Study Unit 3: Expert Systems

Introduction

A system which employs human expertise captured in a CBIS to solve problems which usually require human expertise. An expert system either supports or automates decision making in an area of which experts perform better than non-experts. It is also known as "Expert Computing Systems", or "Knowledge Based Systems".

Expert systems are used in two different ways:

- Decision support: Reminding information or options to an experienced decision maker. Commonly used in medicine.
- Decision making: Allowing an unqualified person to make a decision beyond his or her level or training or expertise. Commonly used in industrial systems.
- Most Popular Applied AI Technology
    a) Enhance Productivity
    b) Augment Work Forces
    c) *Narrow* Problem-Solving Areas or Tasks
- Provide Direct Application of Expertise
- Expert Systems Do Not Replace Experts, But They Make their Knowledge and Experience More Widely Available
- Permit Non-experts to Work Better

An Expert system is a domain in which Artificial Intelligence stimulates the behavior and judgement of a human or an organization containing experts. It acquires relevant knowledge from its knowledge base, and interprets it as per the user's problem. The data in the knowledge base is essentially added by humans who are experts in a particular domain. However, the software is used by non-experts to gain information. It is used in various areas of medical diagnosis, accounting, coding, gaming and more.

Breaking down an expert system, essentially is an AI software that uses knowledge stored in a knowledge base to solve problems. This usually requires a human expert, and thus, it aims at preserving human expert knowledge in its knowledge base. Hence, expert systems are computer applications developed to solve complex problems in a particular domain, at an extraordinary level of human intelligence and expertise.

Box 2.1: Definition of Expert System
An attempt to Imitate Expert Reasoning Processes and Knowledge in Solving Specific Problems.

The Three C's of ES

Characteristics of Expert Systems

- They have high-performance levels
- They are easy to understand
- They are completely reliable
- They are highly responsive

- Capabilities of Expert Systems

The expert systems are capable of a number of actions including:

- Advising
- Assistance in human decision making
- Demonstrations and instructions
- Deriving solutions
- Diagnosis
- Interpreting inputs and providing relevant outputs
- Predicting results
- Justification of conclusions
- Suggestions for alternative solutions to a problem

Expertise

- The extensive, task-specific knowledge acquired from training, reading and experience
    - Theories about the problem area
    - Hard-and-fast rules and procedures
    - Rules (heuristics)
    - Global strategies
    - Meta-knowledge (knowledge about knowledge)
    - Facts
- Enables experts to be better and faster than nonexperts
- Expertise is usually associated with a high degree of intelligence, but not always with the smartest person
- Expertise is usually associated with a vast quantity of knowledge
- Experts learn from past successes and mistakes
- Expert knowledge is well-stored, organized and retrievable quickly from an expert
- Experts have excellent recall

Human Expert Behaviors

- Recognize and formulate the problem
- Solve problems quickly and properly

- Explain the solution
- Learn from experience
- Restructure knowledge
- Break rules
- Determine relevance
- Degrade gracefully

Transferring Expertise

- Objective of an expert system
    - To transfer expertise from an expert to a computer system and
    - Then on to other humans (nonexperts)
- Activities
    - Knowledge acquisition
    - Knowledge representation
    - Knowledge inferencing
    - Knowledge transfer to the user
- Knowledge is stored in a *knowledge base*

