

# ***The Basics of Expert (Knowledge Based) Systems***

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## **1. Introduction**

Many expert systems are not complex or difficult to build. In a very simple case, consider a tree diagram on paper describing how to solve a problem. By making a selection at each branch point, the tree diagram can help someone make a decision. In a sense, it is a very simple expert system. This type of tree structured logic can easily be converted to a computerized system that is easier to use, faster and automated. More elaborate systems may include confidence factors allowing several possible solutions to be selected with different degrees of confidence.

Expert systems can explain why data is needed and how conclusions were reached. A system may be highly interactive (directly asking the user questions) or embedded where all input comes from another program. The range of problems that can be handled by expert systems is vast.

Expert systems can be developed with Expert System Shells. An expert system shell is a software programming environment which enables the construction of expert or knowledge based systems. Expert systems software can be developed for any problem that involves a selection from among a definable group of choices where the decision is based on logical steps. Any area where a person or group has special expertise needed by others is a possible area for an expert system. Expert systems can help automate anything from complex regulations to aiding customers in selecting from among a group of products, or diagnosing equipment problems.

Traditionally expert system development has been a major expense both in time and money. Getting even a single system built was a big project. The cost of system development prohibited building expert systems on more than a few projects. The key to implementing expert systems widely, effectively and at low cost is to have easy-to-use expert system development tools readily available to the experts. As more power is needed for certain applications, higher level tools can be used with advanced features to give you complete control over the inference engine, modularization of the knowledge base, flow of execution, the user interface and integration with other programs.

## **2. Scope of Definition - Formal Description**

Definitions of expert systems vary. Some definitions are based on function. Some definitions are based on structure. Some definitions have both functional and structural components. Many early definitions assume rule-based reasoning. The following is a sample of some definitions.

Expert knowledge is often scarce and valuable. Expert systems are computer programs that capture some of that knowledge and allow its dissemination to others.

An Expert (Knowledge Based) System is a problem solving and decision making system based on knowledge of it's task and logical rules or procedures for using knowledge. Both the knowledge and the logic is obtained from the experience of a specialist in the area (Business Expert).

An Expert System is a program that emulates the interaction a user might have with a human expert to solve a problem. The end user provides input by selecting one or more answers from a list or by entering data. The program will ask questions until it has reached a conclusion. The conclusion may be the selection of a single solution or list of possible solutions arranged in order of likelihood. The program can explain, in English, how it arrived at its conclusion and why.

### **3. *Expert System Component Facts***

#### **3.1 Rule Based Reasoning**

Currently, the most common form of expert system structure of a Rule-based Expert System

- User Interface
- Friendly
- Maybe "Intelligent"
- Knowledge of how to present information
- Knowledge of user preferences...possibly accumulate with use

#### **3.2 Databases**

- Contains some of the data of interest to the system
- May be connected to on-line company or public database
- Human user may be considered a database

#### **3.3 Inference Engine**

- general problem-solving knowledge or methods
- interpreter analyzes and processes the rules
- scheduler determines which rule to look at next
- the search portion of a rule-based system
- takes advantage of heuristic information
- otherwise, the time to solve a problem could become prohibitively long
- this problem is called the combinatorial explosion
- expert-system shell provides customizable inference engine

#### **3.4 Knowledge Base (rule base)**

- contains much of the problem solving knowledge
- Rules are of the form IF condition THEN action
- condition portion of the rule is usually a fact - (If some particular fact is in the database then perform this action)
- action portion of the rule can include
- actions that affect the outside world (print a message on the terminal)
- test another rule (check rule no. 58 next)

- add a new fact to the database (If it is raining then roads are wet).
  - Rules can be specific, a priori rules (e.g., tax law . . . so much for each exemption) - represent laws and codified rules
  - Rules can be heuristics (e.g. If the meal includes red meat then choose red wine). “rules of thumb” - represent conventional wisdom.
  - Rules can be chained together (e.g. “If A then B” “If B then C” since A--->B--->C so “If A then C”).
- (If it is raining then roads are wet. If roads are wet then roads are slick.)
- Certainty factors represent the confidence one has that a fact is true or a rule is valid

