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EXPERT SYSTEMS - THE NEW BUSINESS SIMULATION TOOL

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ABSTRACT

Expert systems are receiving a tremendous amount of attention in the data processing and business communities. But few business educators have been exposed to the base concepts of expert systems or can appreciate the effect they will have on business. This presentation covers the fundamental principles of the design and development of expert systems in business. Special emphasis is placed ability of an expert system to simulate the behavior of a manager or executive in a decision making situation. The structure and operation of a typical expert systems is presented. The use of expert system development tools and expert system shells is discussed. An example is given of how an expert system can be used to capture and simulate management knowledge and the decision making process. As expert system development tools become commonplace, business educators must become as proficient with expert systems as they are now with spreadsheets.

INTRODUCTION

Expert systems are receiving a tremendous amount of attention in the data processing and business communities. Settanni (1987) Nearly every computer magazine or journal contains a report on expert systems. The article often begins by describing expert systems as the exciting new frontier of computer science. However, the facts are very different. Work on the first expert system, MYCIN, began in the early 70s and there were several well established expert systems in place more than 10 years ago. Why, then are expert systems receiving so much attention today And, why is it so critical for business educators to become informed about Expert Systems? Finkel (1985), Guterl (1986).

There are three important reasons. First, expert systems permit the computer to simulate human reasoning and expertise. Therefore, expert systems can be applied to a very wide range of real life problems. If the problem solution can be expressed in terms of a knowledge base of rules and facts, then an expert system can be used. Second, modern expert system development tools allow even data processing novices to construct professional quality expert systems, provided they are familiar with the basic principles of expert system development. Finally, expert systems sill be common in forthcoming business software as embedded “intelligent front ends.’ And, the business person must understand the strengths and weaknesses of these embedded expert systems. Malone (1986)

THE ORIGIN OF EXPERT SYSTEMS

Expert systems are a natural outgrowth of Artificial Intelligence research. The stated goal of Artificial Intelligence (Al) research is to duplicate the functioning of the human brain by computer programs. Al was pioneered and developed at major university laboratories in £111, Stanford, Cal Berkeley, Carnegie- Mellon, and Yale. Mishkoff (1995)

Initially, Al was concerned with the computerization of logic, as it s used in problem solving. Board games like chess and checkers, along with the proof of mathematical theorems, provided the type of highly structured environment where early AI researchers could test their theories and programming skills. Mishkoff (1985)

Chess programs sere developed that played well enough to challenge expert players. The checkers program defeated the world champion. But, despite these initial successes intrinsic problems remained. A! researchers discovered it was very difficult to generalize the experience gained in these early game playing programs into handling real world situations.

Al research then focused on natural language processing. However, processing complex linguistic and semantic structures proved to be far more formidable a task than originally thought. While simple cases could be managed with little difficulty, automatically handling the ambiguity that humans routinely encounter was a far different story. It was soon realized that a staggering amount of information is utilized by a person in digesting even the most rudimentary prose.

Pressures of the economy forced Al research into more commercial areas. Development of industrial robots became an important research goal. Again, initial success was encouraging. But, the real AI breakthrough was to come in a far different area of study.

Medicine always seemed like an ideal Al application area. Medical Artificial Intelligence (MAT) was defined as the use of Artificial Intelligence techniques and computational support to simulate the mental processes a physician exerts in the treatment of patients. This definition allowed computer scientists to consider what was required to capture and simulate the expertise of the physician. Clancey (1994), Buchanan (1984), Fischer (1987), Smith (1996)

KNOWLEDGE-BASED SYSTEMS

The seminal idea needed to simulate human expertise came from a source far removed from either game playing or medicine. A program called DENDRAL, used to assist chemists in the determination of the structure of organic compounds from mass spectrometer data, derived its power not from automating logical functions, as so many Al programs had done before, but from processing tremendous volumes of information about the spectra of thousands of different chemical compounds embedded within the program. Mishkoff (1995)

The program’s developer, Edward Feigenbaum’s of Stanford, contended that “intelligence’ in real world situations comes from the proper employment of enormous amounts of specific knowledge about a subject, not from sophisticated logical operations. In short, Feigenbaum’s maintained that a human expert uses compiled data and experience encapsulated as “rules of thumb” or heuristics to solve problems. And that intelligent programs would have to process this type “knowledge’ to successfully emulate human experts.

