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Computational Intelligence and Mathematics for Tackling Complex Problems

Springer

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Preface

Advances in Computational Intelligence and Mathematics for Tackling Complex Problems

Many areas of modern knowledge encounter problems, whose solution is impossible without applying advanced mathematical techniques as well as computational intelligence-based methods. Moreover, the interaction and interplay between mathematical techniques and computational technologies are fundamental for the adequate approach of the research of such problems. Among the most important mathematical tools for this interaction are fuzzy logic-based mathematical technologies and rough set-based methodologies. These technologies and specifically their interplay allow to address different challenges of the present technological age.

Many areas of modern knowledge encounter the problems the solution of which presupposes the use of both advanced mathematical techniques and computational intelligence-based research methods.

In this volume, these two research areas, computational intelligence and mathematics, are connected in attractive contributions devoted to the solution of some tempting theoretical and real-world important problems. The volume is mainly composed of the extended and reviewed versions of the highest quality papers presented by participants from diverse countries of the world such as Japan, Mexico, Chile and Cuba at the Tenth European Symposium on Computational Intelligence and Mathematics (ESCIM 2018) held in Riga, the capital of Latvia, from October 7 to 10. Besides, the technical programme of the conference included four substantial keynote presentations given by Profs. Janusz Kacprzyk from Poland (description of human-centric systems: a crucial role of bipolarity in judgements and intentions), Oscar Castillo from Mexico (nature-inspired optimization of type-2 fuzzy logic controllers), Gabriella Pasi, from Italy (aggregation guided by fuzzy quantifiers in IR and social media analytics) and Alexander Šostak from Latvia (on many-level fuzzy rough approximation systems). In the sequel, we give a brief summary of the contributions contained in this volume.

The first and the twelfth papers, written by a group of Hungarian authors, are devoted to the development of fuzzy signature-based models. In the first paper, a new fuzzy signature modelling packaging decision is developed. It is based on logistics expert opinions and aimed to support the decision-making process by choosing the right packaging system specifically aimed for dangerous goods packaging. In its turn, the twelfth paper presents a new fuzzy signature-based model for the qualification of residential buildings. This model is using a structure of fuzzy signature with variable aggregations, where the definition of aggregation is made by parameters and the values of parameters are changing depending on the specific application.

The second paper presents a new classifier architecture based on fuzzy fingerprint relevance classifier. This classifier is worked out by a group of Portuguese researchers. Specifically, this classifier allows to get good results in the process of automatic identifying patient innovation solutions from texts obtained by means of the Web.

The authors of the third paper, researchers from the Szechenyi Istvan University in Hungary, propose an interesting population-based memetic algorithm, so-called discrete bacterial memetic evolutionary algorithm, appropriate for solving the one-commodity pickup-and-delivery travelling salesman problem. The algorithm was tested on benchmark instances, and the results were compared with the state-of-the-art methods in the literature, illustrating the advantages of the proposed algorithm.

In the fourth paper presented by researchers from University of Debrecen, some interesting possible connections between concepts of roughness and fuzziness are studied. It is shown that a rough membership function can be interpreted as a special type of a fuzzy membership function. This fact is applied to investigate some interplay between the two theories.

The main goal of the fifth paper, written by a group of Hungarian scientists, is to find a method that would allow to indicate some characteristic points that can be used for fitting two measured surfaces together. In order to get such a method, the authors introduce fuzzy version of a Hough transform that allows to detect straight line segments on the image. As different from the classical Hough transform, its fuzzy version is useful in case when the lines are not precisely given or not precisely straight. The authors apply this method for finding the same location on two measured versions of a surface.

The authors of the sixth paper analyse the behaviour of the so-called rescaled algorithm for fuzzy cognitive maps with respect to the existence and uniqueness of fixed points of such maps. This problem is important for the use of fuzzy cognitive maps in network-like decision support tools.

In the seventh paper, the class of group-like uninorms is introduced as a subclass of group-like FL_e algebras, where the underlying universe is order isomorphic to the real line interval (0,1). The author, from the University of Pécs in Hungary, presents some methods of construction of such uninorms and besides gives a complete characterization of this class in case of uninorms with a finite number of idempotent elements.

The next paper presents the results of the research work in the field of adjoint triples done in the Department of Mathematics, University of Cádiz, Spain. Adjoint triples arise as an important generalization of t-norms and corresponding residuation, since they provide more flexibility and increase the range of possible application. The authors analyse how the exchange principle law should be defined on adjoint triples and what conditions the conjunction of an adjoint triple should fulfil in order to guarantee that the corresponding residuated implications satisfy the prescribed property.

The ninth paper presents the results of the research done by mathematicians from Serbia. Basing on the known fact that in every finite poset each element can be presented as a join of completely join-irreducible elements, the authors justify the introduction of a new concept of a poset-valued reciprocal (preference) relations as well as its intuitionistic counterpart. In this representation, join-irreducible elements represent pieces of information that reflect the grade of preference in this framework.