#### **4. Knowledge Engineering Facts**

The discipline of building expert systems. The Role of the Knowledge Engineer includes:

- Knowledge acquisition
  - the process of acquiring the knowledge from human experts or other sources (e.g. books, manuals)
  - can involve developing knowledge to solve the problem
- knowledge elicitation
  - coaxing information out of human experts
  - Knowledge representation
- Method used to encode the knowledge for use by the expert system
- Common knowledge representation methods include rules, frames, and cases.
- Putting the knowledge into rules or cases or patterns is the knowledge representation process

#### **5. Case-Based Reasoning (Method in which to create a Knowledge Base)**

The Case-based Reasoning Process

- Uses past experiences
- Based on the premise that human beings use analogical reasoning or experiential reasoning to learn and solve complex problems
- Particularly evident in precedence-based reasoning
- Useful when little evidence is available or information is incomplete
- Cases consist of information about the situation, the solution, the results of using that solution and key attributes that can be used for quickly searching for similar patterns of attributes
- Elements in a case-based reasoning system are, the case base - set of cases, and the index library - used to efficiently search and quickly retrieve cases that are most appropriate or similar to the current problem.
- Similarity metrics - used to measure how similar the current problem is to the past cases selected by searching the index library
- The adaption module - creates a solution for the current problem by either modifying the solution (structural adaptation) or creating a new solution using the same process as was used in the similar past case (derivational adaptation).
- Learning: If no reasonably appropriate prior case is found then the current case and its human created solution can be added to the case base thus allowing the system to learn.

#### **6. Sample Applications of Expert Systems**

##### **Credit Analysis**

Many companies use expert systems to assist with credit analysis. The benefits of using expert systems for credit analysis are speed and accuracy, both which far exceed human capacity. American Express uses expert systems to process unusual requests. The system, called Authorizer’s Assistant, can process requests much quicker than the customer service representatives manually, and has decreased the bad guess

rate. The rate was originally 15 percent error, but now has decreased to 4 percent with the installation of the system.

## **Security Trading and Portfolio Analysis**

Morgan Stanley and Rockwell International are just a few of the investment firms that use expert systems. With the rule base in effect, the system can easily evaluate rate of return and risk exposure. Composing a portfolio manually can be time consuming, but the expert system can do it very quickly and generate consistent results. Morgan Stanley announced an increase of \$1 million profit after the installation its system (Holsapple 17).

Manufacturer's Hanover Trust Co. has its own strategic technology and research group called STAR. The company has implemented six knowledge-based systems and plans to implement three more in the near future. The company cites that six out of every eight deals generated by the system is successful (Feinberg 22).

Insurance companies also use expert systems. A study shows that 12 out of 28 of the largest insurance companies in the U.S. have developed expert systems. New York University has designed the Actuary Consultant System (ACS) to assist actuaries with evaluating risk on life insurance policies and disabilities (Holsapple 17). Lockheed Corporation has developed the Medical Charge Evaluation and Control (MEDCHEC) to check medical claims submitted (Holsapple 17).

Financial planning services have typically been very costly. Expert systems reduce the costs of these services making the planning process quicker, easier, and more consistent. Employers are now able to offer this service as a benefit to their employees much more easily than before (Phillips 29).

Financial plans can help individuals with insurance, retirement, investments, income taxes, estate planning, and cash and debt management (Phillips 29). The plans have general rules and should be flexible enough to accommodate personalized options, risk attitudes and individual preferences.

