Expert System

Introduction:
- Expert system provides expert quality advice, diagnoses and commendations given real world problems.
- An expert system is a computer program that simulates the judgment and behavior of a human or an organization that has expert knowledge and experience in a particular field.
- Expert system contains a knowledge base containing accumulated experience and a set of rules that are applied to the knowledge base.
- E.g. Of expert systems are those that play chess and that assist in medical diagnosis.
- Expert systems are meant to solve real problems which normally would require a specialized human expert (such as a doctor).
- Building an expert system involves extracting the relevant knowledge from the human expert.
- Extracting knowledge from the expert in a way that can be used by a computer is generally a difficult task, requiring its own expertise.
- A knowledge engineer has the job of extracting knowledge and building the expert system knowledge base.
- Knowledge acquisition for expert systems is a big area of research, with a wide variety of techniques developed.
- It is acquired by developing an initial prototype based on information extracted by interviewing the expert, and then iteratively refining it based on feedback both from the expert and from potential users of the expert system.
- The most widely used knowledge representation scheme for expert systems is rules.
- Statistical techniques are used to determine these certainties.
- Rule-based systems are easily modifiable and make it easy to provide reasonably helpful traces of the system's reasoning.
- Expert systems have been used to solve a wide range of problems in domains such as medicine, mathematics, engineering, geology, computer science, business, law, defense and education.
- Types of problem that expert system solves involve:
  - diagnosis (e.g., of a system fault, disease or student error);
  - design (of a computer systems, hotel etc);
  - And interpretation (for example, geological data).

The Building Blocks of Expert Systems:
Every expert system consists of two principal parts:
- The knowledge base;
- And the reasoning, or inference engine.

The knowledge base of expert systems contains both factual and heuristic knowledge.
- Factual knowledge is that knowledge of the task domain that is widely shared, typically found in textbooks or journals, and commonly agreed upon by those knowledgeable in the particular field.
- Heuristic knowledge is the less rigorous, more experiential, more judgmental knowledge of performance. Heuristic knowledge is rarely discussed, and is largely individualistic.

Knowledge representation:
- Knowledge representation formalizes and organizes the knowledge.
- One widely used representation is the production rule, or simply rule.
- A rule consists of an IF part and a THEN part (also called a condition and an action).
- The IF part lists a set of conditions in some logical combination.
The piece of knowledge represented by the production rule is relevant to the line of reasoning being developed if the IF part of the rule is satisfied; consequently, the THEN part can be concluded, or its problem-solving action taken.

Expert systems whose knowledge is represented in rule form are called rule-based systems.

If the chaining starts from a set of conditions and moves toward some conclusion, the method is called forward chaining.

If the conclusion is known (for example, a goal to be achieved) but the path to that conclusion is not known, then reasoning backwards is called for, and the method is backward chaining.

These problem-solving methods are built into program modules called inference engines or inference procedures that manipulate and use knowledge in the knowledge base to form a line of reasoning.

Knowledge engineering:

Knowledge engineering is the art of designing and building expert systems.

Knowledge engineers are its practitioners.

Knowledge engineering is an applied part of the science of artificial intelligence which, in turn, is a part of computer science.

A knowledge engineer is a computer scientist who knows how to design and implement programs that incorporate artificial intelligence techniques.

There are two ways to build an expert system.

They can be built from scratch, or built using a piece of development software known as a "tool" or a "shell."

What Knowledge Engineers Do?

A knowledge engineer interviews and observes a human expert or a group of experts and learns what the experts know, and how they reason with their knowledge.

The engineer then translates the knowledge into a computer-readable language, and designs an inference engine, a reasoning structure, that uses the knowledge appropriately.

He also determines how to integrate the use of uncertain knowledge in the reasoning process, and what kinds of explanation would be useful to the end user.

Next, the inference engine and facilities for representing knowledge and for explaining are programmed, and the domain knowledge is entered into the program piece by piece.

It may be that the inference engine is not just right; the form of knowledge representation is awkward for the kind of knowledge needed for the task; and the expert might decide the pieces of knowledge are wrong.

All these are discovered and modified as the expert system gradually gains competence.

Expert System Architecture:

Almost all expert systems also have an explanation subsystem, which allows the program to explain its reasoning to the user.

Expert systems also have a knowledge base editor which helps the expert or knowledge engineer to easily update and check the knowledge base.
The applications of expert system

1. **Diagnosis and Troubleshooting of Devices and Systems of all kinds:**
   - This class comprises systems that deduce faults and suggest corrective actions for a malfunctioning device or process.
   - Medical diagnosis was one of the first knowledge areas to which ES technology was applied (for example, see Shortleaf 1976), but diagnosis of engineered systems quickly surpassed medical diagnosis.

2. **Planning and Scheduling:**
   - Systems that fall into this class analyze a set of one or more potentially complex and interacting goals in order to determine a set of actions to achieve those goals, and/or provide a detailed temporal ordering of those actions.
   - Examples involve airline scheduling of flights, personnel, and gates; manufacturing job-shop scheduling; and manufacturing process planning.

3. **Financial Decision Making:**
   - The financial services industry has been a vigorous user of expert system techniques. Advisory programs have been created to assist bankers in determining whether to make loans to businesses and individuals.
   - Insurance companies have used expert systems to assess the risk presented by the customer and to determine a price for the insurance.

4. **Knowledge Publishing:**
   - This is a relatively new, but also potentially explosive area.
   - The primary function of the expert system is to deliver knowledge that is relevant to the user's problem, in the context of the user's problem.
   - The two most widely distributed expert systems in the world are in this category.
     - The first is an advisor which counsels a user on appropriate grammatical usage in a text.
     - The second is a tax advisor that accompanies a tax preparation program and advises the user on tax strategy, tactics, and individual tax policy.

5. **Process Monitoring and Control:**
   - Systems falling in this class analyze real-time data from physical devices with the goal of noticing anomalies, predicting trends, and controlling for both optimality and failure correction.
   - Examples of real-time systems that actively monitor processes can be found in the steel making and oil refining industries.

6. **Design and Manufacturing:**
   - These systems assist in the design of physical devices and processes, ranging from high-level conceptual design of abstract entities all the way to factory floor configuration of manufacturing processes.

**Benefits of Expert System to End Users:**

Primarily, the benefits of Expert Systems to end users include:

1. A speed-up of human professional or semi-professional work -- typically by a factor of ten and sometimes by a factor of a hundred or more.
2. Within companies, major internal cost savings. For small systems, savings are sometimes in the tens or hundreds of thousands of dollars; but for large systems, often in the tens of millions of dollars and as high as hundreds of millions of dollars. These cost savings are a result of quality improvement, a major motivation for employing expert system technology.
3. Improved quality of decision making. In some cases, the quality or correctness of decisions evaluated after the fact show a ten-fold improvement.

4. Preservation of scarce expertise. ESs are used to preserve scarce know-how in organizations, to capture the expertise of individuals who are retiring, and to preserve corporate know-how so that it can be widely distributed to other factories, offices or plants of the company.

5. Introduction of new products. A good example of a new product is a pathology advisor sold to clinical pathologists in hospitals to assist in the diagnosis of diseased tissue.

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