Preface

The broadly perceived area of intelligent systems has been for quite a long time an object of intensive research in various areas of science and technology, exemplified by computer science, logic, mathematics, data analysis, knowledge engineering, IT/ICT, mechatronics, automation, and robotics, just to name a few more technology-oriented fields.

Novel avenues of research have appeared, and new opportunities of real-world applications have followed an intensive development of computational intelligence and soft computing that have enjoyed a rapid growth of popularity in recent decades.

As it is always the case in such a period of a rapid growth, the flow of new tools and techniques clearly implies new challenges, both conceptual, algorithmic, and implementation. This is also the case of our area. The scientific community through its involvement and hard work tries to promote the area and new tools and techniques. One of the necessary, and effective and efficient ways for reaching such goals is to prepare comprehensive exposures to the area and its main applications through the editing of volumes containing contributions of prominent and active researchers and scholars. This has been the case with this volume, too.

In such initiatives, a group of people who are committed to reach the above-mentioned goal to promote new directions in an area usually meets at some important scientific gathering and, after fruitful discussions triggered by conference contributions, questions from the audience, etc., the idea of such a volume is born. This was the case with this volume too. Its idea has appeared as a result of very interesting presentations and vivid discussions at the Fifth Győr Symposium and First Hungarian-Polish Joint Conference on Computational Intelligence held in Győr, Hungary, in September, 2012. Then, due to a high interest of the scientific community and its willingness to contribute to this important volume, the editors have been able to gather a very good collection of relevant and original papers by prominent representatives of many areas, relevant both to the theory and practice of intelligent systems, artificial intelligence, computational intelligence, soft computing, and the like. The contributions have been divided into seven parts presenting first more fundamental and theoretical contributions, and then applications in relevant areas.

Part I is devoted to conceptual and analytic foundations of the theory of fuzzy systems, and contains two papers.

V. A. Niskanen ("Prospects for Truth Valuation in Fuzzy Extended Logic") is concerned with an important problem of truth valuation in fuzzy logic, and its related alternative ways to many-valued resolution at the meta-level. His analysis is based on Zadeh's fuzzy extended logic (FLe), and is performed on the meta--level from the standpoint of philosophy of science.

D. Coufal ("Coherence and Convexity of Euclidean Radial Implicative Fuzzy Systems") discusses the case of rule-based fuzzy systems, and concentrates on one of their important classes, implicative fuzzy systems. His main concern is to obtain a class of necessary conditions for coherence of radial implicative fuzzy systems, all that in an implicit form. The minimization of a certain function is employed.

We continue with the analysis of various aspects of fuzzy sets theory and fuzzy logic in Part II in which emphasis is more on applications.

P. Nowak and M. Romaniuk ("Catastrophe Bond Pricing with Fuzzy Volatility Parameters") consider an important problem related to natural disasters and catastrophes, which may imply huge losses to the individuals, communities, regions, nations, and even the world as a whole. The authors deal with the problem of catastrophe bonds that are issued to transfer the catastrophic risk to financial markets. More specifically, they are concerned with the catastrophe bond pricing using a combination of stochastic analysis and fuzzy sets theory. Notably, the volatility of the interest rate and market price of risk are represented as fuzzy numbers, and the Monte Carlo simulation approach is used.

A. Bukovics and L. T. Kóczy ("Evaluating Condition of Buildings by Applying Fuzzy Signatures and *R*-fuzzy Operations") show a novel method for qualifying and ranking residential buildings based on various priority aspects and for making an optimum allocation of the material resources available for the renewal of the buildings. Their model is based on many detailed technical-static expert reports available to a stock of residential buildings in Budapest and stored in a database. First, using fuzzy logic, a model for calculating a so-called status characteristic value between 0 and 1 on the basis of the structures and status of the buildings is developed using a fuzzy singleton signature model. Then, a hierarchy is devised related to the stock of buildings to be employed for supporting decision making on intervention on the buildings concerned. Specifically, membership values characterizing the status of the load-bearing structures are defined on the basis of the deterioration of the structures, and a new method is here developed that takes into account other parameters of the structures, and the impact exerted on the quality of the structure, too. The method is based on the use of "real fuzzy values" (*R*-fuzzy sets), an extension of the concept of classic fuzzy sets that allows also the inversion of fuzzy set connectives under certain circumstances.

F. Lilik and L. T. Kóczy ("The Determination of the Bitrate on Twisted Pairs by Mamdani Inference Method") are concerned with the problem of how to predict the available maximal data transfer rate on dedicated telecommunication connections. The authors first provide a critical review of some tools and techniques, which are most often used for this purpose. Then, they present a method

based on the use of a Mamdani-type fuzzy reasoning system. A comprehensive computational analysis of prediction results obtained for the evaluation of the twisted-pair-based local loops of the telecommunication access networks by using various methods is provided and a comparison with those obtained by using that Mamdani-type fuzzy reasoning system is shown.

