Guest Editorial

New vistas of fuzzy methods in real life application

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In the current era of pervasive digitalization, the demand for automation of nearly all spheres of human life has become unprecedentedly high. Automation of routine processes make it possible to achieve higher performance, lower costs and effort on their manual implementation, along with a more viable reallocation of resources and labor contribution. To achieve automation in many aspects of human life, it is necessary to deal with real information. In terms of automated information processing, “information is everything which has influence on the assessment of uncertainty by an analyst. This uncertainty can be of different types: data uncertainty, nondeterministic quantities, model uncertainty, and uncertainty of a priori information. Measurement results and observational data are special forms of information. Such data are frequently not precise numbers but more or less non-precise, also called fuzzy” [3]. Operating such kind of imprecise and noisy data requires the establishment of a flexible and adaptive approach to information processing and the development of methodologies to enhance the ability to manage complicated optimization and decision making aspects involving non-probabilistic uncertainty with the reason to understand, develop, and practice the fuzzy technologies to be used in fields such as economic, engineering, management, and societal problems [1].

The idea of fuzziness in the field of mathematics, Information technologies, and engineering dates back to the 60's of the XX century, when L. A. Zaden defined the concept of a fuzzy set as “a class of objects with a continuum of grades of membership... characterized by a membership (characteristic) function which assigns to each object a grade of membership ranging between zero and one” [4]. With that article the author triggered the construction of a new approach towards datasets applied to a wide range of research tasks, including classification, clustering, and other forms of data processing.

Since that release in the Elsevier press the concept of fuzziness in Mathematics, Engineering, Energy, Decision, and Computer Sciences had been growing gradually until in the 90's, the topic started to gain popularity rapidly (Fig. 1).

Figure 1 represents the statistics on 291,794 papers with the keyword \textit{fuzzy} found in the Elsevier Scopus database. It is clear from the keywords claimed in the found documents, that all the papers to some extent refer to Mathematics, Computing or Engineering. The most frequent ones are Fuzzy Sets, Fuzzy Logic, Fuzzy Systems, Fuzzy Control, Algorithms, Fuzzy Inference, Decision Making, Neural Networks, Mathematical Models, Controllers, Artificial Intelligence, Optimization, Computer Simulation, Membership Functions, Fuzzy Neural Networks, Genetic Algorithms, Fuzzy Clustering, Computer Circuits, Fuzzy Rules, Clustering Algorithms, Learning Systems, Adaptive Control Systems, Fuzzy Set Theory, Problem Solving, Forecasting, Image Segmentation, Data Mining, Uncertainty Analysis, Knowledge Based Systems, Intelligent Systems, etc.
The current edition presents a collection of papers on the usage of fuzzy methods in various areas. In terms of the methods used in the overviewed studies, the articles can be roughly subdivided in two main categories, fuzzy mathematics and fuzzy machine learning. In their research the authors aim at applying fuzzy logics to system modelling, decision making, big data analysis and evaluation. Fuzzy methods are applied to the data, which are like in real life, non-precise. In this case, fuzzy mathematics theory is useful to realize effective and rapid evaluation of dynamic data. Statistical data, which “are not always precise numbers, or vectors, or categories [get new interpretation]. Real data are frequently what is called fuzzy. Examples where this fuzziness is obvious are quality of life data, environmental, biological, medical, sociological and economics data. Also, the results of measurements can be best described by using fuzzy numbers and fuzzy vectors respectively. Statistical analysis methods have to be adapted for the analysis of fuzzy data” [3]. In this regard, the volume includes description of the fuzzy statistical method and various methods of mathematical modelling, such as the multi-objective optimization mathematical modelling and fuzzy comprehensive evaluation mathematical modelling.

To process fuzzy data, the authors address machine learning based on artificial networks of various kinds, including deep convolutional networks for visual patterns recognition, Back Propagation Neural Network Algorithm to analyze independent and dependent variables for the purpose of prediction. Furthermore,
the volume contains description of the fuzzy analytic network process method for the patent value evaluation. Deep neural network modelling also proved efficient for generating high-level features. Besides, one can find a description of a semantic ontology model optimized due to a multilevel neural network with conversion and forward neural levels. The application of Bayesian statistical methods for machine learning can also be observed in the volume. In such methods, data frequently consist of numbers or vectors, which are not precise, and "the a-priori distributions are not exact probability distributions in the standard sense. Therefore, it is necessary to model real data in a suitable way to incorporate the fuzziness of data before they are analyzed by statistical methods. This is possible by using special fuzzy subsets of the set of real numbers [...] so-called non-precise numbers. The mathematical description of non-classical a-priori distributions is possible by so-called fuzzy probability distributions." [2]. The actual effect of the extension of the theory of fuzzy sets to the Bayesian network has been illustrated by using the multi-level fuzzy comprehensive evaluation model in teaching. Thus, the authors demonstrate high potential and error reduction in processing heterogeneous data.

It is known, that "fuzzy analysis represents a method for solving problems, which are related to uncertainty and vagueness. It is used in multiple areas, such as engineering and has applications in decision making problems, planning and production" [1]. Nowadays, the methods of fuzzy logics and mathematics are applied to various scientific areas and fields of human activities. As is seen in Fig. 2, they are highly employable in Computer Science, Engineering, Mathematics, Decision Sciences, Physics and Astronomy, Material Science, Energy, Business, Management and Accounting, Social Sciences, and others.

Articles collected in this volume represent high applicability of fuzzy methods in various fields, namely economics, healthcare, physiology, psychology, tourism business, education, art, geosciences, military sector, emergency and security, fashion, construction, machinery, and transportation. Figure 3, which represents the cloud of the keywords provided in the articles of the current volume, adds to our notion of vast diversity of topics and methods associated with research of intelligent and fuzzy systems.

Figure 3 shows that among the keywords suggested by the authors of the volume, the domineering ones are comprehensive evaluation, artificial intelligence, genetic algorithm, intelligence, fuzzy game, empirical analysis, bp neural network, and factor analysis, which highlight the methodological aspects of the volume, as well as risk evaluation, intellectual property, and marine industry, which call attention to the applied focus of the papers.
In sum, the volume comprises 60 scientific articles, elaborating on the research across fuzzy methods and systems applied for solving real-life problems.

References


