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Editorial

Special Issue "Fuzzy Decision Making and Soft Computing Applications"

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Research on fuzzy logic [1] and soft computing for decision making has a long history. In many fields of application, rule-based fuzzy systems have been employed [2–4] for their unique properties in solving modelling problems. In particular, decision-making systems often deal with uncertain data. Moreover, in some fields of application, such as differential diagnosis in medicine, a meaningful confidence measure is required to be associated with the classification result in order to show all possible outcomes with the relative likelihood. Finally, semantically meaningful systems are often required, providing clear and logical interpretation of the inference process, in order to encapsulate them in interactive frameworks of cognitive systems, or to enable validation by domain experts. These issues can be accomplished, on the one hand, by encoding uncertain numerical data in terms of interpretable linguistic variables [5]. On the other hand, fuzzy rules show a clear and logical justification for each conclusion [6,7]. Finally, if desired, fuzzy systems allow classification results to be presented associated with a confidence measure, such as the probability of different classes [8].

The remarkable progress made by these approaches in various fields underlines their benefits and is stimulating further research. In particular, despite the remarkable successes in different tasks, research on these approaches is a field of increasing interest [9], with regard to theoretical aspects, which are being deepened [10–12], as well as aspects regarding procedures for learning fuzzy systems optimizing accuracy and/or interpretability, or for solving mathematical tasks using fuzzy numbers and soft computing [13–18]. Moreover, these approaches are prone to easily and proficiently be employed in different new fields of application [19–21].

This Special Issue collects original research articles discussing cutting-edge work as well as perspectives on future directions in the whole range of theoretical and practical aspects in this research area. In particular, there are 12 contributions selected for this Special Issue, representing progresses in the following areas specifically addressed.

1. **Theory of fuzzy systems and soft computing.** The authors of [10] consider causal graphs and propose a procedure to explicitly understand underlying assumptions, the kind of data and methodology needed to understand a given relationship, and how to develop explicit assumptions with clear alternatives in order to apply a process of probabilistic elimination. In [11], the authors unambiguously define the relations "greater than", "equal to", and their combination, in the space of all ordered fuzzy numbers, to solve optimization tasks. Moreover, in [12], a problem of "acceptance of an optimal solution" is presented in the form of a vector problem of mathematical programming. The theory of vector optimization is proposed as a mathematical apparatus for the acceptance of optimal solutions of such a class of problems, and the analysis and problem definition of decision making under the conditions of certainty and uncertainty are presented.
2. **Learning procedures.** In [13], the authors propose two types ("infimum type" and "supremum type") of dual double fuzzy semi-metric, as well as different types of

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triangle inequalities, which are used to investigate the convergence. Another contribution [14] proposes an adaptive-network-based fuzzy inference system (ANFIS) model for the accurate estimation of signal propagation. Results on benchmark data show that the proposed model outperforms nondeterministic models in terms of accuracy and presents flexibility, ease of use, robustness, generalization capability, and an alleviated training process for propagation prediction in complex scenarios. Some authors contributed with three different papers. In the first [15], to solve the Cauchy problem, three fuzzy numerical methods, based on the combination of fuzzy transform with one-step, two-step, and three-step numerical methods, are introduced. The error analysis of the new fuzzy methods is discussed, showing more accurate results compared with other existing methods. The other two papers by the same authors [16,17] report parts I and II of the same voluminous work, where new approximation methods for solving systems of ordinary differential equations (SODEs) using fuzzy transform are introduced and discussed. In particular, different modified numerical schemes and new representations of basic functions are proposed, the error analysis of the new approximation methods and the properties of the uniform fuzzy partition are examined, and numerical examples showing improved accuracy are presented. A further work [18] assesses how three shaking procedures affect the performance of a metaheuristic General Variable Neighbourhood Search algorithm. The different schemes were applied on benchmark instances of the Traveling Salesman Problem to examine the potential advantage of any of the three metaheuristic schemes, showing similarities and differences among different methods.

3. **Decision-making applications employing fuzzy logic and soft computing.** Contributions in this field show a variety of possible applications. In the context of the characterization of basmati rice product value using an image-based grading process, the authors in [19] propose a model for quality grade testing and identification, using a novel digital-image-processing- and knowledge-based ANFIS. This approach provides capabilities to simulate the behaviour of an expert in the characterization of rice grains using their physical properties, and compared to other machine learning techniques, its results are promising in terms of classification accuracy and efficiency. In the field of electron beam (EB) measurements, the author of [20] presents a novel method of restoring the EB measurements that are degraded by linear motion blur. The author's approach is based on a fuzzy inference system and a Wiener inverse filter, providing autonomy, reliability, flexibility, and real-time execution, in restoring highly degraded signals without requiring exact knowledge of EB probe size, and a demonstration is given by comparing ground truth signals with restorations. Finally, in [21], the motion control of mobile robots in a cluttered environment with obstacles is considered. In particular, to control the motion of a mobile robot using an eye gaze coordinate as inputs to the system, the paper presents an intelligent vision-based gaze guided robot control, utilizing an overhead camera, an eye-tracking device, a differential drive mobile robot, vision, and an interval-type-2 fuzzy inference tool. Experiments and simulation results indicate that the system can successfully perform operator intention, modulating speed and direction accordingly.

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