B. Kalmár, A. Kalmár, K. Balázs, and L. T. Kóczy ("Construction Site Layout and Building Material Distribution Planning Using Hybrid Algorithms") discuss some novel method for solving the layout problem for construction site and distribution planning of building materials. The layout problem considered is dealt with by applying costs on the moving of construction materials across the site, and the goal is to develop an algorithm which is specialized in solving problems of distributing building materials, exemplified by bricks, on a site by placing their pallets at optimal spots, for each unit built from a given material to be within an optimal reach. The authors describe first a solution of this problem for the engineering practice and interpret the slow but accurate method of the so-called Hungarian Algorithm, and then propose a memetic algorithm which is faster but yields almost as accurate a solution. Conclusions are drawn about the usability of this method.

Part III discusses various aspects of artificial neural networks which are widely used for systems modeling, classification, control, etc.

V. Kurková ("Accuracy of Surrogate Solutions of Integral Equations by Feedforward Networks") is devoted to a study of an important problem of using feed-forward neural networks for surrogate modeling of functional relationships. Potential applications areas range from chemistry with surrogate models of empirical functions assigning to compositions of chemicals measures of quality of catalysers produced by reactions of these chemicals, biology with surrogate models of empirical functions classifying structures of the RNA, economics with surrogate models of functions assigning credit ratings to companies, etc. The author considers from a theoretical point of view surrogate solutions of the Fredholm integral equations, which play an important role in many areas, by using feed-forward neural networks. The author proves the convergence of surrogate solutions computable by those neural networks with increasing numbers of computational units to theoretically optimal solutions, and provides upper bounds on the rates of convergence. It is shown that the results hold for a variety of computational units, notably the perceptron and Gaussian radial units.

P. Šarčević ("Vehicle Classification Using Neural Networks with a Single Magnetic Detector") discusses principles of operation, advantages, and disadvantages for different vehicle detection technologies that are meant to provide speed monitoring, traffic counting, presence detection, headway measurement, vehicle classification, and weigh-in-motion data. The author proposes the idea of a new detection and classification method for a single magnetic sensor-based system. An important feature of the new detection algorithm and the neural network classifier are an easy implementation in a microcontroller-based system. An analysis of results for various benchmark problems is given.

Part IV contains contributions covering two important areas of intelligent data analysis which are crucial for broadly perceived intelligent systems, knowledge engineering, etc., that is, classification and clustering, and image processing.

P. Kulczycki, M. Charytanowicz, P. A. Kowalski, and Sz. Łukasik ("Exemplary Applications of the Complete Gradient Clustering Algorithm in Bioinformatics, Management and Engineering") discuss various aspects related to the applications and prospects of the complete gradient clustering algorithm, a classic clustering procedure developed by Fukunaga and Hostetler. The authors present its ready-to-be-used version by providing a full set of procedures for defining all functions and values of the parameters. Moreover, they analyze how a possible change in those values influences the number of clusters and the proportion between their numbers in dense and sparse areas of data elements. The authors show some possible uses of these properties on some practical problems in the areas of bioinformatics, more specifically the categorization of grains for seed production, management, more specifically the design of a marketing support strategy for a mobile phone operator, and engineering, more specifically the synthesis of a fuzzy controller.

A. T. Duong, H. T. Phan, N. D. Le, and S. T. Tran ("A Hierarchical Approach for Handwritten Digit Recognition Using Sparse Autoencoder") are concerned with handwritten digit recognition, a very important problem that is very relevant for many practical applications, yet difficult, and which still presents a considerable challenge from a theoretical and implementation point of view. Approaches based on higher level features learning algorithms are here promising and popular giving usually better results than just using raw intensity values with classification algorithms. On the other hand, these approaches do not take the advantage of specific characteristics of data. Therefore, the authors propose a new method to learn higher level features from specific characteristics of data using a sparse autoencoder. The main idea of the approach proposed is to divide the handwritten digits into subsets corresponding to specific characteristics. The experimental results obtained show that the proposed method yields lower error rates and time complexity than the original approach of a sparse autoencoder. Moreover, the results obtained indicate that the more correlated are characteristics defined, the better higher level features can be learned.

A. Tormási and L. T. Kóczy ("Fuzzy Single-Stroke Character Recognizer with Various Rectangle Fuzzy Grids") extend theoretical and implementation results on their original FUBAR character recognition method with various fuzzy grid parameters. The accuracy and efficiency of the handwritten single-stroke character recognition algorithm with different sized rectangle (i.e., $N \times M$) fuzzy grids are investigated. The results obtained are then compared to other modified FUBAR algorithms and known commercial and academic recognition methods. Possible applications and further extensions are also discussed.