EXPERT SYSTEMS

Another research team at Stanford carried Feigenbaum’s concept of knowledge-based systems forward with the development of MYCIN. Clancey (1994),Buchanan (1994) MYCIN was designed to act as an “intelligent consultant” to physicians, advising them on the diagnosis and treatment of bacterial infections. In essence, MYCIN was to simulate the decision-making powers of an expert physician.

The "knowledge" about bacterial infections was stored within MYCIN as a series of IF/THEN/ELSE "production" rules. These rules appeared in the form:

IF 1)the stain of the organism is gramneg. And

2)the morphology of the organism is rod, and

3)the aerobicity of the organism is aerobic

THEN there is strongly suggestive evidence (0.9) that the class of the organism is enterobateriaceae.

The IF portion of the rule is called the "premise" and the THEN portion of the rule is called the "conclusion." If the data in the premise is true, then the facts contained in the conclusion can be use to find a solution to a problem.

Because medicine rarely has clear cut 'yes or no" cases, MYCIN rules also allowed a Certainty Factor. The Certain Factor (0.8 in rule above) indicates the degree of brief in the applicability of the rule to the given situation. The knowledge base for MYCIN contained about 550 such rules.

MYCIN also permitted the rules to be displayed so that physicians could "trace" the "logic behind MYCIN's "advice" to the user.

When tested against physicians with an actual set of case studies, MYCIN performed admirably. And, since the program simulated an expert in the field, it was naturally called an 'expert system. A powerful new area of Al was established as a result of the Stanford
research effort.

THE STRUCTURE OF AN EXPERT SYSTEM

The MYCIN program could logically be broken down into three separate parts. the first of these was the knowledge base that contained the rules for diagnosis and treatment. This section contained the "expert" knowledge the program needed to solve problems. The second section was the mechanism required to find the proper rules for a particular case. This part was named the "inference engine." The last section was the "user interface." It collected the information needed by inference engine from the user, displayed results, and facilitated updating and modifying the knowledge base by the system developers. Mishkoff (l985(,Clancey (1984), Buchanan 1998

The inference engine carried out the logical processes needed to offer sound advice. This was done by "backward" chaining through the knowledge base. With backward chaining the inference enqine assumed a specific "goal state' or final diagnosis. This diagnosis is contained in a rule conclusion. The inference engine would examine the premise of that rule, and then find a rule where that premise appeared in a rule conclusion. The inference engine could then "chain" through the knowledge base verifying that the assumed diagnosis was consistent with the "initial state" --the symptoms and test results for the patient. If the symptoms matched the disease, than the diagnosis was correct. If not a new diagnosis was assumed and the process repeated.

Backward chaining is like first looking at the answers on a multiple choice test and then testing each to determine if they meet the question data. Backward chaining works best if there are few goal states and many initial states. It is very efficient in many practical situations and many of us use backward chaining In everyday problem solving.

EXPERT SYSTEM SHELLS

The MYCIN team realized that the user interface and inference engine portions of the program could stand alone and form an "expert system shell." Now, new expert systems could be constructed by subject matter experts merely by creating a new knowledge base. They called their expert system shell EMYCIN.

The potential of production rule-based expert systems using expert system shells was soon recognized by business. A number of commercially successful expert systems were developed in the early '50s. However, the initial expert systems were written in a specialized Al programming language called LISP. LISP programs were slow in execution. Schutzer (1997) Expert systems with large knowledge bases like MYCIN required large and expensive mainframe computers to complete consultations in any reasonable time period.

To improve performance and reduce development time for expert systems, special LISP machines and workstations were developed. These devices used the LISP language for basic machine instructions and could execute Al programs much faster than general purpose computers. But, LISP machines were costly and few organizations could commit to specialized computers that were restricted to expert systems applications.

