



Special issue on “Extensions to type-1 fuzzy logic: theory, algorithms and applications”

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Published online: 27 November 2019
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Recent developments in fuzzy logic have presented new theories, concepts and algorithms extending the original ideas of the pioneering work of Prof. Zadeh. Traditional fuzzy logic, now called type-1 fuzzy logic, has been widely applied in many real-world problems with relative success, ranging from control, pattern recognition, robotics, time-series prediction and economics. However, complex problems usually involve higher degrees of uncertainty that cannot be handled with the traditional type-1 fuzzy logic. In this case, extensions to type-1 like interval type-2 fuzzy logic, general type-2 fuzzy logic, intuitionistic fuzzy logic and other similar approaches have been recently proposed to tackle more complex real-world problems. In particular, problems of intelligent control, robotics, pattern recognition, time-series prediction, decision making have been solved with type 2 fuzzy logic and intuitionistic fuzzy systems. The present special issue is dedicated to the new theories, concepts and algorithms that have been developed to consider situations and problems under high degrees of uncertainty.

The special issue was aimed at publishing the best papers on theoretical aspects and applications of extensions to type-1 fuzzy logic. In particular, extended versions of good papers presented in the International Conference on Information Technology and Applied Mathematics held in Haldia, India, March 7–9, 2019, were invited to be considered in the special issue. In addition, the special issue was also open to contributions from researchers from around the world. In total, more than 20 submissions were received, from which 13 papers after rigorous refereeing

process were finally accepted to be published in the special issue.

In the first paper, by Amita Jain et al., an approach called Senti-NSetPSO for large-sized document-level sentiment analysis using neutrosophic sets and particle swarm optimization was presented. In the second paper, by P. Montes Dorantes et al., an approach for dynamic adaptation of the PID's gains via interval type-1 and nonsingleton type-2 fuzzy logic systems whose parameters are adapted using the backpropagation learning algorithm was presented. In the third contribution by Dipak Jana et al., an approach for qualitative model optimization of almond (*Terminalia catappa*) oil using Soxhlet extraction in type-2 fuzzy environment was outlined. In the fourth contribution, Fatih Kutlu et al. presented an innovative approach for intuitionistic fuzzy adaptive sliding mode control of nonlinear systems, which can be applied to many real-world control problems. In the fifth paper, by Amrit Das et al., an optimal redistribution plan considering aftermath disruption in disaster management was presented with interesting results. In the sixth paper, by Patricia Melin et al., an approach toward a development of general type-2 fuzzy classifiers applied in diagnosis problems through embedded type-1 fuzzy classifiers was presented, which is an original contribution that proposes a general way to build general type-2 fuzzy systems using training data for the corresponding applications. In the seventh paper, by S. Lakshmanaprabu et al., an improved grey wolf optimization-based feature subset selection with fuzzy neural classifier for financial crisis prediction was presented, which described very interesting prediction results. In the eighth paper, by Ahmed Anter et al., an approach with parameter estimation in dynamic model via fuzzy swarm intelligence and chaos theory for faults in wastewater treatment plant was presented, which showed very good results in the particular application. In the ninth paper, by Samarjit Kar et al., a ranking method based on interval type-2 fuzzy sets for multiple-attribute group decision making was

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presented, which is a method that could have multiple applications in diverse areas. In the tenth paper, by Arindam Garai et al., a new approach for multiobjective optimization of cost-effective and customer-centric closed-loop supply chain management model in T-environment was presented with interesting results. In the 11th paper, by Fevrier Valdez and Cinthia Ochoa, a new approach for dynamic parameter adaptation in the harmony search algorithm for the optimization of interval type-2 fuzzy logic controllers was outlined with interesting results in the optimization of benchmark problems. In the 12th paper, by Patricia Ochoa et al., the optimization of fuzzy controller design using a differential evolution algorithm with dynamic parameter adaptation based on type-1 and interval type-2 fuzzy systems was presented with very good results. In the final paper, by Fevrier Valdez, an interesting review of optimization swarm intelligence-inspired algorithms with type-2 fuzzy logic parameter adaptation was presented, and the review outlined interesting trends in this area of research.

It is hoped that the special issue will offer new directions and interests to the research community, especially to

those with interest in extensions of type-1 fuzzy systems and applications.

We are really indebted to all the contributors who have responded to our requests and submitted such high-quality papers, which has made the special issue a huge success. All the reviewers who have given their valuable time in reviewing the works deserve special applause. We are forwarding our sincere thankfulness to the Editor in Chief, Prof. Antonio Di Nola and Editor of Special Issues, Prof. Vincenzo Loia, for giving us the opportunity to organize the special issue. We most humbly acknowledge their kind guidance and support, which has been very instrumental in bringing this special issue to light.

Compliance with ethical standards

Conflict of interest All the authors in the paper have no conflict of interest