Expert Systems Lecture 6

An expert system, is an interactive computer-based decision tool that uses both facts and heuristics to solve difficult decision making problems, based on knowledge acquired from an expert.
An expert system is a model and associated procedure that exhibits, within a specific domain, a degree of expertise in problem solving that is comparable to that of a human expert.

Expert system Vs traditional computer:

Inference engine + knowledge = Expert system
Algorithm + data structures = Program in traditional computer
Expert systems are computer applications which embody some non-algorithmic expertise for solving certain types of problems.
For example, expert systems are used in diagnostic applications. They also play chess, make financial planning decisions, configure computers, monitor real time systems, underwrite insurance policies and perform many services which previously required human expertise.

Expert System Components And Human Interfaces
Expert systems have a number of major system components and interface with individuals who interact with the system in various roles.

Components and Interfaces
- **Knowledge base :** A declarative representation of the expertise; often in IF THEN rules ;
- **Working storage** : The data which is specific to a problem being solved;
- **Inference engine** : The code at the core of the system which derives recommendations from the knowledge base and problem-specific data in working storage;
- **User interface** :The code that controls the dialog between the user and the system.

■ Roles of Individuals who interact with the system
‡ Domain expert :The individuals who currently are experts in solving the problems; here the system is intended to solve;
‡ Knowledge engineer : The individual who encodes the expert's knowledge in a declarative form that can be used by the expert system;
‡ User : The individual who will be consulting with the system to get advice which would have been provided by the expert.

Expert System Shells
Many expert systems are built with products called expert system shells. A shell is a piece of software which contains the user interface, a format for declarative knowledge in the knowledge base, and an inference engine. The knowledge and system engineers uses these shells in making expert systems.
‡ Knowledge engineer : uses the shell to build a system for a particular problem domain.
‡ System engineer : builds the user interface, designs the declarative format of the knowledge base, and implements the inference engine.
Depending on the size of the system, the knowledge engineer and the system engineer might be the same person.

Expert System Characteristics
Expert system operates as an interactive system that responds to questions, asks for clarifications, makes recommendations and generally aids the decision-making process.

Expert systems have many Characteristics :

■ Operates as an interactive system:- This means an expert system :

- Responds to questions
- Asks for clarifications
- Makes recommendations
- Aids the decision-making process.

■ Tools have ability to sift (filter) knowledge

- Storage and retrieval of knowledge
- Mechanisms to expand and update knowledge base on a continuing basis.

■ Make logical inferences based on knowledge stored

- Simple reasoning mechanisms is used
- Knowledge base must have means of exploiting the knowledge stored, else it is useless; e.g., learning all the words in a language, without knowing how to combine those words to form a meaningful sentence.

■ Ability to Explain Reasoning: - Remembers logical chain of reasoning; therefore user may ask

◊ for explanation of a recommendation
◊ factors considered in recommendation

Enhances user confidence in recommendation and acceptance of expert system

■ Domain- Specific: A particular system caters a narrow area of specialization; e.g., a medical expert system cannot be used to find faults in an electrical circuit.

- Quality of advice offered by an expert system is dependent on the amount of knowledge stored.

■ Capability to assign Confidence Values

‡ Can deliver quantitative information
‡ Can interpret qualitatively derived values
‡ Can address imprecise and incomplete data through assignment of confidence values.

Applications

‡ Best suited for those dealing with expert heuristics for solving problems.
‡ Not a suitable choice for those problems that can be solved using purely numerical techniques.

■ Cost-Effective alternative to Human Expert

‡ Expert systems have become increasingly popular because of their specialization, albeit in a narrow field.
‡ Encoding and storing the domain-specific knowledge is economic process due to small size.
‡ Specialists in many areas are rare and the cost of consulting them is high; an expert system of those areas can be useful and cost-effective alternative in the long run.

Expert System Features

Goal Driven Reasoning or Backward Chaining an inference technique which uses IF-THEN rules to repetitively break a goal into smaller sub-goals which are easier to prove;

■ Coping with Uncertainty:- The ability of the system to reason with rules and data which are not precisely known;

■ Data Driven Reasoning or Forward Chaining: - An inference technique which uses IF-THEN rules to deduce a problem solution from initial data;

■ Data Representation :- The way in which the problem specific data in the system is stored and accessed;

■ User Interface:- That portion of the code which creates an easy to use system;

■ Explanations: - The ability of the system to explain the reasoning process that it used to reach a recommendation.

