Basic expert systems

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Summary

An introduction to the basic concepts of expert systems and the characteristics which distinguish expert systems from conventional software. Some of the emerging uses of the technology that may be useful in the nursing professions are also discussed.

Six references

Medical software tools began to emerge during the 1980's, some became known as 'expert systems'. In contrast to conventional software which process data, expert systems process 'knowledge'. For this reason, expert systems are also called 'Knowledge Based Systems' (KBS). The most well known medical example is MYCIN.' This expert system was developed at Stanford University in 1976 to aid physicians in diagnosing and treating patients with infectious blood diseases caused by bacteria in the blood and meningitis. These diseases can be fatal if not recognised and treated quickly. Many other medical expert systems have followed the success of MYCIN. Other medical examples will be outlined later in the paper.

What are expert systems?

An expert system is a program, which attempts to mimic human expertise by applying inference methods to a specific body of knowledge called the domain. Knowledge is different from data or information in that data is passive. Knowledge on the other hand is active in that it can be used to infer new information from what is already known about a problem. As will be seen later, this domain knowledge is frequently represented as rules.

Artificial Intelligence Expert systems owe their origin to the field of Artificial Intelligence (AI). One of the pioneers of AI, Dr. Marvin Minsky defined AI as "The field of study which is attempting to build systems which if attempted by people would be considered intelligent". AI is a broad field, with some of the application areas shown in the diagram below.
Heuristics

Expert systems are considered as a branch of AI because the method of problem solving is predominantly based on heuristics. This contrasts very much with the conventional programming paradigm that uses algorithms to solve problems. An algorithm is a step by step procedure that solves a category of problems. For example, algorithms may be used to process a company payroll. A typical algorithm would use a step by step procedure on the input data such as employee hours worked, overtime rate and so on, to generate output in the form of payslips for employees. The steps in this procedure involve direct manipulation of numeric data to produce information.

Heuristics, on the other hand, solve a problem by trial and error guided by some reference to a predetermined goal. There are many examples that we may encounter in our daily lives. For example, a motorist searching a multi-storey car park for a parking space would not use an algorithm to find a space. There is no guarantee that whatever procedure is adopted a parking space will be found. The motorist may for instance, drive to the top-level first rather than searching each level in turn. Whilst this strategy may sound attractive there is no guarantee it will work: there may be no more spaces on the top-level available. The motorist then may have to try a lower level.

Representing knowledge using rules

As we have already seen, expert systems differ from conventional programming in that they process knowledge rather than data or information. This knowledge is frequently represented in a computer in the form of rules; they store the 'rules of thumb' that guide the human expert. For example, a typical rule used by the MYCIN expert system is
IF the stain of the organism is gram negative
AND the morphology of the organism is rod
AND the aerobicity of the organism is anaerobic
THEN there is strongly suggestive evidence (0.8) that the class of the organism is Enterobacter iaceae.

The inference engine

The real forte of expert systems is their capacity to make inferences or the drawing of conclusions from premises. This is precisely what makes an expert system intelligent. Even when it is possible to represent domain knowledge as rules, a human expert would not only have to know how to apply these rules but in which order they should be applied to solve a particular problem. Similarly, a computer expert system would need to decide which, and in what order, the rules should be selected for evaluation. To do this, an expert system uses an inference engine. This is a program that interprets the rules in the knowledge base in order to draw conclusions. Two alternative strategies are available: backward chaining and forward chaining. A particular inference engine may adopt either or both.

A backward chaining inference engine is 'goal-orientated' in the sense that it tries to prove a goal or rule conclusion by confirming the truth of all of its premises. Thus, to prove the conclusion of the rule above, MYCIN works backward by attempting to prove each premise. These premises may themselves be conclusions of other rules, in which case MYCIN would then try to confirm the premises of whatever rule it is the conclusion of, or the values of these premises may be data supplied by the user from clinical observations. In this way, a chain of inference steps will lead to a value for the goal being found. By contrast, a forward chaining inference engine starts from the other end. It examines the current state of the knowledge base and, finds those rules whose premises can be satisfied from known given data, and adds the conclusions of those rules to the knowledge base. It then re-examines the complete knowledge base and repeats the process, which can now progress further since new information has been added. Both the backward and forward inference process will consist of a chain of steps that can be traced by the expert system. This enables expert systems to explain their reasoning processes.

