Unit 5

Expert system:

Basics concepts of expert system, Applications of expert system, Structure of expert systems, How expert system works, Problems areas suitable for expert systems, Benefits and capabilities of expert systems, Problems and limitations of expert system, Expert system success factors, Types of expert systems, Expert systems on the web

Textbook 2 : Chapter 10:10.5,10.6,10.7,10.8,10.9,10.10,10.11,10.12,10.13,10.14

Basics concepts of expert system

BASIC CONCEPTS OF EXPERT SYSTEMS

- Expert systems are **computer-based information systems** that use **expert knowledge to attain high-level decision performance in a narrow problem domain**.
    - **Example - MYCIN**, developed at Stanford University in the early 1980s for medical diagnosis, is generally considered to be the most well known expert system.
    - Other applications **in taxation, credit analysis, equipment maintenance, and fault diagnosis** have also been popular in most large- and medium-sized organizations as a major tool for improving productivity and quality
- The basic concepts of expert systems include several fundamental issues, including
    - what is expertise,
    - who are experts,
    - how expertise can be transferred, and
    - how the system works.

EXPERTS

- **An expert is a person who has special knowledge, judgment, experience, and methods, along with the ability to apply these talents to give advice and solve problems.**
- It is the expert's job to provide knowledge about how to perform the task that the knowledge- based system will perform.
- The expert knows which facts are important and understands the meaning of the relationships among them.
  - In diagnosing a problem with an automobile's electrical system, for example, an expert mechanic knows that fan belts can break and cause the battery to discharge.
- So far, there is no standard definition of expert, but decision performance and the level of knowledge a person has are typical criteria used in determining whether some-one is an expert.
- **Typical experts have a few general concepts**.
  - **First, they must be able to solve the problem and achieve a performance level significantly better than the average.**
  - **Second, experts are relative.**
    - An expert at one time or in one region may not be an expert in another time or region.
    - Experts have expertise that can solve problems and explain certain phenomenon in the problem domain.
- Typically, **human experts are capable of doing the following:**
  - Recognizing and formulating the problem
  - Solving the problem quickly and correctly
  - Explaining the solution
  - Learning from experience
  - Restructuring knowledge
  - Breaking rules if necessary
  - Determining relevance
  - Degrading gracefully (being aware of one's limitations),

EXPERTISE

- **Expertise is the extensive task -specific knowledge possessed by experts.**
- **The level of expertise determines the performance of a decision.**
- Expertise is often acquired from **training, reading, and experience in practice**.
  - It includes explicit knowledge, such as theories learned in a textbook or a classroom, and implicit knowledge gained from experience.

The following is a list of possible knowledge types:

- **Theories about the problem domain**
- **Rules and procedures regarding the general problem domain**
- **Rules (heuristics) about what to do in a given problem situation**
- **Global strategies for solving these types of problems**
- **Meta knowledge (knowledge about knowledge)**
- **Facts about the problem area.**

- **Experts who have the types of knowledge outlined above are able to make better and faster decisions than non-experts in solving complex problems.**
- **Expertise often has the following characteristics:**
  - Expertise is usually associated with a **high degree of intelligence**, but not necessarily with the smart 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 quickly retrievable** from an expert.
  - Experts can **call up patterns from their experience** (excellent recall)

FEATURES OF EXPERT SYSTEMS

Expert systems must have the following features

1. Expertise:

- Experts are differentiated by their levels of expertise.
- Expert systems must possess the expertise that will enable the system to make expert-level decisions.
- Expert system must exhibit expert performance and adequate robustness

2. Symbolic reasoning:

- The basic rationale of artificial intelligence is to **use symbolic reasoning** rather than mathematical calculation.
- This is also true for expert systems. That is, **knowledge must be represented symbolically, and the primary reasoning mechanism must also be symbolic**.
- Typical symbolic reasoning mechanism include **backward chaining and forward chaining**

3. Deep knowledge:

- This concerns the level of expertise in a knowledge base.
- The knowledge base must contain complex knowledge not easily found among non- experts

4. Self-knowledge:

- Expert systems must be able to **examine their own reasoning** and explain why a particular conclusion was reached.
- Most experts have very **strong learning capabilities** that enable them to constantly update their knowledge

- Expert systems also need to be able to **learn from their successes and failures and from other knowledge sources**.

