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B. Bouchon R.R. Yager (Eds.)

Uncertainty in Knowledge-Based Systems

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Selected and Extended Contributions

Editors

Bernadette Bouchon
Centre National de la Recherche Scientifique
LAFORIA, Université Paris VI, Tour 45
4 place Jussieu, F-75252 Paris Cédex 05, France

Ronald R. Yager
Machine Intelligence Institute, Iona College
New Rochelle, New York 10801, USA

FOREWORD

The past decade has witnessed an exponential growth of activity centering on the development of expert systems for a wide variety of applications ranging from medical diagnosis to stock portfolio selection.

Much of the information which is resident in the knowledge base of a typical expert system is imprecise, incomplete or not totally reliable. For this reason, problems relating to the management of uncertainty in expert systems and, more generally, knowledge-based systems, have begun to attract a great deal of attention on the part of information scientists, probabilists, statisticians and logicians. Even members of the artificial intelligence community, most of whom have been and still are disdainful of probability theory, are reluctantly facing up to the need for methods of approximate, qualitative, and probabilistic reasoning, especially in the context of inference from common sense knowledge.

Despite the obvious need for such methods, only a few of the currently available expert system shells have any kind of a mechanism for dealing with uncertainty. When available, such mechanisms are mostly ad hoc in nature and do not provide a rigorous framework for dealing with certainty factors in ways that lend themselves to validation. What is the explanation for this state of affairs?

The problem is that the conventional probability-based methods do not fit well the types of uncertainty which are encountered in a typical expert system. In the first place, much of the information in the knowledge base of an expert system is in the form of rules which are lexically imprecise, i.e., contain fuzzy predicates in both their antecedents and consequents. And second, many of the probabilities which are needed for Bayesian-style computations are known imprecisely and/ or incompletely.

An effective system for dealing with lexical imprecision is provided by fuzzy logic. The more difficult problem of how to deal with gaps in the knowledge of probabilities is usually avoided by making a liberal use of assumptions concerning conditional independence or, more generally, invoking the maximum entropy principle. An unsatisfactory feature of this approach is that it yields results which are based on assumptions which may or may not be valid. On the other hand, the alternative of making no assumptions concerning the unknown probability distributions has the drawback of leading to results which are insufficiently specific or altogether vacuous. A possible way out of this dilemma is to allow assumptions which are dispositional rather than categorical in nature. Such assumptions will, in gen-

eral, lead to dispositional conclusions. It may well turn out to be the case that, realistically, this is the best that can be achieved with any conceivable schema for the management of uncertainty in expert systems. What this means is that the categorical approaches which are currently in vogue may be intrinsically incapable of solving the problem.

Be that as it may, it is evident that the management of uncertainty in knowledge-based systems presents many complex and as yet not fully understood problems. A number of these problems are addressed directly or indirectly in the papers assembled in this volume, many of which were presented at the International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems, which was held in Paris in 1986.

The Paris Conference was the first international conference on the subject of uncertainty in knowledge-based systems. It brought together many of the leading contributors to information processing and the management of uncertainty, and it laid the foundation for exchanges of information and scientific collaboration cutting across national boundaries. One of the visibly important results of this collaboration is the present volume. Drs. Bernadette Bouchon of France and Ronald Yager of the United States, who jointly organized the Conference, edited the volume and contributed to its contents, deserve our thanks and congratulations. Their efforts have culminated in a truly international collection of papers which for the first time bring together highly authoritative analyses of the issues which are central to the conception and design of knowledge-baded systems.

Lotfi A. Zadeh, Berkeley

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