In their previous research, the authors of the tenth paper showed that the category of Chu correspondences between Hilbert contexts is equivalent to the category of propositional systems (the algebraic counterpart of the set of closed subspaces of a Hilbert space). These researchers from Spain and Slovakia extend in the present paper the previously obtained results to the big toy models (in the sense of S. Abramsky) introduced as a tool to represent quantum systems in terms of Chu spaces. Specifically, the authors obtain a categorical equivalence between big toy models and a suitable subcategory of the category of Hilbert formal contexts and Chu correspondences. This result is a new example of interesting structures which are representable in terms of Chu correspondences.

In the next paper written by Polish scientists, the authors continue their previous research on attribute selection by Hellwig method in case when the data set is expressed via an Atanassov intuitionistic fuzzy set. The authors present a novel extension of Hellwig method for the reduction of data, which was primarily proposed for economic data analysis. In this method, the authors use three-term representation of fuzzy intuitionistic sets, that is taking into account the degree of membership, non-membership and hesitation.

The next two papers are written by scientists from different institutions in Poland. The thirteenth paper is devoted to the day and night design of a fuzzy system for the classification of blood pressure load. The authors analyse the load of 30 patients, which were classified by the fuzzy classifier and indicated a high index of people with a pressure load. The executed analysis indicates that for these patients, a cardiovascular event could occur at any time of day and night.

The authors of the fourteenth paper develop an example of the application of a flower pollination algorithm for the probabilistic neural network learning process. Special attention authors pay on the investigation of the inertial parameters of this algorithm.

In the next paper, written by a group of Japanese scientists and presented by Tsuchiya Takeshi, the authors propose a new search method of various tourist information in one prefecture in Japan. This method is using paragraph vector that

extracts features by a combination of words and word ordering that is included in the content.

The sixteenth paper is presented by a researcher of the Siemens AG, Corporate Technology in Germany. It deals with transform utility values to preference values—the problem actual for decision support and recommender systems. Basing on the Łukasiewicz transitivity, the author derives a new transformation and examines its mathematical properties.

Fuzzy relational equations and inequalities play an important role in many tools of fuzzy modelling and have been extensively studied. In the seventeenth paper, the authors from the University of Latvia present a method allowing to convert a system of fuzzy relational constraints with max-t-norm composition to a linear constraint system by adding integer variables. A numerical example is given to illustrate this method.

The eighteenth paper, written by a team composed by researchers from Cuba, Chile and Spain, analyses the main variables—causes and effect—related to the enterprise architecture and the multifactorial elements impregnated with uncertainty that affects it. The knowledge given by experts is translated into dependence rules, which also have been analysed from a fuzzy point of view using the fuzzy relation equation theory.

For the use of time series, it is often crucial to obtain, as much detailed information as possible, from these series. The team of researchers from the University of Castilla–La Mancha, from Spain, presents in the nineteenth paper a technique for obtaining linguistic description from time series using a representation called fuzzy piecewise linear segments. It is shown how to obtain the information of a modelled series using this representation and the necessary steps to generate the description by using templates.

The twentieth paper is written by Lithuanian and Hungarian researchers, and it presents a new approach for the evaluation of management questionnaires. It combines expert knowledge about the fuzzy signature structure with the hybrid minimization of squared errors among leaves and reconstructed values at the leaves. It is shown that this method is more advanced than the mere use of expert knowledge or expert knowledge enhanced with statistical analysis.

Fuzzy partitions in many cases are the core of the first step of fuzzification procedure. They are defined in different ways, but usually by taking into account aspects of the whole universe. On the other hand, the twenty-first paper, written by mathematicians from Malaga University, presents a method to define fuzzy partition for elements in the universe holding certain fuzzy attribute. Specifically, the presented technique for the construction of fuzzy partitions according to a fuzzy context is based on fuzzy transforms.

The next two papers are written by Latvian mathematicians. In the twenty-second paper, a special construction of a general aggregation operator is proposed. This construction allows to aggregate fuzzy sets taking into account the distance between elements of the universe. Specifically, the authors describe how this construction could be applied for the risk assessment in the case when a strong fuzzy metric is used to characterize the similarity of objects under evaluation.

In the twenty-third paper, a many-level approach to fuzzy rough approximation for fuzzy sets is developed. It is based on the many-level rough approximation operators introduced in the paper. Basic properties of such operators are studied. Besides, the measure of this approximation is defined and studied. This measure in some sense describes the quality of the obtained approximation.

The last paper in this volume presents the research of mathematicians from University of Cádiz, Spain. Here, the philosophy of rough set theory is applied in order to reduce formal context in the environment of formal concept analysis. Specifically, a reduction mechanism based on the consideration of bireducts is proposed, and some properties of the reduced contexts are studied.

Finally, we would like to finish this preface showing our acknowledgement to the authors members of the programme committee and 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 Szechenyi Istvan University, the Institute of Mathematics and CS, University of Latvia and the State Research Agency (AEI) and the European Regional Development Fund (FEDER) research project TIN2016-76653-P. Finally, a word of thanks is also due to EasyChair, for the facilities provided in the submission/acceptance of the papers, and in the preparation of this book.