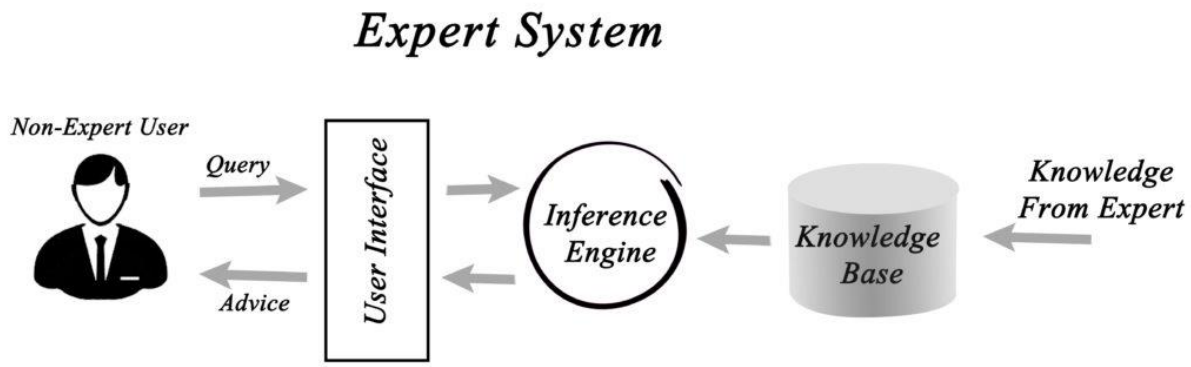
Inferencing

- Reasoning (Thinking)
- The computer is programmed so that it can make inferences
- Performed by the *Inference Engine*

Architecture of Expert Systems

There are 5 Components of expert systems:

1) Knowledge Base
2) Inference Engine
3) Knowledge acquisition and learning module
4) User Interface
5) Explanation module



All ES Components

- Knowledge Acquisition Subsystem
- Knowledge Base
- Inference Engine
- User Interface
- Blackboard (Workplace)
- Explanation Subsystem (Justifier)
- Knowledge Refining System
- User
- Most ES *do not have* a Knowledge Refinement Component

Knowledge Acquisition

- Knowledge acquisition is the accumulation, transfer and transformation of problem-solving expertise from experts and/or documented knowledge sources to a computer program for constructing or expanding the knowledge base
- Knowledge acquisition and learning module: This component functions to allow the expert systems to acquire more data from various sources and store it in the knowledge base.
- Requires a knowledge engineer

Knowledge Base

- The knowledge base contains the knowledge necessary for understanding, formulating, and solving problems

- The knowledge base in an expert system represents facts and rules. It contains knowledge in specific domains along with rules in order to solve problems, and form procedures that are relevant to the domain.
- Two Basic Knowledge Base Elements
    - Facts
    - Special heuristics, or rules that direct the use of knowledge
    - Knowledge is the primary raw material of ES
    - Incorporated knowledge representation

Inference Engine

- The most basic function of the inference engine is to acquire relevant data from the knowledge base, interpret it, and to find a solution as per the user's problem. Inference engines also have explanatory and debugging abilities.
- The *brain* of the ES
- The control structure (rule interpreter)
- Provides methodology for reasoning

User interface:

- This component is essential for a non-expert user to interact with the expert system and find solutions.

Explanation module:

- As the name suggests, this module helps in providing the user with an explanation of the achieved conclusion.

Strategies Used By The Inference Engine

The Inference Engine uses the following strategies to recommend solutions:

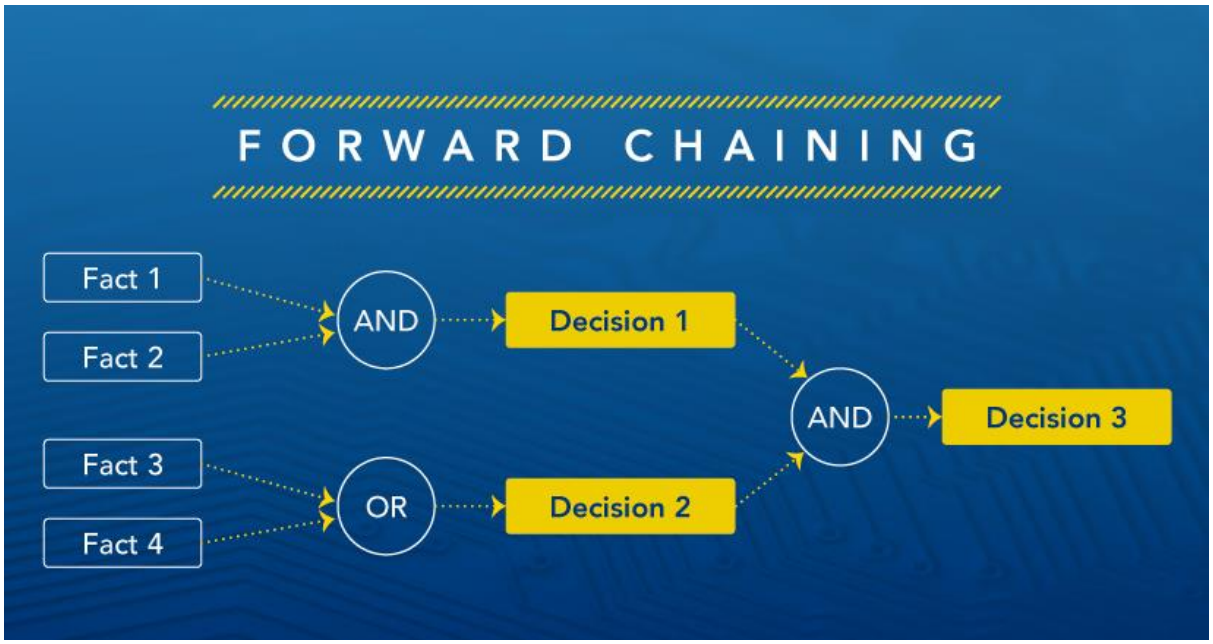
- Forward Chaining
- Backward Chaining

Forward Chaining

With this strategy, an expert system is able to answer the question "What can happen next?"

By following a chain of conditions and derivations, the expert system deduces the outcome after considering all facts and rules. It then sorts them before arriving at a conclusion in terms of the suitable solution.

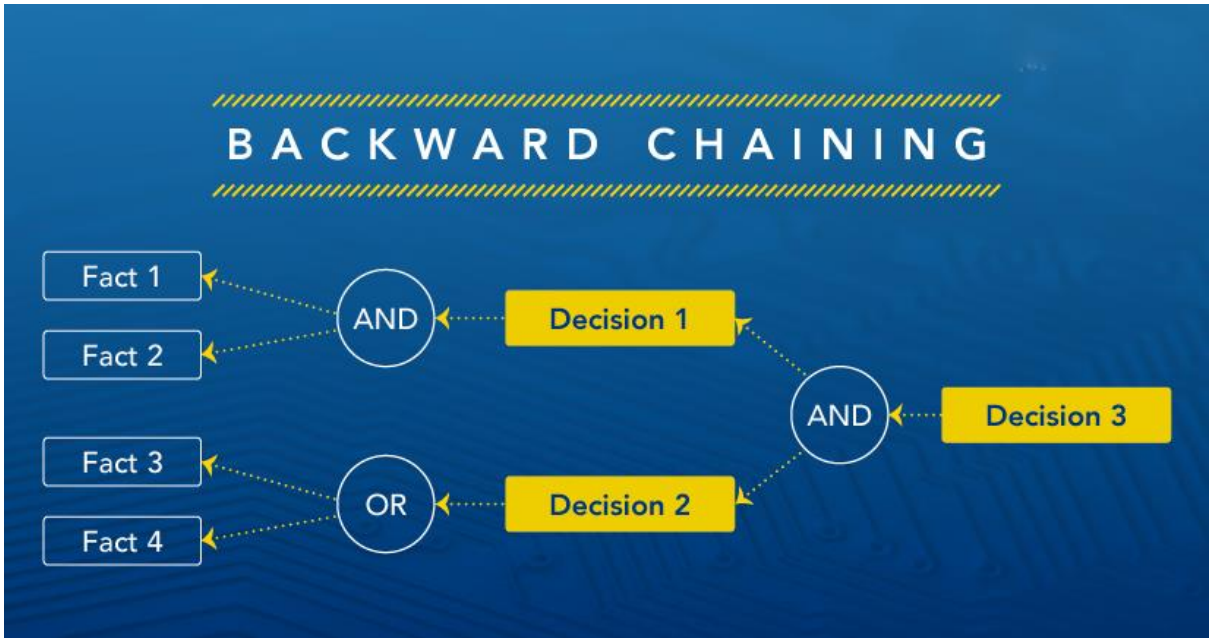
This strategy is followed while working on conclusion, result, or effect. For example, predicting how does the share market prediction of share market will react to the changes in the interest rates.