The development of expert systems is divided into two generations.

1. Most first- generation expert systems use if-then rules to represent and store their knowledge.
2. Second-generation expert systems are more flexible in adopting multiple knowledge representations and reasoning methods.

- They may integrate neural networks with rule- based inferences to pursue a higher decision performance.
- Table 10.1 provides a comparison between conventional systems and expert systems.

TABLE 10.1 Comparison of Conventional Systems and Expert Systems

Conventional Systems	*Expert Systems*
Information and its processing are usually combined in one sequential program.	Knowledge base is clearly separated from the processing (inference) mechanism (i.e., knowledge rules are separated from the control).
Program does not make mistakes (programmers or users do).	Program may make mistakes.
Do not (usually) explain why input data are needed or how conclusions are drawn.	Explanation is a part of most ES.
Require *all* input data. May not function properly with missing data unless planned for.	Do not require all initial facts. Typically can arrive at reasonable conclusions with missing facts.
Changes in the program are tedious (except in DSS).	Changes in the rules are easy to make.
The system operates only when it is completed.	The system can operate with only a few rules (as the first prototype).
Execution is done on a step-by-step (algorithmic) basis.	Execution is done by using heuristics and logic.
Effective manipulation of large databases.	Effective manipulation of large knowledge bases.
Representation and use of data.	Representation and use of knowledge.
Efficiency is usually a major goal.	Effectiveness is the major goal.
Effectiveness is important only for DSS.	
Easily deal with quantitative data.	Easily deal with qualitative data.
Use numerical data representations.	Use symbolic and numerical knowledge representations.
Capture, magnify, and distribute access to numeric data or information.	Capture, magnify, and distribute access to judgment and knowledge.

WHY DO WE NEED EXPERT SYSTEMS?

There are **several reasons** for a company to adopt an expert system.

1. First, experts in the company may retire or leave. Expert systems are an excellent tool for **preserving the professional knowledge** crucial to competitiveness.
2. Second, certain knowledge needs to be documented or examined. Expert systems are an excellent tool for **documenting professional knowledge** for examination or improvement.
3. Third, education and training are important but difficult tasks. Expert systems are a good tool for **training new employees** and disseminating knowledge in an organization.
4. Finally, experts are often rare and expensive. Expert systems allow knowledge to be transferred more **easily at a lower cost**.

- Of course, expert systems are not real experts.
- They have advantages but also short- comings
- Table 10.2 shows the comparison between human experts and expert systems

TABLE 10.2 Difference Between Human Experts And Expert Systems

Features	*Human experts*	*Expert systems*
Mortality	Yes	No
Knowledge transfer	Hard	Easy
Knowledge documentation	Hard	Easy
Decision consistency	Low	High
Unit usage cost	High	Low
Creativity	High	Low
Adaptability	High	Low
Knowledge scope	Broad	Narrow
Knowledge type	Common sense and technical	Technical
Knowledge content	Experience	Symbols

APPLICATIONS OF EXPERT SYSTEMS

- Expert systems have been applied in many business and technological areas to support decision-making.
- A scenario of using expert systems is shown in AIS in Action 10.6.

AIS IN ACTION 10.6

SAMPLE SESSIONS OF A RULE-BASED EXPERT SYSTEM

A rule-based expert system contains rules in its knowledge base. The rules are used to generate questions for the user and to provide recommendations. Suppose you have an expert system that recommends notebook computers based on a customer's needs. The following is a possible consultation session:

☐ What is your primary task to be performed on the notebook computer?

- ☐ Word processing
- ☐ Communications
- ☐ Multimedia applications

Answer: 1 (click the first check box)

☐ Where are you going to use the notebook more often?

- ☐ Office
- ☐ Travel

Answer: 2 (click the second check box)

☐ What is your budget range?

- ☐ below 10K,
- ☐ between 10–12K,
- ☐ above 12K

Answer: 2 (click the third check box)

☐ System recommendation

You should consider buying an IBM X24

Reasons: it is light and more suitable for your word-processing and travel needs, it also fits your budget.