Uncertainty Often the Knowledge is imperfect which causes uncertainty. To work in the real world,

Expert systems must be able to deal with uncertainty. one way is to associate a numeric value with each piece of information in the system. the numeric value represents the certainty with which the information is known. There are different ways in which these numbers can be defined, and how they are combined during the inference process.

Knowledge Acquisition
Knowledge acquisition includes the elicitation, collection, analysis, modeling and validation of knowledge.

Issues in Knowledge Acquisition
The important issues in knowledge acquisition are:
- knowledge is in the head of experts
- Experts have vast amounts of knowledge
- Experts have a lot of tacit knowledge
    - ‡ They do not know all that they know and use
    - ‡ Tacit knowledge is hard (impossible) to describe
- Experts are very busy and valuable people
- One expert does not know everything
- Knowledge has a "shelf life"

Techniques for Knowledge Acquisition
The techniques for acquiring, analyzing and modeling knowledge are : Protocol-generation techniques, Protocol analysis techniques, Hierarchy-generation techniques, Limited-information and Matrix-based techniques, constrained-processing Sorting tasks, techniques, Diagram-based techniques.

Protocol-generation techniques : Include many types of interviews (unstructured, semi-structured and structured), reporting and observational techniques.

Protocol analysis techniques - Used with transcripts of interviews or text-based information to identify basic knowledge objects within a protocol, such as goals, decisions, relationships and attributes. These act as a bridge between the use of techniques. Protocol-based and knowledge modeling techniques.

Hierarchy-generation techniques
Involve creation, reviewing and modification of hierarchical knowledge. Hierarchy-generation techniques, such as laddering, are used to build taxonomies or other hierarchical structures such as goal trees and decision networks. The Ladders are of various forms like concept ladder, attribute ladder, composition ladders.

Matrix-based techniques
Involve the construction and filling-in a 2-D matrix (grid, table), indicating such things, as may be, for example, between concepts and properties (attributes and values) or between problems and solutions or between tasks and resources, etc. The elements within the matrix can contain: symbols (ticks, crosses, question marks), colors , numbers , text.

Sorting techniques
Used for capturing the way people compare and order concepts; it may reveal knowledge about classes, properties and priorities.

- Limited-information and constrained-processing tasks Techniques that either limit the time and/or information available to the expert when performing tasks. For example, a twenty-questions technique provides an efficient way of accessing the key information in a domain in a prioritized order.

■ Diagram-based techniques: Include generation and use of concept maps, state transition networks, event diagrams and process maps. These are particularly important in capturing the "what, how, when, who and why" of tasks and events.

Expert System Shells

An Expert shell is a software development environment. It contains the basic components of expert systems. A shell is associated with a prescribed method for building applications by configuring and instantiating these components.

Shell components and description

The generic components of a shell : the knowledge acquisition, the knowledge Base, the reasoning, the explanation and the user interface.

■ **Knowledge Base :-** A store of factual and heuristic knowledge. It provides one or more knowledge Expert system representation tool schemes for expressing knowledge about the application domain. Some tools use both Frames (objects) and IF-THEN rules. In PROLOG the knowledge is represented as logical statements.

■ **Reasoning Engine** – Inference mechanisms for manipulating the symbolic information and knowledge in the knowledge base form a line of reasoning in solving a problem. simple modus The ponens inference backward mechanism chaining of can range IF-THEN from rules to Case-Based reasoning.

■ **Knowledge Acquisition subsystem** A subsystem to help experts in build knowledge bases. However, collecting knowledge, needed to solve problems and build the knowledge base, is the biggest bottleneck in building expert systems.

■ **Explanation subsystem** - A subsystem that explains the system's actions. The explanation can range from how the final or intermediate solutions were arrived at justifying the need for additional data.

■ **User Interface:** A means of communication with the user. The user interface is generally not a part of the expert system technology. It was not given much attention in the past. However, the user interface can make a critical difference in the perceived utility of an Expert system.