PERSONAL COMPUTER EXPERT SYSTEM DEVELOPMENT TOOLS

The business computer environment changed radically with the introduction of the IBM PC. Expert system shells were developed for personal computers. However, the initial packages were still costly and the PC was slow in executing expert system programs. When the PC/AT and AT compatibles became the standard for business personal computers full-sized desk top expert systems were practical.

In addition, the cost for expert system development tools dropped steadily. Currently, dozens of sophisticated expert systems development tools (ESDT) are available in a price range from several thousand to several hundred dollars. Packages which fall into this price range include GURU, Personal Consultant Plus, Ml, Microexpert, ESIE, Expert Ease, and EXSYS. But the real price break in software occurred in early 1987 when Paperback Software delivered its VP-EXPERT system.

VP-EXPERT offers tools and capabilities of top of the line PC ESOT packages at a price in the $100 range.

The package received outstanding reviews Siegel (19871, and within three months of availability, Paperback Software indicated that more units of VP- EXPERT were delivered than all of the other PC packages put together'

AN EXPERT SYSTEM SIMULATING MANAGEMENT DECISION MAKING

A common problem facing sales executives is the proper strategy for deploying a sales force in the field. The types of strategies available to select selling effort allocation methods are discussed in detail by LaForge, Cravens, and Young LaForge (1996). The type of allocation strategy recommended depends on a number of factors including customer variations among the territories, the effort required to make a sale, the mathematical skills of the executive, the computers available to the organization, and even the reason why this strategy review is being performed.

The authors have taken the knowledge presented in LaForge, Cravens. and Young LaForge (1996) and constructed a expert system using VP-EXPERT to offer advice on sales force allocation methodology. The goal of this expert system is to illustrate how an expert system can be constructed to simulate and automate the reasoning process proposed in the article. indeed, the popular literature already describes the potential of computerized marketing expertise McCann (1987).

VP-EXPERT offers the designer of an expert system a coherent set of tools to construct the knowledge base. The knowledge base can be though of as containing the rules that capture the expertise to solve the problem. Rules can be augmented with WHY clauses that explain the reason each rule is used for a given situation. ASK statements are also utilized to that provide information to the user on how to enter data. In addition, there are a number of procedural statements and declarations to assist the program managing the display of questions and results.

Table 1 shows an edited version of the rules portion of knowledge base for DEPLOY. These rules were derived from the information contained in the article. The rule format is similar to that described for the MYCIN program. The rule premises contain conditional logical expressions. The rule conclusions indicate the action to be taken if the ;remise is true. The CNF values in the rule conclusions indicate the Certainty Factors associated with that particular rule. The semicolon [;] is a delimiter used by VP- EXPERT to indicate the end of rule.

Table 2 shows some of the 4V statements used in the DEPLOY knowledge base. The CHOICES statement allows VP-EXPERT to restrict the user resources to a given set of replies.

Figures 1, 2. 3, and 4 show a topical consultation dialog with VP-EXPERT. The program can be run in two modes, the production or RUNTIME mode and the testing or TRACE mode. These first four figures show the RUNTIME user interface.

Figure 1 illustrates a typical opening screen used to introduce the export system to the user. Figure 2 illustrates the results of the consultation. In this case, two different strategies were plausible, with one, the Empirical model, showing a higher degree of confidence. Figure 3 shows the questions asked by the system of the user, this screen shows three questions. Normally a single question would be displayed and then the screen cleared before the next one is asked. Figure ‘i shows what happens if the user inquired why a question was asked. In this case, the user wanted to know why the expert system asked about the computer facilities of the company

In the TRACE mode, the inner workings of the inference engine are made visible as it chains through the knowledge base to select various rules. This mode is used to debug the knowledge case. The screen is divided into three windows, The too window shows the user dialog, the one the bottom two windows show the rule generating the Question while the other shows the values the user entered as answers to the questions. Figure 5 shows the internal status of the expert system during a consultation. While Figure shows a typical TRACE display at the conclusion of consultation.

