

Preface

Special Issue on Intelligent Decision Support Systems based on Soft Computing and Their Applications in Real-World Problems

Enrique Herrera-Viedma

*Department of Computer Science and Artificial Intelligence, University of Granada, Granada, Spain.
Email: viedma@decsai.ugr.es*

Francisco Chiclana

*Centre for Computational Intelligence, Faculty of Technology, De Montfort University, Leicester, U.
Email: chiclana@dmu.ac.uk*

Yucheng Dong

*Business School, Sichuan University, China.
Email: ycdong@scu.edu.cn*

Francisco Javier Cabrerizo

*Department of Computer Science and Artificial Intelligence, University of Granada, Granada, Spain.
Email: cabrerizo@decsai.ugr.es*

Societal and technological trends make decision environments more and more complex. The emergence of the intelligent decision making technology provides a good decision support to deal with these complex decision making problems, and soft computing plays a core role in the intelligent decision making technology. In recent years, intelligent decision support systems based on soft computing have attracted the attention of both, academic researchers and practitioners in a wide range of disparate areas from computing science, engineering, operations research, economics and also management. Intelligent decision support systems based on soft computing are of great importance to deal with complex decision environments, and involve the design of mathematical models for modeling decision problems, the use of different information technologies (such as the Web and social networks) and artificial intelligence tools (such as computational intelligence tools).

This special issue's focus is on new contributions on the development of mathematical models for modeling decision problems, as well as soft computing approaches that are able to deal with complex decision information (such as uncertain and inconsistent information). Special attention is paid to the rigorous motivation of the approaches put forward and to the validation support using real practical applications.

The special issue has brought together researchers to report their latest and best results and progress in the development of intelligent decision support systems and their application in real-world problems. We have received one hundred and two contributions from authors around the world working in this topic. Some of them are contributors of a special session on the topic that we organized in the international renowned FUZZ-IEEE conference, which was held as part of the WCCI2016 conference celebrated in Vancouver (24-29 July, 2016). We invite them to participate with new proposals or extensions with more than 80% of new material. Other contributors are distinguished researchers who by invitation decided to submit their last results. And others are authors that received information on the special issue after publicly distributing the Call For Papers in September 2016.

After a rigorous review process using anonymous peer review and by avoiding any bias in the referee process when we have received guest editors' contributions, twenty-five high quality papers were accepted and are presented in this special issue. Accordingly, the submissions can be split into three groups. The first one includes four papers presenting new intelligent decision-making tools with preference modeling from a theoretical point of view. The second group includes six papers presenting novel consensus measures taking into account different types of

information and consensus-reaching processes. The third group, in line with the special issue call, covers fifteen real-life applications of intelligent decision support systems based on soft computing tools.

The first group of submissions considers new theoretical intelligent decision making models dealing with unbalanced linguistic information, hesitant fuzzy linguistic term sets, interval-valued fuzzy sets, and ordered qualitative scales. *Cai and Gong* in **Group Decision Making Using Distances between Unbalanced Linguistic Assessments** introduce a new group decision making model based on a new linguistic approach to deal with unbalanced linguistic terms. In this new approach the representation model of linguistic information is defined using graphs and the computational model is defined by means of distance measures defined in the graph. *Sellak et al.* in **A Knowledge-Based Outranking Approach for Multi-Criteria Decision-Making with Hesitant Fuzzy Linguistic Term Sets** present a new outranking method based on a novel knowledge-based paradigm for comparing hesitant fuzzy linguistic term sets. The novel paradigm is associated with a multi-criteria relational clustering algorithm that additionally extracts fuzzy preference relations between the resultant clusters. The paper entitled **Learning Preferences and Attitudes by Multi-Criteria Overlap Dominance and Relevance Functions** defines an interval-valued multi-criteria method for learning preferences and attitudes, identifying priorities with maximal robustness for decision support. The method is based on the notion of weighted overlap dominance, formalized by means of aggregation operators and interval-valued fuzzy sets. *García-Lapresta and Pérez-Román* in **Aggregating Opinions in Non-Uniform Ordered Qualitative Scales** present a new voting system in the setting of ordered qualitative scales. The process is conducted in a purely ordinal way by considering an ordinal proximity measure that assigns an ordinal degree of proximity to each pair of linguistic terms of the qualitative scale.

