs in the accounting domain.

4.8.1 General Limitations of ESs

The current general limitations of ESs include the following development problems (Messier and Hansen 1983).

- A substantial effort is required to build an expert system.
- The size of the knowledge base is limited by current technology.
- The development of expert systems must cope with the current languages, since computers are unable to understand natural language.
- The development of an expert system requires an expert to spend time developing and debugging the system.

The general limitations of ESs also include problems with the current systems (McDermott 1984).

- The systems do not have a general knowledge to fall back on if the specific knowledge is insufficient.
- The systems do not learn from their experience.
- The systems often provide a trace of the decision. However, often this is not a satisfactory explanation of the decision.
- The systems have little knowledge of their own scope and limitations.

Recent efforts in ESs have relied on specific knowledge about the particular domain. Thus the lack of a general knowledge base suggests that current ESs are limited to problems that can be decomposed so that specific knowledge can be used effectively.

The need for the specific knowledge base indicates the importance of the expert. The system is only as good as the expert from whom the knowledge is derived and the ability of the systems personnel to determine the knowledge base from the expert.

4.8.2 Accounting-Specific Limitations of ESs

The accounting-specific limitations of ESs derive from the application of ESs to accounting. The primary limitations derive from changes in the knowledge base, which can occur in at least five ways.

First, the rule-making bodies that affect accounting (e.g., the SEC, FASB, and IRS) are likely to make rapid changes in the knowledge base. This is exemplified by recent proposed changes in the tax code and SEC compliance requirements. Second, the knowledge in the functional accounting discipline is likely to be subject to periodic revision. Third, company policy may lead to changes in the rule base of expert systems of internal auditors, for example. Fourth, the EDP auditor's knowledge base is subject to the technological changes of computers. Fifth, if the system contains information on management, the industry, or the economy (see Kelly 1984), then the system will require periodic updating as this information changes.

4.8.3 AI/ESs in Accounting Are DSSs

Another limitation of AI/ES in accounting is that the systems that have been developed to date are decision support systems (DSSs) and not independent systems. That is, in the applications discussed previously the systems were designed to support the decision making of an experienced user – not replace the decision maker or provide support for the neophyte decision maker. This is a characteristic not only of accounting ESs but of most ESs (Bonczek, Holsapple, and Whinston 1984). However, the example of the sorcerer's apprentice may suggest that at least in the near future the focus will be on the experienced user not the neophyte.

4.9 EXTENSIONS

This section briefly discusses some extensions in the area of accounting AI/ES. These applications come from two sources: (1) related disciplines and (2) functional areas for which few systems have been developed.

4.9.1 Related Applications

There are some ESs that have been developed in other disciplines that can be useful in accounting. For example, accounting firms schedule employees to meet client needs. There have been two ESs that schedule employees: ISIS (Fox and Smith 1984; and Glover, McMillan, and Glover 1984).

A set of related potential applications is found in the legal profession. Sergot (1982) discusses some possibilities of representing the law using AI.

4.9.2 Areas for Which Few or No Systems Have Been Developed

It is apparent from this review that there are only a few applications developed in most of the functional areas of accounting (see Table 4.3). In addition, there are no applications in the financial/SEC accounting area. This suggests that there is room for further applications in each of these

TABLE 4.3
FUNCTIONAL ACCOUNTING APPLICATIONS OF AI/ES

I. Auditing
   A. External Auditing
      1. Braun (1983)—Determine the importance of analytic review information in the audit process
      2. Dungan (1983)—Assessing adequacy of allowance for bad debts
      3. Dillard and Mutchler (1984)—Analysis of the auditor's opinion process
      4. Dillard and Mutchler (1984)—Auditor's analysis of going concern decisions
      5. Kelly (1984)—Audit planning process
      6. Meservy (1984)—Analysis of internal controls
      7. Bailey et al. (1985)—Designing, analyzing, and evaluating internal control systems
      8. Biggs (1985)—Auditor's analysis of going concern decisions
      9. Willingham and Wright (1985)—Loan evaluation system
   B. Internal Auditing
      Dillard, Ramakrishna, and Chandrasekaran (1983)—Analysis of the fairness and reasonableness of contract prices
   C. EDP Auditing
      Hansen and Messier (1985a, 1985b)—Evaluate the reliability of computerized accounting systems

II. Management Accounting/Planning and Control Systems
      Reitman (1985)—Capital budgeting

III. Tax Accounting
   A. McCarty (1977)—Tax implications of corporate reorganizations
   B. Michaelsen (1982a, 1982b, 1984)—Estate tax planning

IV. Accounting Information Systems
      Munakata and O'Leary (1985)—Accounting financial reports

V. Financial Accounting
      No known previous applications

functional areas. Elliot and Kielich (1985) discuss other potential applications.

4.10 CONCLUSION

This chapter has examined the current use of AI/ES in accounting and has outlined the primary functional areas of accounting and their relationship to generic tasks. Based on the information presented, accounting is a fruitful area for the application of AI/ES.

The primary characteristics of the accounting ES, TAXADVISOR, were analyzed and compared with the other systems using the same characteristics.

This chapter also analyzed the commercial and prototype expert systems in terms of their inference engines and knowledge bases. The accounting ESs were compared to each other and to ESs in other disciplines using generic task, function, and language/shell. The similarity was judged by the impact on inference engine and knowledge base. Finally, this chapter discussed the limitations of accounting ESs and some extensions of the current ESs.

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