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Cádiz, Spain — Eloísa Ramírez-Poussa
Riga, Latvia — Alexander Šostak
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Keynote Speakers

Janusz Kacprzyk
Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland
Warsaw School of Information Technology, Warsaw, Poland

Title: **Decisions in Human-Centric Systems: A Crucial Role of Bipolarity in Judgments and Intentions**

Abstract: We are concerned general problems of decision-making in human-centric systems, i.e. those in which a human being, an individual or a group of individuals, are a crucial element in the sense that the human judgments, effects, intentions, preferences, cognitive biases, etc., should be taken into account. This is clearly in line with some crucial modern challenges for science, notably IT/ICT, which—at a general level—boil down to making computers to be "cognitive partners" for the humans and—on a more operational level—to find tools and techniques to develop and implement the human-/society-in-the-loop paradigm which is considered promising.

Since decision-making is the key problem as it is omnipresent in virtually all human activities, even if mimicked by/in inanimate systems, we show our analyses in this context. We start with a brief account of difficulties in traditional, formal approaches to decision-making based on a strict rationality. We indicate inherent difficulties relate to a crucial role related to inherent characteristics of all human-centric problems, i.e. a need to take into account affects, judgments, attitudes, evaluations and intentions of the human being, which are usually imprecise (fuzzy), changeable, subjective, and—which is the main concern here—involve pro and con arguments, i.e. are bipolar. The concept of bipolarity in this context is explained, and some logical, optimization, etc., approaches to its formalization and handling are elaborated. A special emphasis is given to models should involve multiple agents (decision-makers) who should act collectively, for instance, cooperate or collaborate, but may exhibit different general attitudes, notably ranging from greed to fairness. We show some possible solutions, in particular using non-orthodox multicriteria decision-making. We also mention some relations to Wang's cognitive informatics.

Gabriella Pasi
Department of Informatics, Systems and Communication (DISCo), Università degli Studi di Milano-Bicocca, Milan, Italy

Title: **Aggregation Guided by Fuzzy Quantifiers in IR and in Social Media Analytics**

Abstract: Various processes related to the task of information retrieval (IR) can be interpreted as multicriteria decision-making activities. The same applies to some tasks related to the analysis of user-generated content in social media (like the assessment of credibility of online reviews). What is particularly interesting by this interpretation is that depending on the selected aggregation strategy, different behaviours can be modelled for the considered process, which can be intuitively captured by guiding the aggregation by fuzzy quantifiers. In this lecture, the impact of quantifier-guided aggregation (and of aggregation in general) will be shown in both contexts of IR and of the assessment of credibility of user-generated content. It will be also shown that quantifier-guided aggregation offers an interesting alternative to the application of machine learning techniques (in particular classifiers).

Oscar Castillo
Tijuana Institute of Technology, Tijuana, Mexico

Title: **Nature-Inspired Optimization of Type-2 Fuzzy Logic Controllers**

Abstract: The design of type-2 fuzzy logic systems is a complex task, and in general, achieving an optimal configuration of structure and parameters is time-consuming and rarely found in practice. For this reason, the use of nature-inspired meta-heuristics offers a good hybrid solution to find near-optimal designs of type-2 fuzzy logic systems in real-world applications. In particular, type-2 fuzzy control offers a real challenge because the problems in this area require very efficient and accurate solutions; in particular, this is the case for robotic applications. In this talk, we present a general scheme for optimizing type-2 fuzzy controllers with nature-inspired optimization techniques, like ant colony optimization, the chemical reaction algorithm, bee colony optimization and others.

Alexander Šostak
Institute of Mathematics and Computer Science of University of Latvia
Department of Mathematics, University of Latvia

Title: **On Many-Level Fuzzy Rough Approximation Systems**

Abstract: One of the possible approaches to the interpretation of Pawlak's rough sets is the following. Assume we have a plane filled up with pixels, and there is a domain D in this plane. We are looking at the plane from some distance. Then, we may know exactly that a pixel, say p, is in the domain D. Let $l(D)$ be the set of all pixels contained in D for sure. Further, for some pixels, we assume that possibly they are inside D. The set of all such pixels we denote by $u(D)$. Obviously, $l(D)$ and $u(D)$ can be viewed as the lower and the upper Pawlak's rough approximations of the domain D.

But now imagine that we can change the distance from which the observation of the domain D is made. Then, we can expect that the lower and the upper rough approximations of the domain D can vary depending on the distance from which the observation is made. Thus, the lower and the upper rough approximations of the

domain D become *functions* $l_d(D)$ and $u_d(D)$ of the parameter d (*the distance of observation*).

In this and other similar situations, there appears the necessity to extend the technique of rough approximation of sets to the case when this approximation is fulfilled on different levels. And the transition of approximation from one level to the other should be done in a smooth, coordinated way.

To manage with this and other similar cases, in crisp as well as in fuzzy cases, one can apply many-level lower and upper fuzzy rough approximation operators. It is just the main goal of our talk to introduce the concept of a many-level fuzzy rough approximation system and to expound the basic properties of such systems. We also consider many-valued fuzzy rough approximation spaces on the base of such systems. Some examples illustrating applications of such systems will be given. Besides, we will present a (graded) topological interpretation of many-level fuzzy rough approximation spaces.

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