

Fuzzy Measures, Integrals and Quantification in Artificial Intelligence Problems - An Homage to Miguel Delgado

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This special issue is an homage to Professor Miguel Delgado, one of the founders and current member of the Department of Computer Science and Artificial Intelligence of the University of Granada. The topic of this issue, intended to be published before Professor Delgado's retirement, is related to areas where he has provided contributions along his fruitful career, not only with scientific results and publications, but also by advising or collaborating with some of the authors that have contributed to this special issue.

Theoretical advances in fuzzy measures, integrals and quantification have been shown to be a solid basis for solving a wide range of artificial intelligence problems in different areas: Machine Learning, Data Mining, and Big Data; Databases and Information Systems; Data-to-text systems and Linguistic Summarization; Environmental Sustainability and Ambient intelligence; among many others. Though results in this topic have been provided since fuzzy sets were proposed by L.A. Zadeh, they keep being an object of active research. At the same time, they keep supporting the development of many different kinds of intelligent systems. Many challenges remain open from both the theoretical and applied perspectives. From the scientific point of view, the aim of this special issue has been to serve as a meeting point and open discussion forum for researchers and practitioners on the latest developments in these and closely related topics.

The accepted papers contain i) contributions to specific A.I. problems and applications, ii) general methodological proposals, and iii) theoretical studies, all of them related to the topic of the special issue. Papers in the first group include the following:

- Within A.I., more specifically in Machine Learning and Data Mining, one of the main problems to solve is providing classification models for different scenarios. In *Learning rule sets and Sugeno integrals for monotonic classification problems*, the authors Quentin Brabant, Miguel Couceiro, Didier Dubois, Henri Prade, and Agn  s Rico, propose a model for monotonic classification based on decision rules, using qualitative extensions of the Sugeno integral, particularly qualitative decomposable models called

Sugeno Utility Functionals (SUF). These models allow to use Sugeno integrals for representing a set of rules. Two algorithms are provided for learning the classifier: a non-parametric algorithm for fitting a rule set to the training data, that try to minimize the length of rules, and another algorithm that minimizes the number of SUFs for representing the set of rules. The objective is to obtain a good tradeoff between accuracy and understandability in the final classification model.

- An specific classification problem is addressed in the contribution *A Munsell colour-based approach for soil classification using Fuzzy Logic and Artificial Neural Networks*, by M. Carmen Pegalajar, Luis G. Baca-Ruiz, Manuel Sánchez-Marañón and Luis Mansilla. Neural networks and fuzzy logic are employed for building a classifier that provides the closest values of the Munsell chips to an unknown colour of a soil sample. The proposal avoids misclassification caused by the subjectivity of humans when performing this task, which is crucial in the study of soil since color is one of the most informative features in that context. The method developed can be implemented in a mobile device like a smartphone, so that soil experts can obtain the closer Munsell color chip immediately during direct exploration of soils in an area, without the necessity to rely on external servers.
- In *GimmeHop: A recommender system for mobile devices using ontology reasoners and fuzzy logic*, the authors Ignacio Huitzil, Fernando Bobillo, and Fernando Alegre present an intelligent system called **GimmeHop**, a beer recommender system for Android mobile devices. They employ fuzzy quantification in the ontologies that represent and reason with the available expert knowledge; particularly, fuzzy quantifiers allow **GimmeHop** to deal with incomplete data by performing quantified-guided aggregation, benefiting from the large amount of available methods [1].

The following papers contain methodological proposals for dealing with general A.I. problems related to the topic of the special issue:

- A methodology for defining fuzzy datatypes in fuzzy OWL2 is contributed in *Fudge: Fuzzy Ontology Building with Consensuated Fuzzy Datatypes* by Ignacio Huitzil, Fernando Bobillo, Juan Gómez-Romero, and Umberto Straccia. The methodology is implemented by the authors into a freely available tool called **Fudge**, which allows to define membership functions for real-valued fuzzy sets by aggregating the information provided by a group of experts. Different aggregation operators and strategies are available in **Fudge**, and others can be easily incorporated. The proposal addresses one of the main problems in ontology development: the information contained in the ontology must serve in order to clarify the meaning of concepts in a certain context, and hence must represent an agreement between all people involved.

- The paper *Representation by Levels: an Alternative to Fuzzy Sets for Fuzzy Data Mining*, by Carlos Molina, M. Dolores Ruiz, and José M. Serano, illustrates the potential advantages of using Delgado et al.'s Representations by Levels [2, 3] for fuzzy data mining. Particularly, the treatment of negation of Representation by Levels allows to keep the algebraic Boolean structure of set operations, and the corresponding gradual numbers [4, 5] keep the usual properties of ordinary numbers, allowing to extend directly the existing algorithms and quality measures employed in crisp data mining to the fuzzy case. These advantages are illustrated for the case of fuzzy association rules and the related issues of mining exception/anomalous rules and mining fuzzy bag databases. Quality measures can be extended by using generalizations of fuzzy quantification mechanisms to the case of level-based representations [6, 7].

Finally, the following papers are devoted to study theoretical aspects related to the scope of this volume:

- In *Reflections on an old problem: that of preserving the logical forms and symmetry*, by Adolfo R. de Soto, Alejandro Sobrino, Enric Trillas, and Claudi Alsina, ...
- In *Axiomatizing logics of fuzzy preferences using graded modalities*, authors Amanda Vidal, Francesc Esteva and Lluís Godó ...
- The paper *Specificity measures based on fuzzy set similarity*, authored by Nicolás Marín, Gustavo Rivas-Gervilla, Daniel Sánchez, and Ronald R. Yager, studies the definition of specificity measures of a fuzzy set on the basis of the similarity between the fuzzy set and the closest crisp singleton. Different axiomatic definitions of specificity are recalled, and sufficient conditions are provided for a fuzzy set similarity measure to allow the generation of corresponding specificities using the proposed method. It is shown that several existing measures of specificity can be generated this way, and also that new measures are provided that cannot be found in the literature.

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