Part V contains papers on various kinds of problems, solutions, and applications on the use of various paradigms, tools, and techniques from the broadly perceived areas of artificial and computational intelligence in robotics.

J. Kuti, P. Galambos, and P. Baranyi ("Delay and Stiffness Dependent Polytopic LPV Modeling of Impedance Controlled Robot Interaction") operate within an important area of impedance/admittance control algorithms which are considered as key technologies in human–robot interaction and other fields of advanced robotics where complex physical interaction plays a crucial role. The authors employ a tensor product (TP) model transformation-based method to derive the delay and stiffness-dependent polytopic LPV representation of the impedance-controlled physical interaction. The applied transformation method is feasible with a bounded delay that is a nonlinear function of the environmental stiffness. Therefore, the ideal transformation space is nonrectangular which makes it to be improper for the tensor product model transformation. A novel method of a dimensionless parameterization is proposed to define a rectangular grid upon which the tensor product transformation can be applied. The resulted model form is shown to be appropriate for the modern multiobjective LMI-based control design techniques for impedance-controlled robot interaction.

K. Bolla, Zs. Cs. Johanyák, T. Kovács, and G. Fazekas ("Local Center of Gravity-based Gathering Algorithm for Fat Robots") are concerned with groups of the so-called fat (disc-like) mobile robots without global navigation, communication or memory, specifically their gathering the essence of which is the assembly of the scattered robots on the smallest possible area. They present a new and effective and efficient algorithm for solving this task assuming an obstacle-free plan, limited visibility, and synchronous operation. The key idea of the algorithm is that in the case of each robot after detecting the visible neighboring robots, the algorithm sets a target of the next step based on the center of gravity of the encountered visible robots. Positive experience and promising results of simulation for difficult problems are presented which equal or surpass those obtained by previously published algorithms in all of the cases.

A. Ballagi, L. T. Kóczy, and C. Pozna ("Intelligent Robot Cooperation with Fuzzy Communication") deal with an extremely relevant problem of the design of a decision-making engine of a robot which works in a collaborative team. The challenges in this task are not only due to the complexity of the environment uncertainty, dynamics and imprecision, but also due to the necessity of coordination of the team of robots that has to be included in the design phase. The robots must be aware of other robots' actions in order to cooperate and to successfully achieve their common goal. In addition, decisions must be made in real-time and under limited computational resources. The authors propose some novel algorithms for action selection in ambiguous tasks where the communication opportunities among the robots are very limited. Some promising simulation results are presented.

T. T. Cocias, S. M. Grigorescu, and F. Moldoveanu ("Indoor Pose Estimation using 3D Scene Landmarks for Service Robotics") present a new markerless approach for estimating the pose of a robot using only 3D visual information. In contrast to many methods commonly used to solve this problem, the authors' approach makes use of the 3D features to only determine a relative position between the imaged scene (for instance, landmarks present on site) and the robot.

Such a landmark is determined using a stored 3D map of the environment. The recognition of the landmark is performed using a 3D Object Retrieval (3DOR) search engine. The new pose estimation technique proposed by the authors yields reliable and accurate pose information which can be further used for complex scene understanding and/or navigation. In numerical analyses, the performance of the proposed approach is compared with those in a traditional marker-based position estimation library.

The topic of Part VI, Data Manipulation, covers many problems, topics, paradigms, and tools and techniques of data analysis, data mining, and knowledge discovery, which are crucial point of departure of virtually all methods of analysis and synthesis which, for obvious reasons, rely on the availability of tools and techniques for both retrieving proper data and making use of them.

J. Kacprzyk, S. Zadrożny, and M. Dziedzic ("A Novel View of Bipolarity in Linguistic Data Summaries") are concerned with an important problem of data summarization, that is, the derivation of a simple representation of the very essence of a large set of data. The authors assume that there is a large numerical database, which is too large for human comprehension, and—since for the human being the only fully natural way of articulation and communication is natural language—that huge numeric data set should best be summarized by a so-called linguistic summary being a short sentence(s) capturing the very essence related to relations between some important variables. The point of departure is, first, a fuzzy logic-based approach to linguistic summarization originated by Yager, and then developed by Kacprzyk and Zadrożny, and in particular its protoform-based perspective. The second point of departure is the concept of a bipolar query in the sense that the querying criteria may be mandatory and optional, i.e., those which must be satisfied and those which should be satisfied if possible, as initiated by Zadrożny, and then developed by Zadrożny, Kacprzyk, and De Tré. In this paper, the authors combine these two concepts and present a novel concept of a bipolar linguistic summary. A theoretical analysis and some numerical results show that this concept can be useful for capturing the very essence of users' intentions and is computationally viable.

