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Integrated Uncertainty Management for Decision Making: Editorial

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This special volume is a follow-up to the International Symposium on Integrated Uncertainty Management and Applications (IUM 2010), which was successfully held in Ishikawa, Japan, April 9–11, 2010, at the Japan Advanced Institute of Science and Technology. As its title suggests, the main objective of this symposium was to provide a forum for the discussion and exchange of theoretical research results and ideas regarding all aspects of integrated uncertainty modelling and management. The proceedings of this symposium were published as a volume in the Springer series *Advances in Intelligent and Soft Computing* [1].

In response to an open call for papers, a total of 39 submissions were received for this special volume, of which about one-third were extended version of papers presented at IUM 2010. All submitted papers were rigorously reviewed according to the regular peer-review process of the *Annals of Operations Research*. Based on the peer-reviewing reports, the following sixteen papers were accepted for publication in this volume.

"On Some Claims Related to Choquet Integral Risk Measures" (by Hung T. Nguyen, Uyen H. Pham and Hien D. Tran): This paper argues that while the Choquet integral has become a general form for constructing risk measures, we should be careful in assessing its universal properties. In particular, as long as the asset process is not log normal, the canonical Wang's family of distortions is no longer valid for pricing security derivatives. Also, the evaluation of risk measures

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using risk neutral distributions in order to obtain consistency with a time horizon fails in the case of random walk (a Levy process).

"Characterization of a Coherent Upper Conditional Prevision as the Choquet Integral with Respect to Its Associated Hausdorff Outer Measure" (by Serena Doria): In this paper the author proposes a new model of coherent upper conditional previsions based on Hausdorff outer measures. Necessary and sufficient conditions are also given such that a coherent upper conditional prevision is uniquely represented as the Choquet integral with respect to its associated Hausdorff outer measure. The proposed model can be applied to make prevision in chaotic systems, where the final state is often represented by a fractal, i.e., a set with non-integer Hausdorff dimension, or to assess preferences on random variables defined on fractal sets.

"Constraint Programming for Stochastic Inventory Systems under Shortage Cost" (by Roberto Rossi, S. Armagan Tarim, Brahim Hnich and Steven Prestwich): This paper demonstrates the effectiveness of constraint programming when used in the context of stochastic optimization and, in particular, of stochastic inventory control. The computation of non-stationary replenishment cycle policy parameters is a well-known problem in inventory control, and it is a problem typically faced by managers in production/logistics environments. The aim is to determine optimal replenishment periods and their respective order-up-to-levels, to minimize the expected total cost under a non-stationary stochastic demand, and to establish a standard cost structure that comprises fixed ordering costs, linear production and holding costs, and penalty costs. The constraint programming approach does not require a piecewise linear approximation of these costs, unlike previous works in the literature. Furthermore, the model developed typically requires only a fraction of a second to solve real instances that can optimize weekly production for a whole year.

"Efficient Algorithms for Heavy-Tail Analysis under Interval Uncertainty" (by Vladik Kreinovich, Monchaya Chiangpradit and Wararit Panichkitkosolkul): In many practical situations, especially in economics and finance, we encounter power law (heavy-tail) distributions. To make optimal decisions in such situations, we need to know the parameters of these distributions. In this paper, the authors describe practically efficient algorithms for estimating such parameters based on a given sample – in a realistic situation of interval uncertainty, when instead of the exact sample values we have only the lower and upper bounds on each sample value.

"Choquet Integral for Record Linkage" (by Daniel Abril, Guillermo Navarro-Arribas and Vicenç Torra): This paper formulates an optimization problem for the determination of a fuzzy measure to be used with a Choquet integral. The problem establishes a set of preferences or orderings for the results of the integral. The model is then applied to disclosure risk assessment, a problem in data privacy.

"Normal Form Backward Induction for Decision Trees with Coherent Lower Previsions" (by Nathan Huntley and Matthias C.M. Troffaes): When solving sequential decision problems with limited knowledge, it is sometime difficult or even impossible to assign a probability to every event. An alternative is to use a coherent lower prevision, or, equivalently, a closed convex set of probability mass functions. In this paper the authors examine normal form solutions of decision trees under typical choice functions induced by lower previsions.

"Evidential Reasoning in Large Partially Ordered Sets – Application to Multi-label Classification, Ensemble Clustering and Preference Aggregation" (by Thierry Denœux and Marie-Hélène Masson): The main idea of the paper is to define belief functions over a special class of events comprised of intervals of a finite lattice. This departs from the usual approach in which the set of events is taken as the whole power set of the considered frame of discernment. As a result, the complexity is no longer exponential but polynomial, which allows us to define and combine belief functions in very large domain spaces and extend Dempster-Shafer reasoning to new challenging problems. The authors demonstrate three important applications of their method to multi-label classification (classification problems in which an instance may belong to several classes), clustering and preference aggregation. In these three problems, the frames of discernment are, respectively: the powerset of the set of classes, the set of partitions of a finite set of objects, and the set of preorders of a finite set.

