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Uncertain reasoning

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Many applications are increasingly being challenged with how to deal with imperfect data of various kinds. One problem that often arises with imperfect data is that of managing and reasoning about uncertainty. This question is vital in almost all data-driven applications, including healthcare data analytics, genomics, earth sciences, social sciences and psychology, and economics. The choice of an uncertainty model to represent and reason in the presence of uncertain information depends on the nature of the uncertainty to be processed.

In Artificial Intelligence, different models of uncertainty have been proposed. The most widely used uncertainty models are those based on probability theory. An example of these probabilistic models, popular in Artificial Intelligence, is Bayesian networks. Bayesian networks allow a compact representation of probability distributions based on graphical models. They take advantage of independence relations among variables to provide efficient algorithms for reasoning and query answering.

In addition to the probability theory, other uncertainty theories have been developed in Artificial Intelligence. For instance, possibility theory is particularly suited to represent ordinal or qualitative uncertainty relations. Possibility theory-based models can be used to represent dynamics of knowledge due to its close relationship with the ranking or OCF (Ordinal Conditional Functions) models. Imprecise probabilities and the Dempster-Shafer (or belief function) theory are two other powerful and expressive uncertainty theories that can account for a wide variety of data imperfections.

This special issue gathers eight papers on recent methodologies for managing, reasoning, and decision-making under uncertainty.

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Three papers deal with human reasoning using syllogisms and decision-making under uncertainty. The paper "An adaptive model for human syllogistic reasoning", by Jonas Bischofberger and Marco Ragni, deals with the question of modeling human reasoning. It focuses on the tasks of representing, reasoning, and predicting syllogisms. It first offers the state-of-the-art on the various existing reasoning systems on syllogisms, including probabilistic ones, and their implementation. The authors then propose a so-called composite model, parameterized by the basic reasoning models on syllogisms. The studied models of reasoning on syllogisms, both basic and composite, have been evaluated empirically.

The paper "Coherent lower and upper conditional previsions defined by Hausdorff inner and outer measures to represent the role of conscious and unconscious thought in human decision making", by Serena Doria, is concerned with human decision-making. The paper proposes a new modeling of human conscious and unconscious decision-making using Hausdorff inner and outer measures and a new representation of preference orderings. The author proposes a solution to the well-known conjunction fallacy (the conjunction of two events is more probable than one of the constituent events), commonly illustrated by the Linda problem.

The paper "Joint desirability foundations of social choice and opinion pooling", by Arianna Casanova, Enrique Miranda, and Marco Zaffalon, concerns the problem of aggregating pieces of information issued from different sources. The authors consider a problem of social choice where the subjects' states of belief (probability) and utility are represented as coherent sets of desirable gambles. The authors rephrase Arrow's theorem in this context as well as other results, in particular those concerning the weak Pareto property.

Three papers in this special issue are focused on probabilistic graphical models. The paper "Breaking the curse of dimensionality: hierarchical Bayesian network model for multi-view clustering", by Hasna Njah, Salma Jamoussi, and Walid Mahdi, addresses cluster analysis of high-dimensional data. This is achieved by hierarchical Bayesian networks whose latent variables are used to achieve multi-view clustering. Experiments prove the effectiveness of that approach in tackling the distance concentration challenge while preventing overfitting.

The paper "Constraint-based learning for non-parametric continuous Bayesian networks", by Marvin Lasserre, Régis Lebrun, and Pierre-Henri Wuillemin, is focused on Bayesian networks with continuous variables. A new algorithm for structural learning of non-parametric continuous models is presented. The proposed approach, based on the classical PC algorithm and non-parametric independence tests, allows to deal with high-dimensional copula functions. The resulting method outperforms existing parametric approaches.

The paper "Learning tractable NAT-modeled Bayesian networks", by Yang Xiang and Qian Wang, also concerns the learning of Bayesian networks. Yet, in this case discrete models whose local tables are compactly specified by logical relations are considered. This allows one to cope with models of higher treewidth. A scoring function based on the MDL principle is used to search optimal structures and experiments are reported to evaluate the practical applicability of the proposed approach.

The paper "On the correspondence between abstract dialectical frameworks and non-monotonic conditional logics" by Jesse Heyninck, Gabriele Kern-Isberner, Matthias Thimm, and Kenneth Skiba is instead in the field of non-monotonic reasoning and its relations with formal argumentation. A characterization of abstract dialectical frameworks in conditional logics is provided. Different translations possibly providing a foundation for cross-fertilization between the two fields as well as a justification for the adaptation of ideas from one formalism to the other are provided.

Finally, the paper "Ranking kinematics for revising by contextual information" by Meliha Sezgin, Gabriele Kern-Isberner, and Christoph Beierle, addresses belief revision within the formalism of Spohn's ranking functions. By exploiting semantical independencies, the complexity of the revision task is reduced to local contexts. Global belief revision can be therefore set up from revisions on the local contexts via a merging operator.

These eight papers, presented in this special issue, offer to the Artificial Intelligence and Mathematics communities, new results on social choice and decision-making under uncertainty, graphical-based representation of probabilistic uncertain information, belief revision with ranking models, and common sense reasoning based on the use of syllogisms and conditionals.

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