The second group of submissions includes technical and theoretical papers analyzing consensus measures and models for consensus-reaching in fuzzy environments. The first paper by Zhang et al., **Minimum Deviation Ordinal Consensus Reaching in GDM with Heterogeneous Preference Structures**, presents a novel minimum deviation ordinal consensus model for group decision making with heterogeneous preference structures (utility values, preference orderings, multiplicative preference relations and fuzzy preference relations). In this consensus model, the individual derivation methods, associated with different preference structures, are used to obtain the individual preference orderings and also a minimum deviation consensus ranking model together with a feedback adjustment rules are proposed. The second paper entitled **Analyzing the Performance of Classical Consensus Models in Large Scale Group Decision Making: A comparative Study** reviews different classical consensus reaching processes applied to large-scale group decision making, shows a comparative study, analyzes their performance and provides new challenges. *Wu et al.* in **Local Feedback Strategy for Consensus Building with Probability Hesitant Fuzzy Preference Relations** provide a novel consensus reaching process for group decision making problems assuming probability-hesitant fuzzy preference relations to represent expert preferences. In such a decision context, the authors define consensus measures in three levels, pair of alternative, alternative and full relation, and a new feedback method that avoids the need to compute the collective preference relations to provide recommendations to the individuals. The paper entitled **Preference Similarity Network Structural Equivalence Clustering based Consensus Group Decision Making Model** provides a new consensus model based on social networks analysis for large scale group decision making contexts. This new consensus model i) represents the group of experts as an undirected weighted preference network according to experts' preference similarities; ii) models structurally equivalent experts using agglomerative hierarchical clustering algorithm; iii) uses the centrality concept in determining a network leader to drive advices in the feedback mechanism; and iv) provides a new Induced OWA aggregation operator based on associated experts' centrality values. In **Consensus Modeling with Cost Chance Constraint under Uncertainty Opinions** *Tan et al.* define a stochastic optimization cost consensus group decision making model adopting the minimum budget and the maximum utility as objective function simultaneously to study the negotiation consensus with decision makers' opinions expressed in the forms of multiple uncertain preferences such as utility function and normal distribution. This new consensus model is a generalization of the existing cost consensus model and utility consensus model. The last paper of this group, **Consensus via Penalty Functions for Decision Making in Ensembles in Fuzzy Rule-based Classification Systems** proposes a new consensus method via penalty functions for decision making in ensembles of fuzzy rule-based classification systems. The authors design a method based on overlap indices for building confidence and support measures, which are used to evaluate the degree of certainty or interest of a certain association rule.

Then, the authors introduce a consensus method that is based on penalty functions for the decision making related to the selection of the best class.

The last group of submissions includes applications covering different intelligent decision support systems applied in different problems as hotel selection, promising enterprise selection, detection of diabetes disease, evaluation of performance of manufacturing enterprises, heterogeneous wireless networks selection, electric power generation in power systems, sentiment analysis, predicting body fat percentage, negotiation processes, portfolio optimization, selection of maintenance strategy, measuring traffic congestion, detection of spammers on Facebook, and selection of university careers services. *Yu et al.* in **A Multi-Criteria Decision-Making Model for Hotel Selection with Linguistic Distribution Assessments** present a multi-criteria decision making model to select appropriate hotels on tourism websites using the reviews provided by the users. The second paper considered in this group, **How to Select a Promising Enterprise for Venture Capitalists with Prospect Theory under Intuitionistic Fuzzy Circumstance?** introduces a decision making model to select the promising enterprises in China that considers both the bounded rationality of venture capitalists and the uncertain circumstance of venture capital in decision-making. This new decision making model is defined using prospect theory under intuitionistic fuzzy information. *Cheruku et al.* in **RST-BatMiner: A Fuzzy Rule Miner Integrating Rough Set Feature Selection and Bat Optimization for Detection of Diabetes Disease** propose a decision support system based on rough set theory (RST) and bat optimization algorithm (BA) for detection of diabetes disease. The system consists of a set of fuzzy classification rules that are obtained in two steps: firstly, redundant features are removed from the data set through RST-based QUICK-REDUCT approach, and secondly, for each class BA is invoked to generate fuzzy rules by minimizing proposed fitness function. Bolukbas and Guneri in their paper entitled **Knowledge-Based Decision Making for the Technology Competency Analysis of Manufacturing Enterprises** show a new decision making method based on knowledge and cluster analysis to analyse the decision making process and evaluate the performances of manufacturing enterprises in Istanbul. This new method evaluates technology management performances of enterprises based on dimension, criteria and survey data, and on the other hand, it allows benchmarking of manufacturing enterprises from different sub-sectors. The paper entitled **The Utility Based Non-Linear Fuzzy AHP Optimization Model for Network Selection in Heterogeneous Wireless Networks** defines a novel fuzzy-analytic hierarchy process based network selection in heterogeneous wireless networks in order to keep the mobile user always connected to the best wireless network in terms of QoS parameters and user preferences. Parameterized utility functions are used to model the different quality of service attributes (bandwidth, delay, jitter, bit error rate) and user preferences (cost) for three different types of applications. *Zhu et al.* in **Learning Enhanced Differential Evolution for Tracking Optimal Decisions in Dynamic Power Systems** present a new intelligent decision making method to track the optimal decisions of optimal power flow in order to guide operating decisions about electric power generation in power systems. This new method is a learning enhanced differential evolution that incorporates the idea of nearest-neighbor rule from the field of machine learning, with which decisions of the previous tasks are retrieved continually to replace the newly generated individuals of differential evolution. Next paper entitled **An Approach to Improve the Accuracy of Probabilistic Classifiers for Decision Support Systems in Sentiment Analysis** presents a platform to automate the processing of information obtained from social networks, focusing on improving the accuracy of decision support systems for sentiment analysis. This is developed by means of machine learning-based simple probabilistic classifiers, evaluating a naive Bayes classifier. Ferensi and Kovács in **Predicting Body Fat Percentage from Anthropometric and Laboratory Measurements using Artificial Neural Networks** show a decision support system that, using different soft computing tools, linear regression, neural networks and support vector machines, is able to predict the body fat percentage from easily measurable data: age, gender, weight, height, waist circumference and different laboratory results. The paper **A Multi-Demand Negotiation Model Based on Fuzzy Rules Elicited via Psychological Experiments** by *Zhan et al.* defines a new negotiation model based on fuzzy rules that i) introduces the concept of dynamic preference into negotiation models in discrete domains, ii) a new algorithm for multi-demand negotiation using public information of demand and also private information about demand preferences, and iii) users' psychological characteristics about regret, risk and patience influence to adjust the fuzzy rules during the course of a multi-demand negotiation. **Multi-Objective Heuristic Algorithms for Practical Portfolio Optimization and Rebalancing with Transaction Cost** provides a tri-objective portfolio optimization model with risk, return and transaction cost as the objectives to be optimized in the