"An Introduction and Survey of the Evidential Reasoning Approach for Multiple Criteria Decision Analysis" (by Dong-Ling Xu): The Evidential Reasoning (ER) approach has been proposed and developed since the early 1990s as a general approach for analyzing multiple attribute decision making (MADM) problems under various types of uncertainty using a unified framework – belief structure. In this paper, the author provides an important survey of when, how and where the ER approach could be developed and applied. Especially, future research directions in the area are also highlighted and explored in the survey.

"Qualitative and Quantitative Data Envelopment Analysis with Interval Data" (by Masahiro Inuiguchi and Fumiki Mizoshita): In this paper, the authors investigate data envelopment analysis (DEA) so as to be able to deal with interval input-output data. It is shown that the proposed analysis is useful for the relative evaluations of the activities of business units which have the same kinds of inputs and outputs under uncertainty. By the proposed analysis, business units can be sorted into many kinds of efficiency classes with their class scores given at the same time using the imprecise input-output data. Then the activities of business units are simultaneously evaluated qualitatively and quantitatively.

"Different Generalizations of Bags" (by Sadaaki Miyamoto): In this paper, four types of generalized bags including fuzzy bags are studied; and bag relations and their operations are proposed which are at least as useful as fuzzy relations. In addition, applications to graph calculations and data analysis based on bag models are suggested.

"Consistent Union and Prioritized Consistent Union: New Operations for Preference Aggregation" (by Michaël Rademaker and Bernard De Baets): In this paper, the authors formulate a new way to recombine general expressions of preferences in a transitive way. This paper would be of interest to both researchers and practitioners, as it pays attention to both the theoretical properties of the method (commutativity and associativity properties of the method are examined) and to possible applications (both small- and large-scale examples are provided). Easily implementable pseudo-code algorithms are also provided.

"Aggregation Functions and Generalized Convexity in Fuzzy Optimization and Decision Making" (by Jaroslav Ramík and Milan Vlach): By now, various generalizations of convexity of sets and functions play important roles in many areas, particularly in optimization, game theory, and mathematical economics. In this paper, the authors generalize quasiconcave functions in real finite dimensional

spaces in two different ways. First, using analogy with the characterization of quasiconcave functions by the convexity of their upper level sets, they introduce the upper-starshaped functions by requiring their upper level sets to be starshaped instead of being only convex (similarly for quasiconvex and lower-starshaped functions). Second, through allowing the "min" operator in the classical definition of quasiconcave functions to be replaced by a triangular norm T, a new class of T-quasiconcave functions is obtained. In addition, properties of these new types of functions, in particular the properties that are important in optimization and decision making, are also investigated.

"A New Method for Managing the Uncertainties in Evaluating Multi-person Multi-criteria Location Choices, Using a Perceptual Computer" (by Shilian Han and Jerry M. Mendel): This paper shows how the new methodology of perceptual computing can be used in a hierarchical multi-person multi-criteria decision making problem, in which evaluations of major criteria and their sub-criteria can be everything from numbers to words. Using words to do this is very novel and this paper will make decision making using word-evaluations accessible to the readers of this journal. In addition, this paper shows how consensus weights can be computed using a very novel linguistic weighted average.

"Information Cells and Information Cell Mixture Models for Concept Modelling" (by Yongchuan Tang and Jonathan Lawry): Based on the prototype theory and random set theory, this paper proposes a novel model for vague concept modelling referred to as the information cell mixture model (ICMM, for short). Both prototype uncertainty and semantic uncertainty are integrated in the ICMM. In addition, the experimental studies show that ICMM has potential applications in the concept coarsening and classification.

"A Group Nonadditive Multiattribute Consumer-Oriented Kansei Evaluation Model with an Application to Traditional Crafts" (by Hong-Bin Yan, Van-Nam Huynh and Yoshiteru Nakamori): In this paper, the authors propose a three-phase group nonadditive multiattribute *kansei* evaluation model, which is focused on the aesthetic aspects of products. The main advantages of the proposed model are its abilities to deal with semantic overlapping of *kansei* data, different types of personalized *kansei* preferences, as well as mutual dependence among multiple *kansei* preferences. The proposed model acts as a recommendation of products based on the consumer-specified *kansei* requests and can be applied in the e-commerce area.

"An Analytical Model for Building Brand Equity in Hospitality Firms" (by Tsuen-Ho Hsu, Li-Chu Hung and Jia-Wei Tang): This study applies quality function deployment (QFD) and consistent fuzzy preference relations to create systematically a valid and reliable model for building service-based brand equity in hospitality firms. This model not only incorporates the marketing segments, service-based hospitality brand equity categories and attributes, and managerial strategies and activities, but also coordinates them using QFD matrices deployment. This model also could take into account both customer values and business strategies that sustain a hospitality firm's competitive advantage.

Finally, we would like to express our gratitude to all the authors of submitted papers for their efforts and contributions to this special volume of the *Annals of Operations Research*, and to the numerous reviewers for carefully reading and commenting on the papers submitted. Especially, we are very grateful to the Editor-in-Chief, Endre Boros, for the opportunity to publish this special volume, and to

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We hope that the readers will enjoy reading the papers in this special volume.

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