From Clusters to Perceptions: The Evolution of Fuzzy Clustering

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http://sv.cmu.edu/who_we_are/visitor, Bldg. 23, room 118 .
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Abstract:

The ever-increasing amount of data accessible through computer networks has spurred the application of methods for its analysis, summarization, and interpretation. Clustering techniques, in particular, have been employed to discover knowledge and to reduce data complexity. This body of techniques, often described as performing "numerical classification" or "unsupervised pattern recognition," encompass a wide diversity of procedures having different computational goals, which are rarely made either explicit or clear by their developers. Since their inception, clustering approaches based on the theory of fuzzy sets have been extensively applied due to their rich representational capabilities, their formal mathematical underpinnings, and the relations between the nature of fuzzy classifications and utilitarian and metric concepts such as preferences and similarities. Furthermore, the very nature of fuzzy clustering methods readily permits the definition of interesting data structures as instances of paradigmatic models that are approximated by subsets of the dataset being analyzed.

In our presentation, we will review the motivation and evolution of fuzzy-set based methods to discover structures in data. Our point of departure will be the initial proposal for the formulation of relational fuzzy clustering as an optimization problem over the set of all partitions of a subset of a metric space. We will also examine the related problem of partitioning a subset of a vector space and discuss major approaches to its treatment. Continuing our retrospective examination of fuzzy-clustering techniques we will focus on significant milestones in the evolution of this methodology including the generalizations of the notions of prototype, clustering, and fuzzy partition. The objective of this review is to motivate the introduction of qualitative object description methods, which are soft-computing based approaches for the representation of complex objects in terms of significant qualitative features (e.g., interesting substructures in biological molecules) and by identification of qualitative relationships between those features (e.g., spatial relations between features). We will conclude with a brief discussion of recent applications of QOD methods to important problems in the applied sciences.

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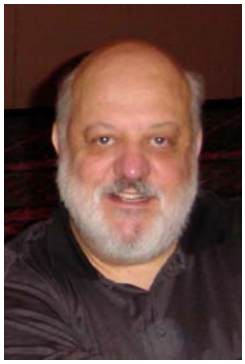

Dr. Enrique H. Ruspini is Principal Researcher and Director of the Collaborative Soft Intelligent Systems Laboratory at the European Centre for Soft Computing in Mieres (Asturias), Spain. Dr. Ruspini received his degree of Licenciado en Ciencias Matemáticas from the University of Buenos Aires, Argentina, and his doctoral degree in System Science from the University of California at Los Angeles. Prior to joining ECSC, he was a Principal Scientist with the Artificial Intelligence Center of SRI International (formerly Stanford Research Institute). Dr. Ruspini has also held positions at the University of Buenos Aires, the University of Southern California, UCLA's Brain Research Institute, and Hewlett-Packard Laboratories. Dr. Ruspini is one the earliest contributors to the development of fuzzy-set theory and its applications, having introduced its use to the treatment of numerical classification and clustering problems. He has also made significant contributions to the understanding of the foundations of fuzzy logic and approximate-reasoning methods. His recent research has focused on the application of fuzzy-logic techniques to the development of systems for intelligent control of teams of autonomous robots, distributed intelligent control, intelligent data analysis, information retrieval, qualitative description of complex objects, and knowledge discovery and pattern matching in large databases.

Dr. Ruspini, who has lectured extensively in the United States and abroad and is the author of over 100 original research papers, is a Life Fellow of the Institute of Electrical and Electronics Engineers, a First Fellow of the International Fuzzy Systems Association, a Fulbright Scholar, an European Union Marie Curie Fellow, and a SRI Institute Fellow. Dr. Ruspini was the General Chairman of the Second IEEE International Conference on Fuzzy Systems (FUZZ-IEEE'93) and of the 1993 IEEE International Conference on Neural Networks (ICNN'93). In 2004, Dr. Ruspini received the Meritorious Service Award of the IEEE Neural Networks Society for leading the transition of the Neural Networks Council into Society status. He is one of the founding members of the North American Fuzzy Information Processing Society and the recipient of that society's King-Sun Fu Award. Dr. Ruspini is the recipient of the 2009 Fuzzy Systems Pioneer Award of the IEEE Computational Intelligence Society. Dr. Ruspini is a former member of the IEEE Board of Directors (Division X Director , 2003–2004), the Past-President (President-2001) of the IEEE Neural Networks Council (now IEEE Computational Intelligence Society) and its past Vice-president of Conferences. Dr. Ruspini, who has led numerous IEEE technical, educational, and organizational activities, is also a member of the Administrative Committee of the IEEE Computational Intelligence Society, and of its Strategic Planning (Chair), Nominations and Appointments and Constitution and Bylaws Committees. Dr. Ruspini is also the Chair of the 2012 Frank Rosenblatt Technical Field Award Committee.