

Special Issue on Challenges for Reasoning under Uncertainty, Inconsistency, Vagueness, and Preferences

A Topical Snapshot

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Managing uncertainty, inconsistency, vagueness, and preferences has been extensively explored in artificial intelligence (AI). During the recent years, especially with the emerging of smart services and devices, technologies for managing uncertainty, inconsistency, vagueness, and preferences to tackle the problems of dynamic, real-world scenarios have started to play a key role also in other areas, such as information systems and the (Social and/or Semantic) Web. These application areas have sparked another wave of strong interest into formalisms and logics for dealing with uncertainty, inconsistency, vagueness, and preferences. Important examples are fuzzy and probabilistic approaches for description logics, or rule systems for handling vagueness and uncertainty in the Semantic Web, or formalisms for handling user preferences in the context of ontological knowledge in the Social Semantic Web. While scalability of these approaches is an important issue to be addressed, also the need for combining various of these approaches with each other and/or with more classical ways of reasoning have become obvious (hybrid reasoning under uncertainty). This special issue presents several state-of-the-art formalisms and methodologies for managing uncertainty, inconsistency, vagueness, and preferences.

In “Polynomial Algorithms for Computing a Single Preferred Assertional-Based Repair”, Abdelmoutia Telli, Salem Benferhat, Mustapha Bourahla, Zied Bouraoui, and Karim Tabia investigate different approaches for handling inconsistent knowledge bases in the description logic *DL-Lite* when the ABox is prioritized and inconsistent with the TBox. Such inconsistency problems often occur when ABoxes are provided by multiple conflicting sources of different reliability levels. The authors propose different inference strategies for

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selecting one consistent ABox, called preferred repair, along with polynomial algorithms for computing the preferred repairs in the different cases.

An inconsistency measure maps a knowledge base to a non-negative real number, where larger values indicate the presence of more significant inconsistencies in the knowledge base. To assess the quality of a particular inconsistency measure, a wide range of rationality postulates has been proposed in the literature. In his paper “On the Compliance of Rationality Postulates for Inconsistency Measures: A More or Less Complete Picture”, Matthias Thimm surveys 15 recent inconsistency measures and compares them relative to their compliance with eight rationality postulates, providing new insights into the adequacy of measures and the significance of postulates.

When reasoning qualitatively from a conditional knowledge base, two established approaches are p-entailment and System Z, using all and just one ranking model(s), respectively, as semantics of a conditional knowledge base. Between these two extremes, the approach of c-representations generates a subset of all ranking models with certain constraints. In “A Practical Comparison of Qualitative Inferences with Preferred Ranking Models”, Christoph Beierle, Christian Eichhorn, and Steven Kutsch follow this idea of using preferred ranking models as the semantics of a conditional knowledge base.

Decision theory is often based on quantitative utility theory. However, in “Analyzing a Bipolar Decision Structure through Qualitative Decision Theory”, Florence Dupin de Saint-Cyr and Romain Guillaume present a qualitative approach to decision theory that allows for elaborating on both positive and negative aspects of options in the context of goals. Their bipolar leveled frameworks are based upon possibility theory, and they establish links between decision principles and possibilistic default rules, thus making connections between decision theory and possibilistic reasoning explicit on an abstract level.

Modelling the reasoning of agents in multi-agent scenarios and open environments demands for meeting various challenges: The beliefs of agents are usually uncertain and imprecise, agents have also to take into account what other agents do and aim at, and the world is evolving continuously. Karsten Martiny and Ralf Möller describe probabilistic doxastic temporal (PDT) logic in their paper “Reasoning about Imprecise Beliefs in Multi-Agent Systems with PDT Logic” as a suitable framework to formalize such complex reasoning. PDT Logic combines temporal logic with imprecise probabilities and is interpreted via a Kripke semantics on possible worlds, and the authors illustrate its applicability in various examples.

The mental attitudes of belief, desire, and intention play a central role in the design and implementation of autonomous agents. In 1987, Bratman proposed their integration into a seminal belief-desire-intention (BDI) theory. Since then, numerous approaches were built on the BDI paradigm. In “BDI Logics for BDI Architectures: Old Problems, New Perspectives” Andreas Herzig, Emiliano Lorini, Laurent Perrussel, and Zhanhao Xiao summarize the state of the art, discuss the main open problems, and sketch how they can be addressed. In particular, they argue that research on intention should be bet-

ter connected to fields such as reasoning about actions, automated planning, and belief revision and update.

First approaches for reasoning in fuzzy description logics (FDLs) were based either on a reduction to reasoning in classical description logics (DLs) or on adaptations of reasoning approaches for DLs to the fuzzy case. But these approaches in general do not work when expressive terminological axioms, called general concept inclusions (GCIs), are present in the FDL. In “Decidability and Complexity of Fuzzy Description Logics”, Franz Baader, Stefan Borgwardt, and Rafael Peñaloza present their project targeting a comprehensive study of the border between decidability and undecidability for FDLs with GCIs, as well as determining the exact complexity of the decidable logics.

In “Hybrid Reasoning for Intelligent Systems”, Gerhard Lakemeyer briefly presents the DFG Research Unit (Forschergruppe) FOR 1513 (HYBRIS) and their joint research projects, which aim at combining different methodologies for knowledge representation in application areas such as robotics and logistics. The handling of uncertainty and preferences in their different forms is a core topic of the second phase.