- As in Action 10.7 shows a few recent sample applications

AIS IN ACTION 10.7

SAMPLE APPLICATIONS

Customer Support at Logitech. LogiTech is one of the world's largest vendors of mouses and Web cameras. Because it offers many different models of mouses and Web cameras, customer support is a major challenge. To take advantage of the Internet and technologies in intelligent systems, the company deploys an interactive knowledge portal to provide Web-based self-help customer support to its QuickCam customer in North America. The noHold Knowledge Platform emulates the way a human would interact with a customer, allows the user to ask questions or describe problems in natural language, and carries on an intelligent conversation with the user until it has enough information to provide an accurate answer. (Source: "Logitech Deploys Online Customer Support," *Expert Systems*, November 2001.)

China's freight train system. An expert system was developed in China to allocate freight cars and determine what and how much to load on each car. The ES is integrated with the existing MIS, and the system is distributed to many users. For details see Geng et al. (1999).

Electricity market forecaster. EnvaPower developed an electricity market forecasting system, called MarketMonitor, that uses artificial intelligence techniques to gather, synthesize, and analyze a large amount of factors that may affect the consumption of electricity. (*Source: Expert Systems*, May 2002, Vol. 19, No. 2.)

- Early applications, such as DENDRAL for molecular-structure identification, and MYCIN for medical diagnosis, were primarily in the field of science.
- XCON, or configuration of the VAX computer system in the Digital Equipment Corporation, was a successful example in business.
- More recent applications in risk management and pension fund advising are also interesting. ‘
- Table 10.3 shows some representative expert systems and their application domains.

TABLE 10.3 Sample Applications Of Expert Systems

Expert Systems	*Organization*	*Application Domain*
MYCIN	Stanford University	Medical diagnosis
XCOM	DEC	System configuration
Expert Tax	Coopers & Lybrand	Tax planning
Loan Probe	Peat Marwick	Loan evaluation
La-Courtier	Cognitive Systems	Financial planning
LMOS	Pacific Bell	Network management
Fish-Expert	North China	Disease diagnosis

The following pre some classic applications that we should know,

DENDRAL

- The DENDRAL project was initiated by Edward Feigenbaum in 1965.
- **It used a set of knowledge or rule-based reasoning commands to deduce the likely molecular structure of organic chemical compounds from known chemical analyses and mass spectrometry data**
- DENDRAL proved to be fundamentally important in demonstrating how rule based reasoning could be developed into powerful knowledge-engineering tools and led to the development of other rule-based reasoning programs at the **Stanford Artificial Intelligence Laboratory (SAIL**), the most important of which was MYCIN

MYCIN

- **MYCIN is a rule-based expert system that diagnoses bacterial infections of the blood.**
- It was developed by a group of researchers at Stanford University in the 1970s.
- By asking questions and backward-chaining through a rule base of about 500 rules, MYCIN can recognize about 100 causes of bacterial infections. This allows **MYCIN to recommend effective drug prescriptions. '**
- In a controlled test, its performance was rated to be equal to human specialists.
- The reasoning and uncertainty processing methods are pioneers in the areas and have generated long-term impact in expert system development

The following pre some classic applications that we should know, (contd..)

XCON

- XCON is a **rule-based system** developed at the **Digital Equipment Corporation**, a big mini-computer manufacturer merged with **Compaq** Computers in 2000.
- The system uses rules to help determine the optimal system configuration that fits customer requirements.
- The system **can handle in one minute a customer request that typically took the sales team 20-30 minutes**.
- With the expert system, **service accuracy increased to 98 percent** from a manual approach of 65 percent, thereby saving millions of dollars every year.

CREDIT ANALYSIS

- Expert systems have been developed to support the **needs of commercial lending institutions**.
- They can help **analyze the credit record of a customer and assess a proper credit line**.
- Rules in the knowledge base can also help assess the **risk and risk-management policies**
- This kind of system is employed in over **one-third of the top 100 commercial banks** in the United States and Canada.

PENSION FUND ADVISER

- Nestle Foods Corporation has developed an expert system that provides **information on employee pension fund status**.
- The system maintains **an up-to-date knowledge** base to give participants advice concerning the impact of regulation changes and conformance with new standards.
- A system offered on the Internet at the Pingtung Teacher's College in southern Taiwan has functions that allow the participants to plan their retirement through a **what-if analysis** that calculates their pension benefits under different scenarios.

