Fuzzy logic in knowledge engineering

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The aim of Knowledge Engineering, implementing human knowledge in computers, hardly depends on the modelling of uncertainty, imprecision and vagueness. Apart qualitative methods, one of the most promising quantitative methods to deal with them is the so-called Fuzzy Logic (FL). This extended logic covers a wide range of models but can be presented as two main fields: the one who deals with vague, fuzzy predicates and degree of truth [1], and the other which is more involved with the modelling of uncertainty by the use of possibility theory [2]. Often, imprecision and uncertainty resides together in knowledge-based systems. In that cases, FL provides an unified framework to deal with it [3]. That is the power of FL with respect to the other models.

This book gathers a collection of papers devoted to various applications of FL, particularly in database management systems and expert systems inference engines. It is not possible to report widely on all the issues, however let us mention briefly the topic of each of them in order to stress on the most interesting feature of this book which is the practical way to implement FL to real problems.

Part I deals with the representation and the management of fuzzy information in database systems. Buckles, Petry and Sachar generalize the ordinary relational databases model by a similarity based model where equivalence relationship among domain value is replaced by a measure of "nearness". The fuzzy functional dependency is discussed. In a same way, Ruspini extends the Entity-Relationship model of Chen [4] for dealing with imprecision and uncertainty by defining multivalued precision and certainty scales, extensions of the concepts of value-set and attribute, and some others special structures. Testemale proposes an extension of the basic operations of relational algebra to fuzzy and/or partially unknown attribute values. Single and multiple-valued attributes, treatment of irrelevant attributes, answer to a request in term of two fuzzy sets (the sets of items which certainly/possibly satisfy the query) are some interesting features of her paper. Kacprzyk & Ziolkowski focus on queries involving linguistic quantifiers [5] for non-fuzzy databases. A prototype expert system for information retrieval in unformatted full text databases is exposed by Tong. Rules with attached uncertainty imbedded

the user description of what constitutes a document of interest. He defines a semantics and a calculus of "relevance", a measure which estimates how documents are relevant to the user query. Three experiments are given for estimating the system performance according to the choice for T-norms in its calculus. Finally, Zemankova provides a PROLOG-like fuzzy model for relational databases which is designed to answer queries by the use of fuzzy inference rules.

The second part of this book deals with FL applied in inference systems. The starting article by Bandler and Kohout give us a nice paradigm, the "Checklist Paradigm", which models decisions concerning the truth of two propositions in a multiple-valued logic. They found that two structures exists for compound propositions: the fine and the coarse structure. The fine structure gives us the appropriate fuzzy measures for all propositional functions of the two propositions. Conversly, the coarse structure gives us only the fuzzy measures of the two propositions. They estimate how much information is lost by using the coarse structure instead of the fine. Dubois & Prade extend the Modus Ponens and the Modus Tollens to deal with degrees of necessity/possibility of premisses. A practical tool for performing these schemes is proposed with a pseudo-matrix product based on max-min composition. Martin-Clouaire studies a particular class of rules for production systems, the "quantitative rules": a precise conclusion with a set of imprecise antecedents. In that case, the degree of uncertainty of the conclusion is shown to be a fuzzy degree which can be estimated from two points of view he called optimistic v. pessimistic. Moreover, one can use rules where antecedents cannot be treated as independent contributions of evidence to the conclusion, where independence assumption is invalid. Proposals for a fuzzy production systems are made in the paper of Lopez de Mantaras & all. and by Umano. Finally, three papers depart from implementing FL in production systems. Bergadano, Giordana & Saitta design a learning methodology of production rules from examples which contains errors, noise and irrelevant details. Fuzzy classification is applied to computer-assisted diagnosis systems by Bocklisch, Peschel & Schüler. Instead of classical cluster methods, a so-called evolutionary concept based on the Lotka-Volterre equations is used for their cluster-building process. Baldwin's C.R.I.L. (Concept Relational Inference Language for Knowledge Engineering) is a very original, and powerful language based on an extension of the theory of conceptual graphs [6].

Part III is devoted to application-oriented systems. First, two commercially oriented fuzzy production systems are presented. The REVEAL system of Jones is analyzed, and a lot of applications of this environment are presented: corporate modelling, diagnosis and tuning of VAX computers, network maintenance, ... The second paper deals with the FLOPS systems of Buckley, Siler & Tucker, a system based on a fuzzy extension of the well-known rule-based OPS5 shell [7]. The end of the part contains papers that covers some currently running

applications of FL in the fields of medicine, speech recognition and financial analysis. Adlassnig, Scheithauer & Kolarz analyze their datadriven fuzzy rule-based system (CADIAG-2) for medical diagnosis in the very wide domain of internal medicine. CADIAG-2, thanks to its connection to a medical information system, has been tested among 500 cases and yielded to a performance of 93%. Soula, Vialettes & San Marco describe the PROTIS fuzzy production system currently applied in medicine for the treatment of diabetes and the classification of dyslipoproteinemias. Rules are defined using possibility distribution with "evocation" and "rejection" parameters, and so-called "links" used to take in account a given context to adjust the conditions and/or the weights of a rule. Finally, De Mori & Lam show us a speech recognition system based on a planning activity and Whalen & Schott use linguistic variables and FL for financial ratio analysis.

On the whole, this book presents a widely-range exposition of the state of art in the field of FL applications in knowledge engineering. The quality of papers is rather homogeneous. Some contributions are particulary significant with a broad coverage, but a few other appear a bit less of interest by a lack of theory, ill-structured, poor bibliography, or redundancy.

Except these unvoidable restrictions, I think this book stands for one of the most valuable source of information for application of FL by its contains of goals, components, concepts and solutions applied to real situations. It should be useful for the knowledge engineering community interested by the quantitative method of modelling imprecision and uncertainty that is fuzzy logic. Moreover, the fuzzy community will certainly enjoy to have some good information on the way to treat practical problems by FL. So far, I think that the title of this book should have mention its main characteristic: an application book.

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[1] Bellman, R.E., Zadeh, L.A. Local and fuzzy logics. In: Modern Uses of Multiple-Valued Logic (J.M. Dunn, G. Epstein, Eds.), pp. 103-165, Reidel Pub., Dordrecht, 1977.

2 Zadeh, L.A. Fuzzy sets as a basis for a theory of possibility. Fuzzy Sets and Systems. **1**, pp. 3-28, 1978.

3 Zadeh, L.A. A theory of approximate reasoning. In: Machine Intelligence, Vol. 9 (J.E. Hayes, D. Michie, L.I. Mikulich Eds.), pp. 149-194, Elsevier, 1979.

4 Chen, P.P. The Entity-Relationship Model: Towards a unified view of data, ACM Trans. Database Systems, **1**, pp. 9-36, 1976.

5 Zadeh, L.A. The concept of a linguistic variable and its application to approximate reasoning. Information Science, Part I, vol.8, pp. 199-249, 1975, Part II, vol.8, pp. 310-357, 1975, Part III, vol.9, pp. 43-80, 1976.

6 Sowa, J.F. Conceptual Structures, Addison Wesley, 1984.

7 Forgy, C.L. OPS5 User's Manual. Technical Report, Computer Science Dept., Carnegie-Mellon University, Pittsburgh, PA.