Explanation facilities

The ability to explain their reasoning processes are another key feature of expert systems. Such explanation facilities provide the user with a means of understanding the system behaviour. This is important because a consultation with a human expert will often require some explanation. Many people would not always accept the answers of an expert without some form of justification. For example, a medical expert providing a diagnosis and treatment of a patient would be expected to explain the reasoning behind his/her conclusions: the uncertain nature of this type of decision may demand a detailed explanation so that the patient concerned is aware of any risks, alternative treatments, and so on.

The characteristics that distinguish expert systems from conventional systems are summarised in table 1.
Current applications of expert systems

A survey conducted by Waterman in 1986 showed that the majority of applications of expert systems that were built in the 1980's were in the field of medicine. Durkin suggested that expert systems in medicine still account for about 12% of those under current developments. However, other useful problem areas are emerging which lend themselves well to expert systems. These include: help desk systems, knowledge publishing, configuration and intelligent front-ends.

Knowledge Publishing

Knowledge Publishing is a growing application area of expert systems. The idea of knowledge publishing is encapsulated in the concept of a book. A book is a passive object in that it awaits us to read the part of interest. Knowledge Publishing delivers knowledge to the user actively, by providing what the user specifically requests. There are examples in common use that are disguised; that is, working within other systems. An example is GRAM@TIK the very popular grammar checker sold with WordPerfect software.

Help desk applications

Help desk systems are likely to be a key growth area in the future. Most help desk programs are expert system based and growth in this market is predicted at 20% - 30% per annum. Large savings in time and costs can be achieved because people increasingly turn to the telephone when they have a problem rather than read manuals. The Compaq computer company now includes an online printer help desk program with all printers sold. The Quicksource program includes 5000 cases of...
printer problems to help diagnose the printer fault and it is estimated that 20% fewer customers are telephoning the company for support. This has resulted in substantial savings for the company as well as a better service for its customers.

**Configuration**

The configuration system XCON is one of the most well known expert systems in use today. It was built by DEC corporation for turning customer orders into feasible VAX computer configurations. The system was completed in the early 1980's. It has been an enormously successful application and was followed by other large computer companies. Another new wave of configuration applications is beginning to emerge suited to 'mass customisation' applications.

**Intelligent front-end processors**

An Intelligent Front-End (IFE) is software which sits between a user and a conventional software program. An IFE uses KBS or AI techniques to make more effective use of software packages. Classical examples are found in database software. An IFE would provide an easier to use interface with the database for example, by permitting more flexible user dialogue. The IFE would do this by gaining an understanding of the user's requirements, and then using this specification to generate instructions for running the software package. The dialogue with the user will often be interactive. The IFE may also use a variety of techniques, particularly when carrying out the dialogue with the user to produce the specification of the user's problem. This idea has already been exploited in some commercial databases, such as 'Superbase'.

**Examples of medical expert systems**

While MYCIN is the most well known medical expert system another notable example is PUFF: An expert system that diagnoses the presence and severity of lung disease in a patient by interpreting measurements from respiratory tests administered in a pulmonary function laboratory. The data being interpreted include test results, for example, total lung capacity, and patient history. 1 Brain Tumors Diagnostic System (BTDS) is another expert system that assists a physician in the diagnosis of brain tumours. BTDS consists of an expert system and a learning system. The former can help in judging the causes of brain tumours according to computed pictures. The latter is a learning method based on induction. Examples from known data are used to induce rules which represent the knowledge in the domain.

The system was developed in Taiwan. Breast Cancer Diagnosis Application is an expert system that was developed for early detection of breast cancer. The system undertakes a dialogue with a woman who is anxious about breast cancer. The ensuing conversation is divided into two parts: one is listening to the woman's symptoms regarding the breast then giving advice, the other is an explanation of the breast cancer and how to detect it in its early stages. After listening to the woman's symptoms, the system presents its conclusions and suggests courses of action that the woman should take. This system was developed in Japan.
References


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