AREAS FOR APPLICATIONS

Expert systems have been applied commercially in the following areas

1. **Finance:**
   - insurance evaluation,
   - credit analysis,
   - tax planning,
   - financial report analysis,'
   - financial planning,
   - performance evaluation.
2. **Data processing:**
   - system planning,
   - equipment selection,
   - equipment maintenance,
   - vendor evaluation,
   - network management.
3. **Marketing:**
   - customer-relationship management,
   - market analysis,
   - product planning,
   - market planning
4. **Human resources:**
   - human resource planning,
   - performance evaluation,
   - staff scheduling,
   - pension management,
   - legal advising.
5. **Manufacturing:**
   - production planning,
   - quality management,
   - product design,
   - plant- site selection,
   - equipment maintenance and repair

STRUCTURE OF EXPERT SYSTEMS

Expert systems can be viewed as having two environments:

i) **the development environment and**

ii) **the consultation (runtime) environment** (Figure 10.3).

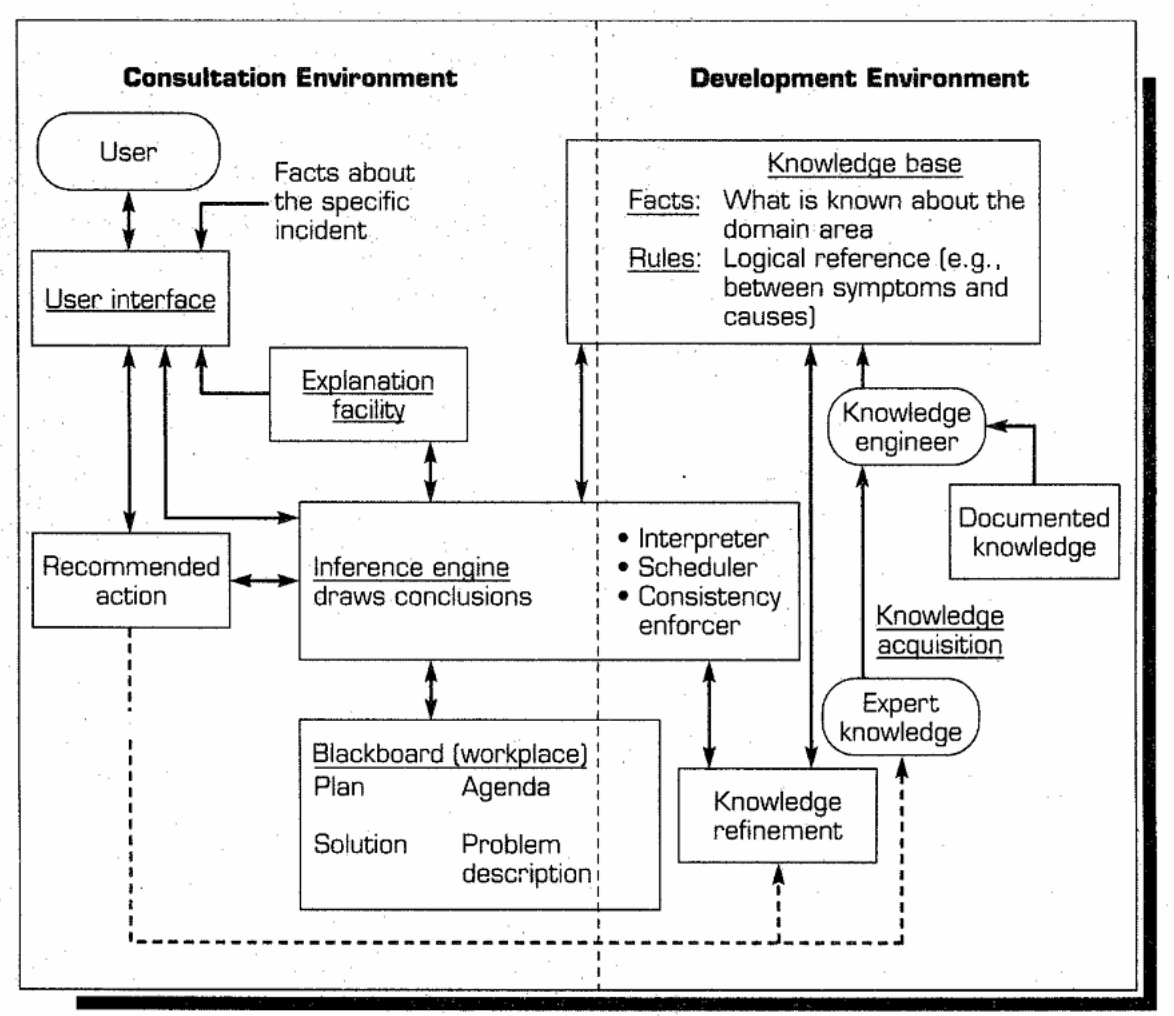

FIGURE 10.3 STRUCTURE OF AN EXPERT SYSTEM

- **The development environment is used by an ES builder to build the components and put knowledge into the knowledge base.**
- **The consultation environment is used by a non-expert to obtain expert knowledge and advice.**
- **These environments can be separated once a system is completed.**
- The **three major components** that appear in virtually every expert system are
  - **i) the knowledge base,**
  - **ii) inference engine, and**
  - **iii) user interface.**
- An expert system that interacts with users may also contain the following additional components.
  - **Knowledge acquisition subsystem**
  - **Blackboard (workplace)**
  - **Explanation subsystem (justifier)**
  - **Knowledge-refining system**
- Most expert systems do not at present contain the knowledge-refinement component.

A brief description of each component of ES is as follows.

KNOWLEDGE ACQUISITION SUBSYSTEM

- Knowledge acquisition is the **accumulation, transfer, and transformation of problem- solving expertise from experts or documented knowledge sources to a computer program for constructing or expanding the knowledge base.**
- Potential sources of knowledge include **human experts, textbooks, multimedia documents, databases** (public and private), special research reports, and information available on the Web.

INTELGENT DECISION SUPPORT SYSTEMS

- Acquiring knowledge from experts is a complex task that often creates a bottleneck in ES construction.
- In building large systems one needs a knowledge engineer or knowledge elicitation expert to interact with one or more human experts in building the knowledge base,