CONCLUSION

Expert system development tools are now in the class of electronic spreadsheets. Any business persons with access to a personal computer can avail themselves of this powerful instrument for capturing and automating complex business decisions. Reinstein (1986), Keim (l986), Deitz (1996) VP-EXPERT broke the price barrier by offering as impressive ESDT at cost within the reach of any company. Now, business educators must be in a position to understand expert system applications and illustrate their use so that the next generation of executives and managers are as comfortable with automating complex decision processes as they are now at automating complex calculations.

TABLE 1 -- RULES FROM THE DEPLOY EXPERT SYSTEM KNOWLEDGE BASE.

```
RULE 1
     IF     Territory_Variations = high AND
            Effort_Sales = high

     THEN   Analysis = Empirical_Model CNF 40
            Analysis = Portfolio_Model CNF 30
            ;
RULE 2
     IF     Territory_Variations = high AND
            Effort_Sales = low

     THEN   Analysis = Portfolio_Model CNF 40
            Analysis = Single_Factor_Model CNF 30
            ;
RULE 3
     IF     Territory_Variations = low AND
            Effort_Sales = high
     THEN   Analysis = Empirical_Model CNF 40
            Analysis = Judgment_Base_Model CNF 30
            ;
RULE 4
     IF     Territory_Variations = low AND
            Effort_Sales = low
     THEN   Analysis = Single_Factor_Model CNF 40
            Analysis = Portfolio_Model CNF 30
            ;
RULE 5
     IF     Purpose_Of_Analysis = Total_Reorganization
            AND    Analytical_Skill = high

     THEN   Analysis = Empirical_Model CNF 40
            Analysis = Portfolio_Model CNF 30
            ;
RULE 6
     IF     Purpose_Of_Analysis = Total_Reorganization
            AND           Analytical_Skill = low

     THEN   Analysis = Portfolio_Model CNF 40
            Analysis = Single_Factor_Model CNF 30
            ;
RULE 7
     IF     Purpose_Of_Analysis = Small_Adjustment AND
            Analytical_Skill = high

     THEN   Analysis = Empirical_Model CNF 40
            Analysis = Judgment_Base_Model CNF 30
            ;
RULE 8
     IF     Purpose_Of_Analysis = Small_Adjustment AND
            Analytical_Skill = low

     THEN   Analysis = Single_Factor_Model CNF 40
            Analysis = Portfolio_Model CNF 30
            ;
 RULE 9
     IF     Computer = none

     THEN   Analytical_Skill = low
            ;
RULE 10
     IF     Computer = MicroComputer  AND
            Use_Other_Models = yes

     THEN   Analytical_Skill = High CNF 80;
            RULE 11
```

```
     IF      Computer = MicroComputer OR
             Computer = MiniComputer AND
             Use_Other_Models = no

     THEN    Analytical_Skill = low
             ;
RULE 12
     IF      Computer = MainFrame

     THEN    Analytical_Skill = high
             ;
RULE 13
     IF      Computer = MiniComputer AND
             Use_Other_Models = yes

     THEN    Analytical_Skill = high
             ;
RULE 14
     IF      Market_Concentration = similar

     THEN    Territory_Variations = low
             ;
RULE 15
     IF      Market_Concentration = different

     THEN    Territory_Variations = high
             ;
RULE 16
     IF      Change_In_Sales = yes

     THEN    Effort_Sales = high
             ;
RULE 17
     IF      Change_In_Sales = no

     THEN    Effort_Sales = low
```

TABLE 2 -- ASK AND CHOICES STATEMENTS USED 10 COLLECT INFORMATION FROM THE USER DURING THE CONSULTATION

ASK Change In Sales:
If your sales people called on customers half as frequently as they currently do would your sales drop dramatically
CHOICES Change In Sales" yes/no:

ASK Market Concentration:
Is the concentration of customers quite similar from sales territory to sales
territory or are customer concentrations
different in different territories?; CHOICES Market Concentration: similar, different;

