Expert Systems

Chapter 6

Introduction

An Expert System is a collection of programmes or Computer Software that solves problems in the domain of interest.

It is called system because it consists of both problem solving component and a support component.

The process of building Expert System is called knowledge engineering and is done by knowledge Engineer

An Expert system is a set of program that manipulates encoded knowledge to solve problem in a specialized domain that normally requires human expertise.

A computer system that simulates the decision- making process of a human expert in a specific domain.

An expert system's knowledge is obtained from expert sources and coded in a form suitable for the system to use in its inference or reasoning processes. The expert knowledge must be obtained from specialists or other sources of expertise, such as texts, journals, articles and data bases.

An expert system is an "intelligent" program that solves problems in a narrow problem area by using high-quality, specific knowledge rather than an algorithm.

Expert systems provide the following important features:

Facility for non-expert personnel to solve problems that require some expertise

Speedy solution

Reliable solution

Cost reduction

Power to manage without human experts

Wider areas of knowledge

Use of expert system is especially recommended when

Human experts are difficult to find

Human experts are expensive

Knowledge improvement is important

The available information is poor, partial, incomplete

Problems are incompletely defined There is lack of knowledge among all those who need it The problem is rapidly changing legal rules and codes

Block Diagram

There is currently no such thing as "standard" expert system. Because a variety of techniques are used to create expert systems, they differ as widely as the programmers who develop them and the problems they are designed to solve. However, the principal components of most expert systems are **knowledge base, an inference engine, and a user interface,** as illustrated in the figure.

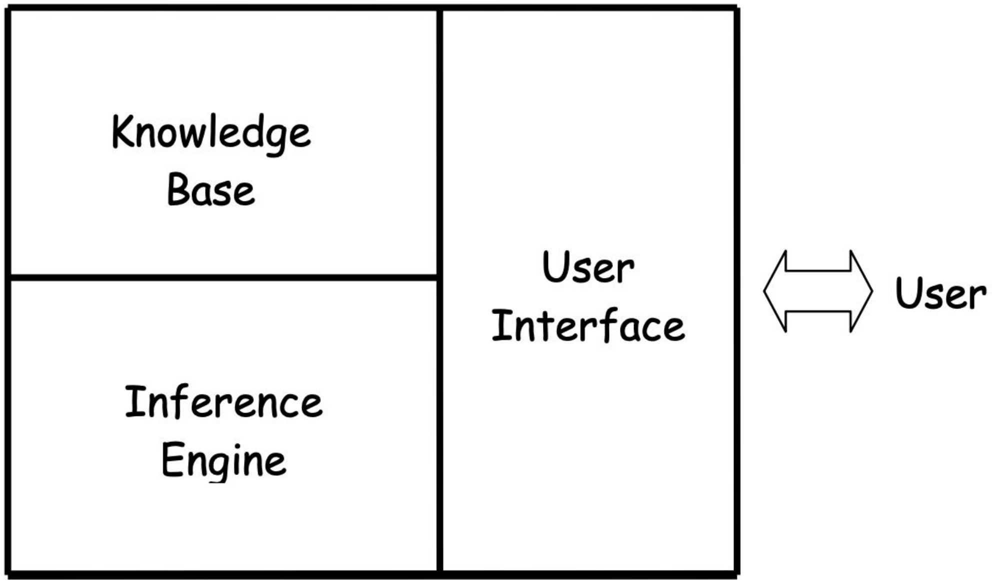

Fig: Block Diagram of expert system

1. Knowledge Base

The component of an expert system that contains the system's knowledge is called its knowledge base. This element of the system is so critical to the way most expert systems are constructed that they are also popularly known as *knowledge-based systems*

A knowledge base contains both declarative knowledge (facts about objects, events and situations) and procedural knowledge (information about courses of Depending on the form of knowledge representation chosen, the two

knowledge may be separate or integrated. Although many knowledge representation techniques have been used in expert systems, the most prevalent form of knowledge representation currently used in expert systems is the *rule-based production* system approach.

To improve the performance of an expert system, we should supply the system with some knowledge about the knowledge it posses, or in other words, meta-knowledge.

2. Inference Engine

Simply having access to a great deal of knowledge does not make you an expert; you also must know how and when to apply the appropriate knowledge.

Similarly, just having a knowledge base does not make an expert system intelligent.

The system must have another component that directs the implementation of the knowledge. That element of the system is known variously as the *control structure*, the *rule interpreter*, or the *inference engine*.