decision making about the process of allocating capital among a universe of assets to achieve better risk–return trade-off. In this model decision-makers can examine the trade-offs between risk, return and the incurred transaction costs while choosing a portfolio from the efficient frontier. To consider more realistic scenarios, the proposed model also considers practical constraints like cardinality, quantity, pre-assignment, self-financing and equality constraints arising due to the inclusion of transaction costs. In **Extending a Pessimistic-Optimistic Fuzzy Information Axiom based Approach Considering Acceptable Risk: Application in the Selection of Maintenance Strategy** *Seiti et al.* provide a fuzzy axiomatic design based mathematical model for decision making in the assessment and selection of proper maintenance strategy in risky situations, wherein each evaluation has both optimistic and pessimistic fuzzy scores, as the fuzzy evaluations themselves have risks. In order to improve the accuracy of the presented method, a new concept called “acceptable risk” is defined too. *Beliakov et al.* in **Measuring Traffic Congestion: An Approach based on Learning Weighted Inequality, Spread and Aggregation Indices from Comparison Data** investigate the problem of objectively measuring traffic congestion in cities taking into account not only the volume of traffic moving throughout a network, but also the inequality or spread of this traffic over major and minor intersections. For modeling such data, the proposal does use of weighted congestion indices based on various aggregation and spread functions. In **SpamSpotter: An Efficient Spammer Detection Framework based on Intelligent Decision Support System on Facebook** the authors show an intelligent decision support system that uses eight different machine learning classifiers on the baseline dataset in order to distinguish spammers from legitimate users on Facebook. This new system includes some newly proposed and existing features of Facebook user profiles to detect spammers and provides a framework that constructs a baseline dataset to resolve the issue of public unavailability and uncertainty about critical pieces of Facebook information. *Nguyen et al.* in **A Linguistic Multi-Criteria Decision-Aiding System to Support University Career Services** present a linguistic multi-criteria decision support system to assist students with identifying internship positions most related to their interests. Authors consider that students and internship positions profiles are expressed by means of hesitant fuzzy linguistic terms sets. As novelty the system proposes to perform a matching between students and internships from the perspective of the job candidate rather than the position. This is the reverse of the more popular matching to find the best candidate for a position. More specifically, the system is directed at students or new graduates with very little experience. Finally, the work entitled **Teranga Go!: Carpooling Collaborative Consumption Community with Multi-Criteria Hesitant Fuzzy Linguistic Term Set Opinions to Build Confidence and Trust** provides intelligent decision support systems working in an online community for sharing services and experience and information. The novelty of the site is the possibility of using hesitant linguistic expressions to assess a set of qualitative criteria, the use of the community members as the pool of experts and the idea that alternatives are the experts themselves. The linguistic information represented by hesitant fuzzy linguistic term sets is used to set a linguistic variable named karma in the profile of each user.

As Guest Editors, we would like to thank the Editor-in-Chief of Applied Soft Computing Journal for giving us the opportunity of preparing this special issue. We would also like to thank all the authors for their submissions and the anonymous referees who have put in the hard work and long hours needed to review each paper in a timely, professional manner. We hope that this collection of research papers will reveal the new research trends and challenges in intelligent decision support systems based on soft computing and will also spur new advances and real applications in the field.