Expert Systems in Medicine
by Roger Salamon

The original goal of Expert Systems, to support physicians in medical decisions, may have been a bit presumptuous. But they may nevertheless prove worthwhile in medicine.

Medicine is a discipline that requires both judgment and action. Information science can help in several aspects:
- it can help the physician in collecting complete and relevant data;
- it can support the physician by providing access to the rapidly increasing sets of medical knowledge through different kinds of data bases;
- it can facilitate the management of medical records which may be used for clinical follow-up of patients, clinical research, evaluation of medical action and education.

In all these aspects, information science gives indirect help to medical decision. But there are many other practical uses designed to help the physician directly in what he considers as his personal privilege: the decision process itself.

The physician considers diagnosis as both a science and an art. It is a science because it uses all the components of a scientific method of observation, generation and expression of hypotheses, experimentation and verification. It is an art because it frequently requires a large degree of intuition.

Two types of medical approach can be distinguished. The first is related to the "recognition of forms." The physician recognises the disease and identifies it, as he would recognise a well-known face, not analytically but in an overall manner. This approach is intuitive, the analysis of the various factors involved in the diagnostic decision being reached unconsciously and not by a reasoning process.

In a certain number of cases, however, the overall approach proves ineffective, and a sequential analysis of the parameters is required. In these cases "diagnostic aid methods" find their place, and the computer may become a useful tool, especially when the small amount of data that the human brain can process simultaneously is considered.

Research on computer-aided diagnosis began in the 1960s; the objectives were to resolve clinical problems by the use of mathematical formulations. Therefore, most of the work centred on the application of either logical or probabilistic methods.

But, except in extremely narrow clinical domains, these two techniques proved to have little or no practical value. Most observers were led to believe that, for a programme to have expert capability, it must in some fashion mimic the behaviour of experts.

Components

Expert Systems are built on three components. The Knowledge Base contains the granular elements of problem solving (descriptive knowledge) and the expression of the links that have to be applied between those elements (operating knowledge). The Inference Engine allows for selection of the appropriate elements of knowledge and application of the rules; interrogation of the use (regarding questions which cannot be inferred or resolved by the system itself); management of the events' uncertainty; and explanation of the results. The Events Base describes the treated case, possibly enriched by the inferred events.

Expert systems incorrectly became almost synonymous with the term "artificial intelligence" in the mind of most physicians and this was probably one of the reasons for their first success.

Pioneering work was done on rule-based systems, and was designed to deal with medical applications, but their greatest successes have occurred in fields other than medical ones. This not surprising because so much medical knowledge is difficult to grasp and to summarise with simple rules.

By the late 1970s, dissatisfaction with rule-based systems led investigators into new directions; they became aware that clinical findings must be linked with patho-physiological knowledge. Such knowledge is complex; its representation is done either by "frames systems" or by "semantic networks", which are able to organize information with many links and a hierarchical order. Only programmes relying on such reasoning would be able to cope with the enormous diversity with which

Installed in a European doctor's surgery, this nuclear magnetic resonance imager represents a technical advance on conventional X-rays.
diseases can exist, evolve and interact with each other.

Associative procedures are still in a research phase and have not yet reached a stage of practical application in the clinical field; unfortunately this situation will probably remain the same for several years.

Before the development of Expert Systems, the clinical uses of medical decision-making programmes were very limited. The methodology used (in particular probabilistic procedures) were too distant from the usual way of thinking of the physicians, and the programmes were applied to only a few limited clinical situations. The procedures used “non-fuzzy” data known with a high degree of certainty (a situation which is relatively rare in medicine), and these systems were unable to explain to the physician how they reached their conclusions. A further criticism from an informatics perspective was that their programming was too rigid.

Fuzzy data

Expert Systems avoid these major pitfalls by using symbolic reasoning, being capable of handling fuzzy data, and explaining their proposed conclusions. Instead of “procedural” programming, Expert Systems are based on “declarative” programming which allows for a large degree of flexibility. Nevertheless, with experience covering several years, we must acknowledge a certain failure in the sense that expert systems have not yet proven to have great practical value. The main reason for this failure seems to be related to initial underestimating of the difficulty of mastering medical knowledge.

To date, there is sufficient evidence to assert that the original stated goal of Expert Systems to support physicians in medical decisions may have been a bit presumptuous. Most probably, Expert Systems will not be able to provide conclusive evidence to reach such an objective. The use of such systems may nevertheless be worthwhile in medicine if the objectives are narrowed down and orientated towards such very precise targets as the communication of simple knowledge to non-experts, and alarm function (sometimes called the “watchdog” role), and assistance in education and teaching in health-related fields.

To what degree can Expert Systems support physicians in medical decisions?

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