

Preface

Mathematics and Computational Intelligence Synergies for Emerging Challenges

Jesús Medina¹, Juan Moreno-García^{2*}, Eloísa Ramírez-Poussa¹, László T. Kóczy^{3,4}¹Department of Mathematics, University Cádiz, Cádiz, Spain²Escuela de Ingeniería Industrial Universidad de Castilla La Mancha, Toledo, Spain³Department of Information Technology, Széchenyi István University, Győr, Hungary⁴Department of Telecommunications and Media Informatics, Budapest University of Technology and Economics, Hungary

© 2021 The Authors. Published by Atlantis Press B.V.

This is an open access article distributed under the CC BY-NC 4.0 license (<http://creativecommons.org/licenses/by-nc/4.0/>).

Nowadays, in all applied fields, there exists a wide range of challenges that need the development of techniques with solid mathematical foundations, in order to give answers to different problems. Many of these problems require advanced mathematical techniques, among which we can mention fuzzy techniques capable of dealing with imprecise, uncertain or incomplete information or methods based on other branches of computational intelligence (CI), such as various kinds of connectionist systems, and algorithms that copy the evolution of biological species, or the behavior of whole populations, and which often help solve “unsolvable” (intractable) mathematical problems in the form of high quality and efficient approximation. A special class of these methods is the group of memetic algorithms, which always combine CI in the form of the latter class of methods with the classic optimization techniques developed by classical mathematics, such as gradient-based techniques, or local subgraph optimization. Combining the advanced computer science techniques provided by CI with mathematical foundations makes them more efficient, robust and solid. As a consequence, the results of those processes in which they are applied are improved, compared to both purely mathematical and purely CI methods, this way making them more efficient, more reliable and much wider applicable.

The published works in this special issue show that not only the independent development of mathematical techniques or methods based on computer science is interesting, but the interaction between both areas of knowledge becomes essential in responding to a large number of current problems. The obtained advances in these papers continue the considered research lines, which are fundamental for future applications in diverse fields of science.

It is important to mention that all papers included in this special issue are essentially extended versions of a number of selected

communications presented at the 11th *European Symposium on Computational Intelligence and Mathematics* (ESCIM 2019) held in Toledo, Spain, from October 2nd to 5th, 2019. All contributions at ESCIM have been subjected to a primary peer review process, through which those papers with the highest scientific quality had been selected, and the authors had been asked to work on the extended articles, which again, had been peer reviewed.

The first accepted paper [1] is focused on the fuzzy generalization of an important notion in set theory, the inclusion of sets. This notion was directly translated into fuzzy sets on the unit interval, as an inequality between the membership functions of the fuzzy sets, that is, a fuzzy sets A is less or equal to other fuzzy set B , if their membership functions μ_A and μ_B satisfy $\mu_A(x) \leq \mu_B(x)$, for all $x \in [0, 1]$. Since this definition can be considered a crisp definition given by the crisp inequality \leq , other definitions of fuzzy inclusion have been included in the literature. This paper studies one of the most interesting notions, the degree of f -inclusion, which differs from others existing ones in the literature because the degree of inclusion is considered as a mapping instead of a value in the unit interval. Moreover, the authors present the degree of f -weak-contradiction in order to represent the contradiction between two fuzzy sets via a mapping, as well as the relationships between both f -degrees, the f -inclusion and the f -weak-contradiction.

Enterprise architecture (EA) is an important research field in the business sector, which needs the use of new technologies for obtaining more efficient results. It is clear that analytics (data and variable analysis) provide competitive advantages for companies. Indeed, Forbes has announced that companies that still are not investing heavily in analytics by 2020 probably will not be in business in 2021. The second paper [2] presents a new integration approach for managing Information Technology (IT) variables within EA in an integrated way, in order to increase the efficiency and effectiveness levels in a company. This integration is an important

* Corresponding author. Email: Juan.Moreno@uclm.es

contribution of this work since the current management models do not consider IT variables in an integrated way. Moreover, due to the presence of uncertainty and imprecision is evident in the dataset, the development and application of fuzzy tools in the integration is also an important aspect of the paper, in order to obtain representative and useful results. Specifically, first of all, the authors have studied the different variables and their theoretical relationships to be considered in the integration approach. Then, a novel method based on fuzzy logic, fuzzy relation equation theory and fuzzy graph, for cause–effect variable analysis is proposed as a useful support decision-making tool for companies, in order to know the main actions they must perform for increasing their benefits.

Multicriteria group decision-making (MCGDM) is a useful theory with a great impact in many fields, such as in engineering, sustainability and biology. It is focused on ranking a set of elements according to a specific set of criteria. Since these criteria are usually based on expert judgments, subjectivity and vagueness are clearly present. Therefore, fuzzy set theory can be used in these performance-assessment-related decision-making processes. The use of a fuzzy approach provides approximate reasoning methods that can handle the inherent subjectivity. The third paper [3] develops a new framework for evaluating players in collective sports based on multicriteria group decision-making and linguistic labels. Specifically, the authors introduce a novel fuzzy model to aggregate expert judgments, for selecting those criteria that best represent the handball player's performance in a match and for setting their relevance weights. From the obtained results, the new methodology has solved various drawbacks of classical systems, and has shown useful insights regarding player performance in different matches. For example, the authors have proven that the introduced methodology offers better results than the usual plus–minus (PM) methodologies in order to represent the performance of specialized players who only play when their team attacks or defends, as in handball it normally happens.