The inference engine decides which heuristic search techniques are used to determine how the rules in the knowledge base are to be applied to the problem.

In effect, an inference engine “runs” an expert system, determining which rules are to be invoked, accessing the appropriate rules in the knowledge base, executing the rules , and determining when an acceptable solution has been found.

3. User Interface

The component of an expert system that communicates with the user is known as the *user interface*.

The communication performed by a user interface is bidirectional.

At the simplest level, we must be able to describe our problem to the expert system, and the system must be able to respond with its recommendations.

We may want to ask the system to explain its “reasoning”, or the system may request additional information about the problem from us.

Beside these three components, there is a Working Memory - a data structure which stores information about a specific run. It holds current facts and knowledge.

Stages of expert system development

Although great strides have been made in expediting the process of developing an expert system, it often remains an extremely time consuming task.

It may be possible for one or two people to develop a small expert system in a few months; however the development of a sophisticated system may require a team of several people working together for more than a year.

An expert system typically is developed and refined over a period of several years.

We can divide the process of expert system development into five distinct stages.

In practice, it may not be possible to break down the expert system development cycle precisely.

However, an examination of these five stages may serve to provide us with some insight into the ways in which expert systems are developed.

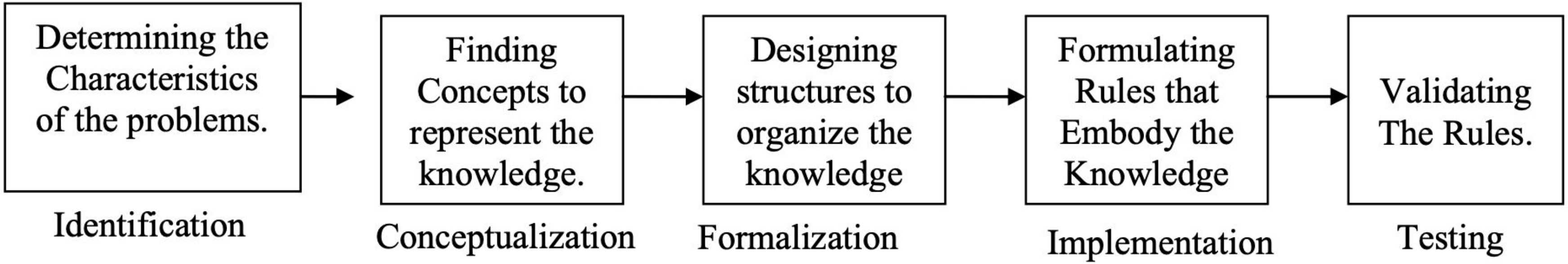

Fig: Different phases of expert system development

Identification:

Beside we can begin to develop an expert system, it is important that we describe, with as much precision as possible, the problem that the system is intended to solve.

It is not enough simply to feel that the system would be helpful in certain situation; we must determine the exact nature of the problem and state the precise goals that indicate exactly how we expect the expert system to contribute to the solution.

Conceptualization:

Once we have formally identified the problem that an expert system is to solve, the next stage involves analyzing the problem further to ensure that its specifics, as well as it generalities, are understood.

In the conceptualization stage the knowledge engineer frequently creates a diagram of the problem to depict graphically the relationships between the objects and processes in the problem domain.

It is often helpful at this stage to divide the problem into a series of sub-problems and to diagram both the relationships among the pieces of each sub-problem and the relationships among the various sub-problems.

Formalization:

In the preceding stages, no effort has been made to relate the domain problem to the artificial intelligence technology that may solve it. During the identification and the conceptualization stages, the focus is entirely on understanding the problem. Now, during the formalization stage, the problem is connected to its proposed solution, an expert system, by analyzing the relationships depicted in the conceptualization stage.

During formalization, it is important that the knowledge engineer be familiar with the following:

The various techniques of knowledge representation and heuristic search used in expert systems.

The expert system “tools” that can greatly expedite the development process. And

Other expert systems that may solve similar problems and thus may be adequate to the problem at hand.

Implementation:

During the implementation stage, the formalized concepts are programmed onto the computer that has been chosen for system development, using the predetermined techniques and tools to implement a “first pass” prototype of the expert system.

Theoretically, if the methods of the previous stage have been followed with diligence and care, the implementation of the prototype should be as much an art as it is a science, because following all rules does not guarantee that the system will work the first time it is implemented.

