

Foreword

Uncertainty is an attribute of information. Decisions are based on information. More often than not, decision-relevant information is uncertain and/or imprecise. As we move further into the age of machine intelligence and automated decision-making the issue of how to deal with uncertainty and imprecision becomes a matter of pressing importance.

Uncertainty and Intelligent Information Systems is an important contribution to a better understanding of how to deal with information processing and decision-making in an environment of uncertainty, imprecision and partiality of truth. *Uncertainty and Intelligent Information Systems* draws on papers presented at the 2006 Conference on Information Processing and Management of Uncertainty (IPMU) which was held in Paris in 2006. IPMU was born in 1986, the brainchild of Bernadette Bouchon-Meunier and Ronald Yager. Over the years, IPMU evolved into a leading conference in its field, embracing a wide-variety of methodologies for dealing with uncertainty and imprecision. Unlike many other conferences, IPMU has not been committed to a particular methodology. It rolls out a welcome mat for all schools of thought. Representative of the breadth of scope of IPMU are the papers: “The Game-Theoretic Framework for Probability,” by G. Shafer; “Generalized Naïve Bayesian Modeling,” by Ronald Yager; “An Increment Hierarchical Fuzzy Clustering for Category-based News Filtering,” by Gloria Bordogna, Marco Pagani, Gabriella Pasi; “A Possible Worlds Interpretation of Label Semantics,” by Jonathan Lawry and Van Nam Huynh; “A Study on the Analytic Hierarchy Process,” by Shin-ichi Ohnishi, Didier Dubois, Henri Prade and Takahiro Yamanoi; “Comparison of Spatiotemporal Difference of Brain Activity Between Correct and Approximation Answer Choices on Addition,” by Takahiro Yamanoi, Yuta Fujiwara, Hisashi Toyoshima, Michio Sugeno and Elie Sanchez;

“Comparing Dynamical Systems by Using Temporal Fuzzy Models,” by Juan Moreno-Garcia, Jose Jesus Castro-Schez and Luis Jimenez; “Improvement of Approximation Properties of a First-order Takagi Sugeno Fuzzy System,” by Felipe Fernandez, Julio Gutierrez, Gracian Trivino and Juan Carlos Crespo; “Using the Fuzzy Spatial Relation ‘Between’ to Segment the Heart in Computerized Tomography Images,” by A. Moreno, C.M. Takemura, O. Colliot, O. Camara and I. Bloch; “Neurofuzzy Network with On-Line Learning in Fault Detection of Dynamic Systems,” by Walmir Caminhas and Fernando Gomide; “Imperfect Information Representation through Extended Logic Programs in Bilattices,” by Daniel Stamate; “Geometric Representation of Weak Orders,” by Sergei Ovchinnikov; “Efficient Tracking of the Dominant Eigenspace of a Normalized Kernel Matrix,” by Geert Gins, Ilse Smets and Jan Van Impe.

In science, there is a deep-seated tradition of dealing with uncertainty and imprecision through the use of concepts and techniques drawn from probability theory. Until the advent of fuzzy logic, there was no questioning of this tradition. Today, this is no longer the case. More specifically, there has been and continues to be an ongoing debate between two schools of thought. First, there are those who believe that standard probability theory, PT, is sufficient for dealing with all kinds of uncertainty. An eloquent exponent of this school of thought — call it “PT is sufficient” school of thought — is the eminent Bayesian, Professor Dennis Lindley. In his view:

“The only satisfactory description of uncertainty is probability. By this I mean that every uncertainty statement must be in the form of a probability; that several uncertainties must be combined using the rules of probability; and that the calculus of probabilities is adequate to handle all situations involving uncertainty . . . probability is the only sensible description of uncertainty and is adequate for all problems involving uncertainty. All other methods are inadequate . . . anything that can be done with fuzzy logic, belief functions, upper and lower probabilities, or any other alternative to probability can better be done with probability.”

On the other side of the debate is the “PT is insufficient,” school of thought. This school holds the view that even though PT is powerful

and important, it is not sufficient for dealing with many types of real-world problems. More specifically, PT has fundamental limitations which are rooted in the fact that PT is based on bivalent logic — a logic which is intolerant of imprecision and partial truth. In PT, a concept is either true or false with no shades of truth allowed. Thus, an event either occurs or does not occur; a process is either stationary or nonstationary; events are either independent or not independent, and so on. Clearly, this is not a good model of reality. More importantly, PT does not provide effective tools for computation with imprecise probabilities and imprecise probability distributions — as most real-world probabilities and probability distributions are. There is a literature on imprecise probabilities and growing interest in computation with imprecise probabilities within PT, but what can be done through the use of bivalent-logic-based methods is rather limited. It is of interest to note that the debate between the Sufficientists and the Insufficientists has many historical parallels. Familiar examples are: Newtonian mechanics versus quantum mechanics; deterministic mechanics versus statistical mechanics; Euclidian geometry versus non-Euclidian geometry; and deterministic versus stochastic models in economics. In almost all cases, it is the Insufficientists whose views eventually prevail.

Within the “PT is insufficient” school of thought there are those, as I am, who feel that probability theory has much to gain from addition of concepts and techniques drawn from fuzzy logic. Among such concepts are those of fuzzy event, fuzzy probability, fuzzy probability distribution, fuzzy relation, the concept of a protoform, the concept of a linguistic variable, the concept of fuzzy rule set and the concept of a generalized constraint. In fuzzy logic, computation with fuzzy probability distributions involves propagation of generalized constraints. Importantly, in fuzzy logic everything is or is allowed to be graduated, that is, be a matter of degree or, equivalently, fuzzy. Furthermore, in fuzzy logic everything is or is allowed to be granulated, with a granule being a clump of elements drawn together by indistinguishability, equivalence, similarity, proximity or functionality. Graduation and granulation play key roles in human cognition.

The most significant limitation of PT is that PT does not have NL-capability, that is, the capability to operate on information described in natural language. The importance of NL-capability derives from the fact that much of human knowledge is described in natural language. This applies, in particular, to perception-based

knowledge. An example is the following problem. Assume that X is a real-valued random variable. I do not know the probability distribution of X but my perceptions are: (a) usually X is much larger than approximately a ; and (b) usually X is much smaller than approximately b , with $a < b$. What is the expected value of X ? Another example: I ask a cab driver to take me to address A the shortest way. This problem has a provably valid solution. But if I ask the driver to take me to address A the fastest way, the problem does not have a provably valid solution.

Generalization of PT through the addition of concepts and techniques drawn from fuzzy logic leads to what may be called the Generalized Theory of Uncertainty (GTU). The fundamental thesis of GTU is that information is representable as a generalized constraint. The traditional view that information is statistical in nature is a special case. Unlike PT, GTU is based on fuzzy logic. By construction, GTU is not a replacement for PT, but its conceptual framework is much broader than the conceptual framework of PT. In particular, as in fuzzy logic, graduation and granulation play pivotal roles in GTU.

In sum, "Uncertainty and Intelligent Information Systems," contains much that is forward-looking, informative and authoritative. Bernadette Bouchon-Meunier, Ronald Yager, Christophe Marsala, Maria Rifqi, the contributors and the publisher deserve our thanks, congratulations and loud applause.

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