Backward Chaining

Backward chaining is used by an expert system to answer the question "Why did this happen?"

Depending upon what has already occurred, the inference engine tries to identify the conditions that could have happened in the past to trigger the final result. This strategy is used to find the cause or the reason behind something happening. For example, the diagnosis of different types of cancer in humans.



Problem Areas Addressed by Expert Systems

a) Interpretation systems
b) Prediction systems
c) Diagnostic systems
d) Design systems
e) Planning systems
f) Monitoring systems
g) Debugging systems
h) Repair systems
i) Instruction systems
j) Control systems

Types of Expert System Technology

ES technologies come in various levels; they are:

Expert System Development Environment

- The ES development environment contains a set of hardware tools (Workstations, minicomputers, mainframes), High level symbolic programming languages [LISt

Programming (LISP) and PROgrammation en LOGique (PROLOG)], as well as large data bases.

Tools

- Tools, as an ES technology, assists in reducing the effort and cost involved in developing an expert system to a large extent.

Shells

- A Shell an expert system that functions without a knowledge base. It provides developers with knowledge acquisition, inference engine, user interface, and explanation facility. For example – Java Expert System Shell (JESS), Vidwan, etc.

Expert Systems Benefits

1) Increased Output and Productivity
2) Decreased Decision Making Time
3) Increased Process(es) and Product Quality
4) Reduced Downtime
5) Capture Scarce Expertise
6) Flexibility
7) Easier Equipment Operation
8) Elimination of Expensive Equipment
9) Operation in Hazardous Environments
10) Accessibility to Knowledge and Help Desks
11) Integration of Several Experts' Opinions
12) Can Work with Incomplete or Uncertain Information
13) Provide Training
14) Enhancement of Problem Solving and Decision Making
15) Improved Decision-Making Processes
16) Improved Decision Quality
17) Ability to Solve Complex Problems
18) Knowledge Transfer to Remote Locations
19) Enhancement of Other MIS

Problems and Limitations of Expert Systems

- Knowledge is not always readily available
- Expertise can be hard to extract from humans
- Each expert's approach may be different, yet correct
- Hard, even for a highly skilled expert, to work under time pressure
- Expert system users have natural cognitive limits
- ES work well only in a *narrow domain* of knowledge
- Most experts have no independent means to validate their conclusions
- Experts' vocabulary often limited and highly technical
- Knowledge engineers are rare and expensive
- Lack of trust by end-users
- Knowledge transfer subject to a host of perceptual and judgmental biases
- ES may not be able to arrive at valid conclusions
- ES sometimes produce incorrect recommendations

Traditional Systems versus Expert Systems

A key distinction between the traditional system as opposed to the expert system is the way in which the problem related expertise is coded. Essentially, in conventional applications, the problem expertise is encoded in both program as well as data structures. On the other hand, in expert systems, the approach of the problem related expertise is encoded in data structures only. Moreover, the use of knowledge in expert systems is vital. However, traditional systems use data more efficiently than the expert system.

One of the biggest limitations of conventional systems is that they are not capable of providing explanations for the conclusion of a problem. That is because these systems try to solve problems in a straightforward manner. However, expert systems are capable of not only providing explanations but also simplifying the understanding of a particular conclusion.
Generally, an expert system uses symbolic representations to perform computations. On the contrary, conventional systems are incapable of expressing these terms. They only simplify the problems without being able to answer the "how" and "why" questions. Moreover, the

problem-solving tools are present in expert systems as opposed to the traditional ones, and hence, various types of problems are most often entirely solved by the experts of the system.

Expert Systems Types

- Expert Systems Versus Knowledge-based Systems
- Rule-based Expert Systems
- Frame-based Systems
- Hybrid Systems
- Model-based Systems
- Ready-made (Off-the-Shelf) Systems
- Real-time Expert Systems