Book Review of

Fuzzy Sets and Fuzzy Logic
Theory and Applications

by George J. Klir and Bo Yuan

Prentice Hall, Upper Saddle River, New Jersey, 1995, 574 pages

This book is an extensive overview of fuzzy set theory that can be viewed as an update of past existing monographs with broad coverage, such as the one by Dubois and Prade (1980), and the books in the same style such as the one by Kandel (1986), or the one by Zimmermann (1985) for instance. It is also a follow-up to a previous monograph by Klir and Folger (1988) which was more specialized on information-theoretic aspects. At the theoretical level, this book covers the main chapters of fuzzy set theory, including representations of fuzzy sets, fuzzy set-theoretic operators, computations with fuzzy numbers, fuzzy relations (especially generalizations of equivalences and orderings, and fuzzy relation equations), possibility theory, the representation of fuzzy propositions, and the measurement of information contained in a fuzzy set. The second part called "applications" still contains theoretical developments on approximate reasoning. Apart from this particular chapter, the application part contains basically introductory notes to various methodological aspects or to fuzzy methods in various fields of information engineering such as systems analysis and control, pattern recognition, computerized information systems, decision-making. A chapter is devoted to the elicitation or measurement of membership functions.

It is interesting to compare the contents of this book with the contents of the monograph we wrote almost 20 years ago. Indeed, a good correspondence exists between chapters of one book and chapters of the other. It is clear that by 1980, most basic notions were already available, but sometimes in preliminary form. For instance, the three basic t-norms were known, and appear in the 1980 book and since then, the t-norm approach to fuzzy connectives has been considerably studied and used, as witnessed by the material in Chapter 3, which reports on fuzzy complements, intersections and unions in considerable details. Chapter 6 witnesses the blossoming of techniques for solving fuzzy relational equations, where composition involves triangular norms. Similarly, Chapter 7 shows that possibility theory has acquired some maturity, and that its links with evidence theory and probability theory have been investigated in depth. This topic was very new and dealt with in a much more sketchy way is the 1980 monograph. Similarly, Chapter 9 contains many results obtained in the 1980's and the early 1990's by Klir and colleagues on fuzzy or non-probabilistic information measures. On the contrary chapters on topics like fuzzy arithmetic (Chapter 4), and the representation of fuzzy propositions (Chapter 8) seem to report only few new results, although fuzzy arithmetics has improved from an algorithmic point of view, and our understanding of what fuzzy rules mean and how they behave in reasoning process has also improved. The chapter on measuring membership grades and fuzzy set connectives has especially benefited from advances in learning techniques such as neural networks; however no path breaking view on foundational issues has emerged in the last twenty years. On the side of applications, while some topics were already treated as full chapters in the 1980 monograph such as pattern recognition, fuzzy control and decision analysis, new fields of activity have emerged and receive now a more extensive coverage, such as information systems (fuzzy databases), fuzzy data analysis, or image processing. However the book also witnesses the tremendous progress of fuzzy systems science with the arrival of fuzzy neural nets and fuzzy rule-based modeling, and the success of stochastic optimization algorithms that easily lend themselves to the learning of fuzzy rule-based models or the solving of fuzzy optimization problems. All these issues were absent twenty years ago.

When a book is really good, it is harmless to point out some limitations. Among some debatable choices and questionable issues found in the book let us mention

- The treatment of the extension principle and fuzzy arithmetic without relationship to possibility theory. Clearly the membership grade [f(A)](y) of y to the fuzzy image f(A) of A via f can be explained as a computation of $\Pi(f^{-1}(y))$ the possibility level of the converse image of y, computed from the possibility distribution that equates the membership function of A. This approach enables a fruitful comparison between random and fuzzy arithmetics to be carried out;
- The restriction of aggregation functions that are neither conjunctions nor disjunctions to idempotent functions, hence averaging operators. What about symmetric sums that are De-Morgan autodual functions? While this family, which is not idempotent, has been deleted from the landscape, the authors mention associative averaging operations which form a very restricted class as shown by Fung and Fu (1975) or Dubois and Prade (1984), a result recalled at the end of Chapter 2 without any pointer to the literature;
- The restriction of fuzzy arithmetic to bounded-support fuzzy numbers and to binary arithmetic operations. Computing with fuzzy polynomials or fuzzy weighted averages is more tricky, and cannot be expressed in terms of product, sums, or division of fuzzy numbers;
- Sometimes the authors forget to give credit to previous contributors. For instance the weighted min operation introduced on page 92 (as well as variants thereof) is originally due to Yager (1981); OWA operations introduced on page 90 are also due to Yager (1988); the properties of the extended min and max applied to fuzzy numbers (page 110) were studied by Mizumoto and Tanaka (1976). Fuzzy equations A + X = B (page 115) were studied in the early eighties by Dubois and Prade (1983) as well as the LR-fuzzy numbers in the late seventies. Comparative possibility relations (pages 206) were introduced by David Lewis in 1973, and independently studied in (Dubois, 1986).

These little defects seem difficult to avoid in what is called "a magnum opus" by Zadeh in his preface, when the number of pages is limited to form a single volume. In spite of these local oversights, the scientific contents and the bibliographical material provided by the book are generally very rich (especially in the notes accompanying each chapter). By and large, it makes sense to consider this book as the most extensive and the most authoritative treatise on fuzzy sets that was published in the last 10 years. Any serious scientist in fuzzy set should have it on the shelf. It is a very precious document that helps the reader find his way in the huge maze of the recent fuzzy literature from which the authors have selected some 1700 references, without any hope of being exhaustive.

On the whole, what this book teaches us is that in twenty years, it is not so much the theory of fuzzy sets that has changed; with the emergence of convincing applications, what has emerged is a deep penetration of fuzzy methods (sometimes elementary ones, to be honest) in the area of engineering, and more particularly information engineering. It is now timely to focus on empirical foundations of the field.

Didier DUBOIS - Henri PRADE

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