- Typically the knowledge engineer helps the expert structure the problem area by interpreting and integrating human answers to questions, drawing analogies, posing counterexamples, and bringing conceptual difficulties to light.

KNOWLEDGE BASE

- The knowledge base contains the relevant knowledge necessary for understanding, formulating, and solving problems.
- It includes two basic elements:
  (1) facts, such as the problem situation and the theory of the problem area, and
  (2) special heuristics or rules that direct the use of knowledge to solve specific problems in a particular domain. (In addition, the inference engine can include general purpose problem- solving and decision-making rules)
- The heuristics express the informal judgmental knowledge in an application area. Knowledge, not mere facts, is the primary raw mate- rial of expert systems.

INFERENCE ENGINE

- The "brain" of the ES is the inference engine, also known as the control structure or the rule interpreter (in rule-based ES).
- This component is essentially a computer pro- gram that provides a methodology for reasoning about information in the knowledge base and on the blackboard, and for formulating conclusions.
- This component provides directions about how to use the system's knowledge by developing the agenda that organizes and controls the steps taken to solve problems whenever consultation takes place

EXPLANATION SUBSYSTEM (JUSTIFIER)

- The ability to trace responsibility for conclusions to their sources is crucial both in the transfer of expertise and in problem-solving. The explanation subsystem (also called Justifier) can trace such responsibility and explain the ES behavior by interactively answering questions like the following:
  - Why was a certain question asked by the expert system?
  - How was a certain conclusion reached?
  - Why was a certain alternative rejected?
  - What is the plan to reach the solution?
  - For example, what remains to be established before a final diagnosis can be determined?
  - In simple ES, the explanation shows the rules used to derive the specific recommendations.

KNOWLEDGE REFINING SYSTEM

- Human experts have a knowledge-refining system; that is, they can analyze their own knowledge and its use, learn from it, and improve on it for future consultations.
- Similarly, such evaluation is necessary in computerized learning so that the program can analyze the reasons for its success or failure.
- This could lead to improvements that result in a more accurate knowledge base and more effective reasoning.
- Such a component is not available in commercial expert systems at the moment but is being developed in experimental ES at several universities and research institutions.