M. Krawczak and G. Szkatuła ("On Reduction of Data Series Dimension") introduce a new procedure for the reduction of dimensionality of multidimensional data (time) series. The procedure proposed consists of multiple steps with each step giving a new data series representation as well as a dimension reduction. The approach is based on the concept of a data series aggregated envelope, and principal components, called here essential attributes, are generated by a multilayer neural network. The essential attributes are generated by outputs of hidden layer neurons. Next, all differences of the essential attributes are treated as new attributes. The real values of the new attributes are nominalized in order to obtain a nominal representation of data series. The approach proposed leads to a nominal representation of the original data series and considerably reduces its dimension. The proposed approach is tested numerically on some problems of classification and clustering of time series, and the results obtained are promising.

P. Kulczycki and P. A. Kowalski ("Bayesian Classification of Interval-Type Information") deal with the problem of Bayesian classification of imprecise multidimensional information of interval type by means of patterns defined through precise data, that is, deterministic or sharp. The authors apply tools and techniques of the statistical kernel estimators which helps avoid the pattern shape for the resulting algorithm, and also eliminate elements of pattern sets which have insignificant or negative influence on the correctness of classification. The idea of the procedure proposed is based on the sensitivity method used in the domain of artificial neural networks. As a result of this procedure, the number of correct classifications and—above all—the calculation speed increase significantly. Moreover, a further increase of the quality of classification is obtained by using an algorithm for the correction of classifier parameter values.

P. Kulczycki and Sz. Łukasik ("Reduction of Dimension and Size of Data Set by Parallel Fast Simulated Annealing") propose a universal method of dimension and sample size reduction designed for exploratory data analysis procedures. The dimension is reduced by applying a linear transformation with the requirement that it has the least possible influence on the respective locations of sample elements. For this purpose an original version of the heuristic parallel fast simulated annealing method is used. As an additional element of the algorithm proposed, those elements which change the location significantly as a result of the transformation may be eliminated or assigned smaller weights in further analyses. This reduces the sample size and improves the quality of the method applied for knowledge extraction. Experimental results confirm the usefulness and efficiency of the procedure for a wide variety of problems in the class considered such as clustering, classification, identification of outliers, etc.

Part VII, Control, covers some selected problems in the area of modeling and control. Basically, the two contributions are concerned with applications in a more specific and lower scale, technologically oriented problem, and those dealing with larger systems in which control problems occur and should be effectively and efficiently solved, and in which both technological and economic, social, environmental aspects are relevant.

W. Radziszewska, Z. Nahorski, M. Parol, and P. Pałka ("Intelligent Computations in an Agent-Based Prosumer-Type Electric Microgrid Control System") deal with some issues related to microgrids which have emerged as a modern and promising concept resulting from a growing number of small prosumers, progress in the construction of renewable energy sources and the opening of energy markets. To increase the efficiency of electricity consumption, production, and trading, energy managing systems (EMSs) are developed. The authors present a project of a complex EMS that will combine load scheduling, power balancing, and smart trading methods to optimize electric energy costs of running a simulated research and education center. More specifically, they present the concept of a distributed agent-based power balancing system that is meant to control the power flow in a microgrid by a decentralized and distributed decision making. The program optimizes the operating (exploitation) cost of the devices in the microgrid by internally balancing, as much as possible, the produced and

consumed power and by trading the remaining energy excesses or deficits on the external market. Agents associated with the devices cooperate using communication protocols. Their aim is to use the energy from renewable energy sources whenever it is only available, and at the same time to limit the use of energy from sources that are more expensive and less environment friendly.

J. Sziray ("Test Generation for Short-Circuit Faults in Digital Circuits") considers an important problem of how to effectively and efficiently generate tests for detecting faults in digital circuits. In the first part, the author presents a test calculation principle, called a composite justification. The considered fault model includes stuck-at-0/1 logic faults. Both single and multiple faults are taken into account. The author considers the combinational logic only. Computations are performed at the gate level. The calculation principle is comparatively simple and is based only on successive line-value justification which makes possible the development of an efficient computer program. Then, the author discusses another fault class, namely, short-circuit or bridging faults which is implied by an erroneous galvanic connection between two circuit lines. A new algorithm is presented for generating tests and the composite justification is extended to handle this type of faults too.

The volume is, therefore, a unique position in the literature both with respect to the width of coverage of tools and techniques, and to the variety of problems that could be solved by the tools and techniques presented and also many other ones known from the literature. We are sure that the academic, research, and industrial community involved in the theoretical analyses, design, and applications of broadly perceived intelligent systems will greatly benefit from this special and unique collection of papers by leading specialists.

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