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SS02: Uncertainty Handling in Recommender and Decision Support Systems

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The explosion of available data in decision support domains and their rapidly growing scalability, are naturally accentuating the need for capably dealing with uncertainty and imperfect information in order to face complex decision-making situations. Examples of such domains include medical diagnosis systems, personalization and item recommendation in the Internet, planning by autonomous systems and sustainable energy policy management, to name a few. Integrating and handling uncertain information originated by imperfect, imprecise - and sometimes conflicting - data sources, becomes therefore a cornerstone task to procure reliable, informed decisions. For instance, recent research trends in recommender systems design take account of a wider range of contextual knowledge about users, products and services, preferences, social interaction, etc. The necessity of approaches to effectively deal with disparate sources of information pervaded by uncertainty, has has long been an active subject of research, with significant progress made in the last decades. Most advances achieved within the aforementioned decision-making contexts, have undeniably laid their foundations on several well consolidated *Uncertainty Theories* in the discipline, such as: the classical (but still widely adopted) probability theory, Zadeh's fuzzy set theory, its extensions into possibilistic theory and the methodology of "Computing with Words", and Dempster-Shafer's Theory of Evidence.

This Special Session brings together a number of recent research trends in *Uncertain Information Handling within the contexts of Decision Support and Recommender Systems, and their Practical Applications*. A total of seven contributions have been accepted for publication in this session, with a significant focus on reasoning, data fusion and decision-making processes in scenarios whose information dealt with exhibit different forms of uncertainty. Likewise, ongoing challenges and directions for future work in this area of research are set forth by the authors.

In the first contribution, *Uncertain Information Fusion and Knowledge Integration: How to Take Reliability into Account*, Nguyen et al. investigate the problem of uncertain information fusion and knowledge integration from multiple sources with varying reliability. The authors highlight the importance of considering reliability in addition to the other forms of uncertainty that may appear, in situations when sensors record wrong measurements or human expert information could possibly be incorrect. A twofold approach that extends existing Maximum Likelihood-based methods is postulated, taking account of reliability in the fusion and integration process of fuzzy and probabilistic uncertain information.

Martin and Azvine in *Graded Associations in Situation Awareness*, expound the importance of bridging the gap between crisp representations of information used by computers, and their vague human counterparts. Accordingly, they present a mathematical framework that, by combining formal concept analysis and graded tolerance relations (based on fuzzy set theory), allows to define graded fuzzy representations of associations involving both crisp and imprecise data, namely via formal concept lattices. The potential applicability of the proposed framework is

demonstrated in the context of frequent item-set discovery and, more generally, in association rule discovery problems upon transactional data.

The third contribution, *An Interval Type-2 Fuzzy Model for Review Topic based Recommendation*, considers the problem of modeling the uncertainty underlying diversity in the context of review topic-based recommender systems. In their paper, Ma et al. motivate the usefulness of interval type-2 fuzzy sets to handle and meaningfully describe diversity in topic distributions. The authors develop a novel dual topic sampling method, followed by an illustrative example and performance comparison against other recommender methods, demonstrating the practical benefits of conducting dual sampling to handle uncertainty in topic-based recommender domains.

In *Probabilistic Assumption-based Argumentation with DST Evidence*, Hung investigates the relationship between Probabilistic Assumption-based Argumentation (PABA) and Dempster-Shafer Theory of Evidence. The paper outlines the semantic relationship between Probabilistic Argumentation and the belief-plausibility functions that typically characterize a body of evidence. Subsequently, Hung defines an extended PABA framework that can naturally manage evidential information in the fusion, reasoning and decision-making processes, contrary to traditional PABA frameworks which formerly dealt with logical knowledge exclusively in the aforementioned processes.

Oki and Inuiguchi study the binary classification problem in *A Mixture Model Approach to Utilizing Published Decision Rules*. Concretely, they propose a mixture model that combines published and individually owned rule bases stemming from different datasets. Their approach constructs and conflates score distributions over classes, with each distribution describing the extent to which new data instances may belong to the existing class labels. A comparative study shows that the accuracy in Oki and Inuiguchi's mixture approach outperforms similar baseline methods under the presence of biased data.

In *An Axiomatic Approach to the Estimation of Interval-valued Preferences in Multi-Criteria Decision Modeling*, Franco et al. explore the interval extensions of popular models for multi-criteria decision support to deal with imprecision. Based on an axiomatic analysis of preference modeling, some weaknesses are identified, including the difficulty to reason over the uncertainty of interval-valued decision outcomes. In their study, the authors introduce a number of axioms for interval-valued preference estimation, concluding that the Weighted Overlap Dominance model can suitably satisfy these axioms.

In the seventh and last contribution to the Special Session, *Multi-criteria Decision Analysis based on Hesitant Fuzzy Linguistic Term Sets: application in Photovoltaic Technologies Assessment*, Sellak et al. investigate the paradigm of linguistic multi-criteria decision-making. The authors present an outranking method for multi-criteria decision-making, in which decision makers use hesitant fuzzy linguistic term sets to qualitatively express their preferences under varying degrees of uncertainty. The proposed solution alleviates the difficulties that frequently arise when comparing and ranking preferential information expressed linguistically, thus leading to accurate computational processes with understandable decision results. An application in the assessment of solar photovoltaic technologies is provided.

We hope that the outcome of this Special Session constitutes a notable contribution in the field, to continue fostering joint research efforts and addressing the new challenges of effectively managing uncertainty in complex decision support domains. The Special Session Organizers would like to acknowledge all the contributors for their effort in submitting high quality papers, the reviewers for their generous willingness to evaluate the contributions received, and the conference Special Session Chairs, Drs. Susana Montes and Yasuo Kudo, for their assistance during the organization of this scientific event.

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