EXPERT SYSTEMS

Principles and case studies

SECOND EDITION

Edited by

Richard Forsyth

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Preface to the first edition

An expert system is a computer system that encapsulates specialist knowledge about a particular domain of expertise and is capable of making intelligent decisions within that domain. Areas successfully tackled so far within the expert systems framework include medical diagnosis, geological exploration, organic chemistry and fault-finding in electronic equipment.

Although expert systems typically focus on a very narrow domain, they have achieved dramatic success with real-life problems. This has excited widespread interest outside the research laboratories from which they emerged.

Expert systems have given rise to a new set of **knowledge engineering** methods constituting a new approach to the design of high-performance software systems. This new approach represents an evolutionary change with revolutionary consequences.

Many people, whether they think of themselves as computer professionals or not, are aware that something momentous is taking place in the field of computing, and want to educate themselves to the point where they can evaluate and, if necessary, apply the new techniques.

This book serves that need by explaining the concepts behind expert systems to computer users unfamiliar with the latest research. It has been written as an introductory handbook for people who want to find out how expert systems work. It is not an academic text: it is a practical guide written by active practitioners in the field, designed to open your eyes to developments in a new and dynamic area of computer science. After reading it you should be able to begin work on practical knowledge engineering projects of your own.

Richard Forsyth,
March 1984.

Preface to the second edition

When the first edition of this book was published, only four years ago, the **expert system** was a new and exciting concept, fresh out of the research laboratory. Today expert systems are part of the accepted scenery of information technology.

Because the change from avant-garde idea to standard practice has been so fast and so complete, a new kind of book is needed. In the first edition we were promoting the concept and trying to convey the excitement that the breakthrough into knowledge-based computing had given us, the authors. Now there is no need to sell the basic concept, indeed it has been over-sold already; instead, we have tried to distil some of the practical experiences gained over the last four years in the application of knowledge-based computer systems to real-world problems – for the benefit of those who do not wish to repeat our mistakes.

Like the first edition, however, this book is intended as a practical introductory guide for people who actually want to make use of expert systems in their own work.

Richard Forsyth,
March 1988.

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Dr Max Bramer is manager of the Knowledge Engineering Programme at Hewlett-Packard's Research Laboratories in Bristol. Until March 1988 he was Head of the School of Computing and Information Technology at Thames Polytechnic in London. He has been actively involved in artificial intelligence since 1972 and was awarded the degree of Doctor of Philosophy for research in the field in 1977. His current principal interests are in the automatic derivation of rules from examples, and more generally in the establishment of a sound theoretical and methodological basis for expert systems development.

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MASOUD YAZDANI

Masoud Yazdani was born in Iran, but has lived in England since 1975. He obtained a BSc in Computer Science at Essex University in 1978 before moving on to do research in artificial intelligence at the University of Sussex. From 1981 to 1987 he was a lecturer in the Computer Science Department at Exeter University. Recently he has moved to Oxford to work as the training manager of Expert Systems International Ltd. His special interests include educational computing and computer creativity. He has authored numerous technical papers and edited a number of publications, most notably *Artificial Intelligence Review*, a quarterly survey and tutorial journal published by Blackwell Scientific Publications of Oxford.

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Background

1

The expert systems phenomenon

RICHARD FORSYTH

The aim of this introductory chapter is to say what expert systems are by setting them in their historical context. In order to understand the phenomenon of the expert system, we must step back and examine the soil from which it sprang – the fertile field of artificial intelligence, or AI for short.

1.1 AI: FROM Dr FRANKENSTEIN TO Dr FEIGENBAUM

AI has a long and chequered prehistory stretching back at least as far as the legend of Pygmalion and Galatea. Mankind's enduring fascination with intelligent artefacts is a long and sometimes blood-curdling tale of golems, talking heads and, most notably, Frankenstein's monster. (See Aldiss, 1975; McCorduck, 1979.) We can skip over the first 2000 years of AI and pick up the story in the 1950s, when the fantasy at last showed signs of becoming fact, thanks to the digital computer.

Table 1.1 is a brief synopsis of AI history in the computer age. It has been boiled down to four digestible decade-size chunks and therefore, of course, simplified drastically. Nevertheless, it highlights the important milestones.

The column labelled Paradigm is the answer you would have got if you had asked an AI worker of the time what AI research was all about. The column labelled Workers identifies one or two key figures who seem to characterize the

Table 1.1 A bottled history of AI

	Paradigm	*Workers*	*System*
1950s	Neural networks	Rosenblatt (Wiener, McCulloch)	Perceptron
1960s	Heuristic search	Newell & Simon (Shannon, Turing)	GPS
1970s	Knowledge engineering	Shortliffe (Minsky, Feigenbaum)	MYCIN
1980s	Machine learning	Lenat (Samuel, McCarthy)	EURISKO

spirit of their times in AI. (Underneath the main worker or workers I have put, in brackets, the thinkers or theorists whose ideas laid the foundations for their work.) Finally, the column headed System picks out one typical system (not necessarily the best) which exemplifies the underlying trend or fashion.

1.1.1 Neural nets

In the 1950s AI researchers – who mostly called themselves cyberneticians – tried to build intelligent machinery essentially by imitating the brain. With hindsight, it is hardly surprising that they failed: the hardware was just not up to the job, to say nothing of the software.

The key system I have picked out was the Perceptron (Rosenblatt, 1957–1962). This was a trainable automaton which can be thought of as a crude model of the retina in the Vertebrate eye. It could be taught to recognize patterns, but only a limited class of patterns, as Minsky and Papert (1969) proved later.

At the time there was a good deal of enthusiasm for systems such as Rosenblatt's, based on the pioneering cybernetic ideas of Norbert Wiener (1948) and Warren McCulloch (1965) about abstract neural networks. It was felt that a richly interconnected system of simulated neurons could start off knowing nothing, be subjected to a training regime of reward and punishment, and end up doing whatever its inventor wanted. The fact that the human brain contains ten billion neurons, each as complex as, say, an Intel 8088 microprocessor, was conveniently overlooked.

This false optimism had evaporated even before Minsky and Papert did their comprehensive theoretical demolition job on the Perceptron concept. The empirical results were simply not good enough. And so a new idea took hold of the imagination of AI workers, who swept the cybernetic approach into the dustbin of recent history – which was a pity in so far as the cyberneticians had recognized two important facts which would later have to be rediscovered:

1. There can be no machine intelligence without machine learning;
2. Human intelligence is approximately 99% pattern recognition and only 1% reasoning.

1.1.2 Heuristic search

The trailblazers on this new frontier of AI were Allen Newell and Herbert Simon at Carnegie-Mellon University; and their work culminated in GPS, the 'General Problem Solver' (Ernst and Newell, 1969).

Central to their approach was the notion of heuristic search. They believed that human thinking is accomplished by the coordination of simple symbol-manipulating tasks such as comparing, searching, modifying a symbol and the like – the kind of things a computer can do. They viewed problem solving as a search through a space of potential solutions, guided by heuristic rules which

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