The fourth contribution [4] is related to natural language processing (NLP). NLP consists in the analysis of texts written in natural language with the goal of allowing the extraction of information from texts. Machine learning and techniques based on deep neural networks are used to generate language models that are used in NLP techniques. This paper presents a technique based on two Recurrent Neural Networks to identify the subject and predicate in a sentence. The first step makes a part-of-speech (POS) tagging process of each sentence while the second one identifies the member of the subject and of the predicate. Some public datasets have been used to validate the proposed architecture. The tests raise high rates of accuracy for the two processes done, POS tagging and subject and predicate classification. Moreover, the introduced architecture is compared with Natural Language Toolkit (NLTK), pyStatParser and spaCy, and better results are obtained.

The fifth paper [5] deals with a very challenging and hot topic, the efficient approximate solution of NP-complete graph search problems, which cannot be exactly solved in general. The Traveling Salesman Problem (TSP) is one of the problems addressed by the most researchers, and there exist numerous approximate solvers (with guaranteed, although not very high accuracy), while a large number of tailor-made meta-heuristics provide much better solutions, often the exact optimum, and usually, a result very close to the unknown optimum (which can be estimated by the lower bound

calculated from the spanning tree). A further related, although even more difficult NP-complete problem is the cumulative extension of the TSP that is called Traveling Repairman Problem (TRP). The main difference is that here all costs from the starting point (depot) to the individual vertices are added, this way, the sections in the beginning of the solution route are added multiple times. The Bacterial Evolutionary Algorithm is one of the most efficient evolutionary approaches, and the authors had combined it with n -opt type local search, thus obtaining the Discrete Bacterial Memetic Evolutionary Algorithm. The solution proposed in this contribution overperforms all other authors' approaches to the TRP in accuracy and speed. Moreover, the method used here is more predictable if the necessary running time is estimated in terms of the graph size, and it is also rather universal, as it had been efficiently used for a number of other TSP-related difficult optimization problems successfully.

The sixth paper [6] presents a theoretical study about a kind of operators of special interest in the theory and the applications of aggregations in fuzzy logic, the class called uninorms. The author introduces a particular class of uninorms, called group-like uninorms, together with a structural description of a large subclass of them. In addition, a complete characterization for square group-like uninorms with finitely many idempotent elements is also given. This characterization provides the whole spectrum of choice of this type of square group-like uninorms, which is fundamental for potential applications in several fields.

The last paper [7] is framed within the lattice theory. The presented study addresses the use of congruences defined on complete lattices. In particular, it presents a study on the conditions under which the equivalence relation on a complete lattice determined by cuts of a lattice-valued function is a complete congruence. The authors use the framework of residuated maps induced by lattice-valued functions, to analyze complete congruences on complete lattices. Then, they prove that every complete congruence on a complete lattice is the kernel of the residuated map induced by a particular lattice-valued function. Furthermore, some versions of representation theorem for lattice-valued functions by means of the notion of residuated maps are introduced.

Finally, we would like to finish this preface expressing our acknowledgment to all authors, the members of the Program Committee and the reviewers, since without their effort and interest this special issue would not have been possible. We also acknowledge the support received from the University of Cádiz, the Hungarian Fuzzy Association, the Széchenyi István University (Győr), the Institute of Mathematics and CS, University of Castilla la Mancha, and the 2014–2020 ERDF Operational Programme in collaboration with the State Research Agency (AEI) in projects TIN2016-76653-P and PID2019-108991GB-I00, the Department of Economy, Knowledge, Business and University of the Regional Government of Andalusia in project FEDER-UCA18-108612, the National Research, Development and Innovation Office (Hungary) for grant nr. K124055 and the European Cooperation in Science & Technology (COST) Action CA17124.

REFERENCES

- [1] N. Madrid, M. Ojeda-Aciego, On contradiction and inclusion using functional degrees, *Int. J. Comput. Intell. Syst.* 13 (2020), 464–471.

- [2] C. Rubio-Manzano, J.C. Díaz-Moreno, D. Alfonso-Robaina, A. Malleuve, J. Medina, A novel cause-effect variable analysis in enterprise architecture by fuzzy logic techniques, *Int. J. Comput. Intell. Syst.* 13 (2020), 511–523.
- [3] F.P. Romero, E. Angulo, J. Serrano-Guerrero, J.A. Olivas, A fuzzy framework to evaluate players' performance in handball, *Int. J. Comput. Intell. Syst.* 13 (2020), 549–558.
- [4] D. Muñoz-Valero, L. Rodríguez-Benítez, L. Rodríguez-Benítez, L. Jiménez-Linares, J. Moreno-García, J. Moreno-García, Using recurrent neural networks for part-of-speech tagging and subject and predicate classification in a sentence, *Int. J. Comput. Intell. Syst.* 13 (2020), 706–716.
- [5] B. Tüü-Szabó, P. Földesi, L.T. Kóczy, An efficient evolutionary metaheuristic for the traveling repairman (minimum latency) problem, *Int. J. Comput. Intell. Syst.* 13 (2020), 781–793.
- [6] S. Jenei, Group-like uninorms, *Int. J. Comput. Intell. Syst.* 13 (2020), 954–965.
- [7] B. Šešelja, A. Tepavčević, Kernels of residuated maps as complete congruences in lattices, *Int. J. Comput. Intell. Syst.* 13 (2020), 966–973.