## **7. Advantages and Disadvantages**

### **7.1. Advantages of Expert Systems**

- Permanence - Expert systems do not forget, but human experts may
- Reproducibility - Many copies of an expert system can be made, but training new human experts is time-consuming and expensive
- If there is a maze of rules (e.g. tax and auditing), then the expert system can "unravel" the maze
- Efficiency - can increase throughput and decrease personnel costs. Although expert systems are expensive to build and maintain, they are inexpensive to operate . Development and maintenance costs can be spread over many users. The overall cost can be quite reasonable when compared to expensive and scarce human experts. Cost savings: Wages - (elimination of a room full of clerks) Other costs - (minimize loan loss)
- Consistency - With expert systems similar transactions handled in the same way. The system will make comparable recommendations for like situations.
- Humans are influenced by recency effects (most recent information having a disproportionate impact on judgment) primacy effects (early information dominates the judgment).
- Documentation - An expert system can provide permanent documentation of the decision process
- Completeness - An expert system can review all the transactions, a human expert can only review a sample
- Timeliness - Fraud and/or errors can be prevented. Information is available sooner for decision making
- Breadth - The knowledge of multiple human experts can be combined to give a system more breadth that a single person is likely to achieve
- Reduce risk of doing business
- Consistency of decision making
- Documentation
- Achieve Expertise

- Entry barriers - Expert systems can help a firm create entry barriers for potential competitors
- Differentiation - In some cases, an expert system can differentiate a product or can be related to the focus of the firm.
- Computer programs are best in those situations where there is a structure that is noted as previously existing or can be elicited

## **7.2. Disadvantages of Rule-Based Expert Systems**

- Common sense - In addition to a great deal of technical knowledge, human experts have common sense. It is not yet known how to give expert systems common sense.
- Creativity - Human experts can respond creatively to unusual situations, expert systems cannot.
- Learning - Human experts automatically adapt to changing environments; expert systems must be explicitly updated. Case-based reasoning and neural networks are methods that can incorporate learning.
- Sensory Experience - Human experts have available to them a wide range of sensory experience; expert systems are currently dependent on symbolic input.
- Degradation - Expert systems are not good at recognizing when no answer exists or when the problem is outside their area of expertise.

## **8. Criticisms of Expert Systems**

When the rule set for an expert system is written, the knowledge of humans are observed. Video tapes, interviews, protocol, and other techniques are used to try to capture the thought process of experts. A problem with expert systems is writing the rules themselves. Thought processes that are highly rule-oriented are easier to write than ones that rely more on creativity or intuition. Another problem is that often experts themselves disagree. Different experts might take different courses of action or go through different thought processes when given the same problem to solve. Thus there is disagreement in the professional community about the validity of expert systems.

Expert systems are improving as technology advances. In the past, expert systems have received criticism and some negative publicity because of the failures that were highly publicized. Unfortunately, the successes are less publicized, because companies want to maintain their competitive edge. Expert systems are a great tool for companies especially, as depicted here, companies in finance. It is important for companies to remember, however, that humans should make the final decision, and not the computer. Humans still have the insight and intuition that computers are unable to possess--for now, anyway.

## **9. References**

Implementations & Uses, 1986, Chichester, England: Ellis Horwood Ltd. • Brule, James F. Artificial Intelligence: Theory, Logic and Application, 1986, Blue Ridge Summit, PA: TAB Books. •Edwards, Alex and Connell, N.A.D. Expert Systems in Accounting, 1989, Herfordshire, UK: Prentice Hall International (UK) Ltd. •Forsyth, Richard, Expert Systems:

Principles and Case Studies, 1984, London: Chapman and Hall Computing. • Harmon, Paul and King, David. Expert Systems: Artificial Intelligence in Business. 1985, New York: Wiley. •Liebowitz, Jay, Introduction to Expert Systems, 1988, Santa Cruz, CA: Mitchell Publishing, Inc. •Michaelsen, Robert H.; Michie, Donald and Boulanger, Albert. "The Technology of Expert Systems" Byte; April 1985; 10(4): pp. 303-312. •Rich, Elaine and Knight, Kevin. Artificial Intelligence Second Edition. 1991, New York:

McGraw-Hill. •Waterman, Donald A. A Guide to Expert Systems, 1986, Reading, MA: Addison-Wesley. •Winston, Patrick H. and Prendergast, Karen A. (Editors). The AI Business: Commercial Use of Artificial Intelligence, 1984, Cambridge, MA: The MIT Press.

Dictionary of Computing, 1986, New York: Oxford University Press. •Bishop, Peter. Fifth Generation Computers Concepts