ASK Computer:
What is the most powerful Computer to which your company has access?;
CHOICES Computer: MicroComputer, MiniComputer, MainFrame, None;

49K Use_Other_Models:
Does your company use computerized mathematical models to aid in the decision-making process?";
CHOICES Use_Other_Models: Yes/No;

ASK Purpose_Of_Analysis:
Are you planning to make small, incremental adjustments to your sales force or a total reorganization or your selling effort?';
CHOICES Purpose_Of_Analysis: Small Adjustment, Iota 1 Reorganization;

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Personal Consultant Plus 1e<as Instruments, PD Box 8090a3. Dallas, TX 75380

Nil, Teknowledge, 525 University Aye, Suite 200, Palo Alto, CA 94301

Micro Expert, McGraw-Hill. NY. NY

ESIE, Lightwave Consultants, P.O. Box 290539, Tampa, FL 33617

Expert Ease, Human Edge Software, 2445 Faber Place, Palo Alto, CA 94303

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FIGURE 1
OPENING SCREEN OF CONSULTATION

```
SELL-STRONG

This EXPERT SYSTEMS program will assist you in
selecting an appropriate method for analyzing the
deployment   the sales force in your company.

Press any key to begin. . . .

Copyright 1987 Briggs and Sondak
```

FIGURE 2
TYPICAL CONCLUSION SCREEN

```
CONCLUSIONS

Several analysis techniques to select selling effort methods are
listed below in order from the most appropriate to least
appropriate for the task of deploying of your sales force.

Empirical Model CNF 59
Judgment Base Model CNF 46

1Help   2Go   3WhatIf   4Variable 5Rule   6Set   7Quit
Help the user
```

FIGURE 3
TYPICAL CONSULTATION SESSION SCREEN

```
Is the concentration of customers quite similar from sales
territory to sales territory or are customer concentrations
different in different territories?
similar                  different

If your sales people called on customers half as frequently
as they currently do would your sales drop dramatically?
yes                      no

Are you planning to make small, incremental adjustments to your
sales force or a total reorganization or your selling effort?
Small Adjustment         Total Reorganization

Enter to select   END to complete   /Q to Quit   ? for Unknown
```

FIGURE 4
CONSULTATION SESSION WITH "WHY" COMMAND INVOKED

```
     If your sales people called on customers half as frequently
     as they currently do would your sales drop dramatically?
yes                          no

 The question is being asked because:
 It would be difficult to perform the sophisticated mathmatics
  required by the Empirical Model and the Judgement-Based Model
  without the use of a computer.
 (Press Any Key to Continue)

MicroComputer               MiniComputer               MainFrame
None
```

FIGURE 5
CONSULTATION SESSION IN TRACE MODE

```
   The question below illustrates that the system could include many
   questions to determine how changes in sales efforts would be
   likely to affect sales levels.


     If your sales people called on customers half as frequently
     as they currently do would your sales drop dramatically?
yes                          no
```

```
Finding Effort_Sales
Testing 16

RULE 16 IF
Change_In_Sales = yes
THEN
Effort_Sales = high CNF 100

Finding Change_In_Sales
```

```
Market_concentration = different CNF
100

Territory_Variations = high CNF 100
```

FIGURE 6
[illegible]

```
                             CONCLUSIONS

     Several analysis techniques to select selling effort methods are
     listed below in order from the most appropriate to least
     appropriate for the task of deploying of your sales force.


Empirical Model CNF 64
Judgment Base Model CNF 51
```

```
Testing 8

RULE 8 IF
Purpose_Of_Analysis =
Small_Adjustment AND
Analytical_Skill = low
THEN
Analysis = Single_Factor_Model CNF 40
Analysis = Portfolio_Model CNF 30
```

```
Computer = MiniComputer CNF 100

Use_Other_Models = Yes CNF 100

Analytical_Skill = high CNF 100

Analysis = Empirical_Model CNF 64

Analysis = Judgment_Base_Model CNF 51
```