

## EXPERT SYSTEMS IN WATER RESOURCES SIMULATION AND OPTIMIZATION

K. FEDRA

*Advanced Computer Applications*

*International Institute for Applied Systems Analysis (IIASA)*

*A-2361 Laxenburg*

*Austria*

**ABSTRACT.** Expert systems (ES) as a new and emerging technology of information processing and decision support are becoming increasingly useful tools in numerous application areas. Expert systems are man-machine systems that perform problem-solving tasks in a specific domain. They use rules, heuristics, and techniques such as first-order logic or semantic networks, to represent knowledge, together with inference mechanisms, in order to derive or deduce conclusions from stored and user-supplied information.

Application- and problem-oriented, rather than methodology-oriented, systems are most often hybrid or embedded systems, where elements of AI technology, and expert systems technology in particular, are combined with more classical techniques of information processing and approaches of operations research and systems analysis. Here traditional numerical data processing is supplemented by symbolic elements, rules, and heuristics in the various forms of knowledge representation.

Applications containing only small knowledge bases, of at best a few dozen to a hundred rules, can dramatically extend the scope of standard computer applications in terms of application domains, as well as in terms of an extended non-technical user community.

This review covers a basic introduction to what expert systems and AI methods are, what they can, and cannot do; the state of the art in applications in the field of water resources systems analysis and modelling and selected examples of expert and hybrid systems in the field that integrates simulation modelling, optimization and AI technology.

### 1. AI and Expert Systems

In discussing a domain as loosely defined as expert systems, it may be useful to present a few definitions selected from the literature, to set the stage and introduce the jargon. Equally instructive are the essentially graphic definitions that are available (Figures 1, 2). "Artificial Intelligence is the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behaviour ..."

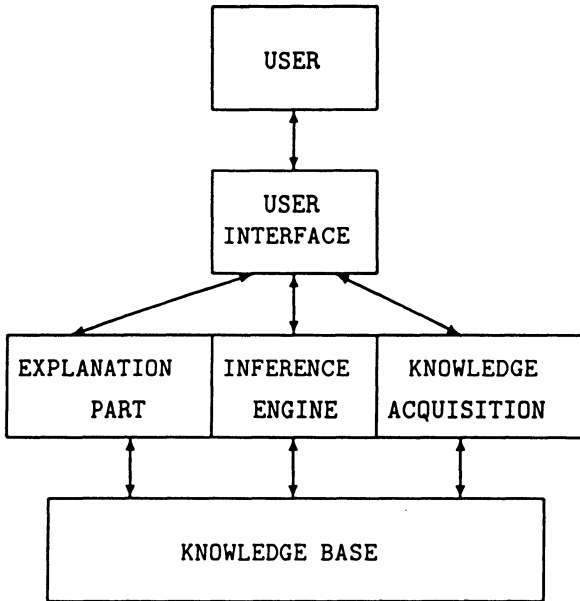


Figure 1. The five main components of an expert system (Trappl, 1985)

(Barr and Feigenbaum, 1981). Unfortunately, this does not really say much more than the name itself, other than indicating that we are talking about a branch of computer science. A somewhat more operational definition is: "Artificial Intelligence is that part of computer science that investigates symbolic, nonalgorithmic reasoning processes, and the representation of symbolic knowledge for use in machine inference" (Davis and Lenat, 1982).

Expert Systems, or Knowledge Based Systems, are a loosely defined class of computer software within the more general area of AI, that go beyond the traditional procedural, algorithmic, numerical and mathematical representations or models, in that they contain large empirical knowledge e.g., in the form of rules or heuristics, and inference in mechanisms for utilizing this form of information to derive results by logical operations. They are fashioned along the lines of how an expert would go about solving a problem, and are designed to provide expert advice. Like any other model, they are sometimes extreme simplifications and caricatures of the real thing, i.e., the human expert.

However, definitions of functional descriptions of expert systems and claims to the expert system category of software cover a broad spectrum, ranging from fairly modest to rather optimistic parallels to human, or even super-human, performance:

"Most existing expert systems work in analytic domains, where problem solving consists of identifying the correct solution from a pre-specified finite list of potential answers ..." (Merry, 1985).

"Expert systems are computer programmes that apply artificial intelligence to narrow and clearly defined problems. They are named for their