Many scientists actually consider the first prototype to be a “throw-away’ system, useful for evaluating progress but hardly a usable expert system.

Testing:

Testing provides opportunities to identify the weakness in the structure and implementation of the system and to make the appropriate corrections.

Depending on the types of problems encountered, the testing procedure may indicate that the system was

Features of an expert system

What are the features of a good expert system? Although each expert system has its own particular characteristics, there are several features common to many systems. The following list from Rule-Based Expert Systems suggests seven criteria that are important prerequisites for the acceptance of an expert system .

1. “The program should be useful.” An expert system should be developed to meet a specific need, one for which it is recognized that assistance is needed.

2. “The program should be usable.” An expert system should be designed so that even a novice computer user finds it easy to use .

3. “The program should be educational when appropriate.” An expert system may be used by non-experts, who should be able to increase their own expertise by using the system.

4. “The program should be able to explain its advice.” An expert system should be able to explain the “reasoning” process that led it to its conclusions, to allow us to decide whether to accept the system’s recommendations.

5. “The program should be able to respond to simple questions.” Because people with different levels of knowledge may use the system , an expert system should be able to answer questions about points that may not be clear to all users.

6. “The program should be able to learn new knowledge.” Not only should an expert system be able to respond to our questions, it also should be able to ask questions to gain additional information.

7. “The program’s knowledge should be easily modified.” It is important that we should be able to revise the knowledge base of an expert system easily to correct errors or add new information.

Machine Vision

Machine vision is a technology that enables automatic inspection and analysis for applications including automatic inspection, process control, and robotic guidance by using image processing. It’s important to know that when mentioning machine vision it can be in reference to many different technologies, software and hardware products, integrated systems, actions, methods, and expertise.

Machine vision is a technical capability that is integrated with existing technologies in new ways and applies it with the aim to solve real-world problems.

Machine vision is a systems engineering discipline and can be considered distinct from computer vision which is a form of computer science and not done through a tangible piece of hardware such as a vision box or camera attached to a robot.

Machine vision is the body of a system and computer vision is the intelligence of the system, similar to how a computer is a frame for what goes inside such as the computer chips that power up the computer.

Machine vision is the ability of a computer to "see." A machine-vision system employs one or more video cameras, analog-to-digital conversion (ADC), and digital signal processing (DSP).

The resulting data goes to a computer or robot controller.

Machine vision is similar in complexity to voice recognition .

The machine vision systems use video cameras, robots or other devices, and computers to visually analyze an operation or activity.

Typical uses include automated inspection, optical character recognition and other non-contact applications.

One of the most common applications of Machine Vision is the inspection of manufactured goods such as semiconductor chips, automobiles, food and pharmaceuticals.

Just as human inspectors working on assembly lines visually inspect parts to judge the quality of workmanship, so machine vision systems use digital cameras, smart cameras and image processing software to perform similar inspections.

Machine vision systems have two primary hardware elements: the camera, which serves as the eyes of the system, and a computer video analyser.

The recent rapid acceleration in the development of machine vision for industrial applications can be attributed to research in the areas of computer technologies.

The first step in vision analysis is the conversion of analog pixel intensity data into digital format for processing.

Next, an appropriate computer algorithm is employed to understand the image data and provide appropriate analysis or action.

A typical machine vision system will consist of most of the following components:

One or more digital or analogue cameras (black-and-white or colour) with suitable optics for acquiring images, such as lenses to focus the desired field of view onto the image sensor and suitable, often very specialized, light sources

Input/Output hardware (e.g. digital I/O) or communication links (e.g. network connection or RS-232) to report results

A synchronizing sensor for part detection (often an optical or magnetic sensor) to trigger image acquisition and processing and some form of actuators to sort, route or reject defective parts

A program to process images and detect relevant features.

The aim of a machine vision inspection system is typically to check the compliance of a test piece with certain requirements, such as prescribed dimensions, serial numbers, presence of components, etc.

The complete task can frequently be subdivided into independent stages, each checking a specific criterion. These individual checks typically run according to the following model:

1. Image Capture
2. Image Preprocessing
3. Definition of one or more (manual) regions of interest
4. Segmentation of the objects
5. Computation of object features
6. Decision as to the correctness of the segmented objects

Machine vision is used in various industrial and medical applications. Examples include:

- Electronic component analysis
- Signature identification
- Optical character recognition
- Handwriting recognition
- Object recognition
- Pattern recognition
- Materials inspection
- Currency inspection
- Medical image analysis