Many logic-based approaches to representing and reasoning with knowledge under uncertainty have excellent properties but lack implementation, and frameworks that allow for combining different approaches to implement a computer system are especially rare. The Tweety library collection offers such a framework, in particular, containing Java implementations for conditional logics, probabilistic logics, computational argumentation, belief revision, and preference reasoning, but also libraries for dealing with agents, multi-agent systems. In his system description “The Tweety Library Collection for Logical Aspects of Artificial Intelligence and Knowledge Representation”, Matthias Thimm gives a survey on the current state of this library.

Finally, Andreas Ecke summarizes the main aims and results of his doctoral dissertation “Quantitative Methods for Similarity in Description Logics”. He investigates expressing vagueness, i.e., that something is close enough by using similarity and dissimilarity measures, in particular, in the context of description logic reasoning. Moreover, he considers prototypical distance functions in Gärdenfors’ conceptual spaces.

All in all, this special issue gives a good overview on recent developments in reasoning under uncertainty, inconsistency, vagueness, and preferences. We hope that you enjoy reading it.

This special issue is the result of the efforts of many persons. Special thanks go to the authors for their contributions and their help in putting this special issue together, to the referees for their timely expertise in carefully reviewing the contributions, and to the KI team, in particular the editor in charge of this issue, Anni-Yasmin Turhan (TU Dresden), for her excellent support.

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1 Content

1.1 Survey

- *Many Facets of Reasoning under Uncertainty, Inconsistency, Vagueness, and Preferences—A Brief Survey*
Gabriele Kern-Isberner, Thomas Lukasiewicz

1.2 Technical Contributions

- *Polynomial Algorithms for Computing a Single Preferred Assertional-Based Repair*
Abdelmoutia Telli, Salem Benferhat, Mustapha Bourahla, Zied Bouraoui, and Karim Tabia
- *On the Compliance of Rationality Postulates for Inconsistency Measures: A More or Less Complete Picture*
Matthias Thimm
- *A Practical Comparison of Qualitative Inferences with Preferred Ranking Models*
Christoph Beierle, Christian Eichhorn, and Steven Kutsch
- *Analyzing a Bipolar Decision Structure through Qualitative Decision Theory*
Florence Dupin de Saint-Cyr and Romain Guillaume
- *Reasoning about Imprecise Beliefs in Multi-Agent Systems with PDT Logic*
Karsten Martiny and Ralf Möller
- *BDI Logics for BDI Architectures: Old Problems, New Perspectives*
Andreas Herzig, Emiliano Lorini, Laurent Perrussel, and Zhanhao Xiao

1.3 Research Projects

- *Decidability and Complexity of Fuzzy Description Logics*
Franz Baader, Stefan Borgwardt, and Rafael Peñaloza
- *Hybrid Reasoning for Intelligent Systems*
Gerhard Lakemeyer
- *The Tweety Library Collection for Logical Aspects of Artificial Intelligence and Knowledge Representation*
Matthias Thimm

1.4 Doctoral Dissertations

- *Quantitative Methods for Similarity in Description Logics*
Andreas Ecke

2 Service

2.1 Conferences and Workshops

- International Joint Conference on Artificial Intelligence (IJCAI)
- AAAI Conference on Artificial Intelligence (AAAI)
- European Conference on Artificial Intelligence (ECAI)
- International Conference on Principles of Knowledge Representation and Reasoning (KR)
- Conference on Uncertainty in Artificial Intelligence (UAI)
- International Conference on Scalable Uncertainty Management (SUM)
- European Conference on Symbolic and Quantitative Approaches to Reasoning with Uncertainty (ECSQARU)
- International Symposium on Imprecise Probability: Theories and Applications (ISIPTA)
- International Conference on Logic Programming and Nonmonotonic Reasoning (LPNMR)
- International Symposium on Foundations of Information and Knowledge Systems (FoIKS)
- German Conference on Artificial Intelligence (KI)
- European Conference on Logics in Artificial Intelligence (JELIA)
- International Conference on Computational Models of Arguments (COMMA)
- International Symposium on Methodologies for Intelligent Systems (ISMIS)
- International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems (IPMU)
- International Workshops on Nonmonotonic Reasoning (NMR)
- International Workshop on Description Logics (DL)
- International Workshop on Uncertainty Reasoning for the Semantic Web (URSW)

2.2 Journals

- Artificial Intelligence
<http://www.journals.elsevier.com/artificial-intelligence>
- Journal of Artificial Intelligence Research
<http://www.jair.org>
- International Journal of Approximate Reasoning
<http://www.journals.elsevier.com/international-journal-of-approximate-reasoning>
- ACM Transactions on Computational Logic
<http://tocl.acm.org>
- Journal of Automated Reasoning
<http://www.springer.com/computer/theoretical+computer+science/journal/10817>
- Journal of Applied Logic
<http://www.journals.elsevier.com/journal-of-applied-logic>

- Argument & Computation
<http://www.tandfonline.com/toc/tarc20/current>
- Fuzzy Sets and Systems
<http://www.journals.elsevier.com/fuzzy-sets-and-systems>

2.3 Books

- Bertossi, L.: Database Repairing and Consistent Query Answering. Morgan & Claypool (2011)
- Besnard, P., Hunter, A.: Elements of Argumentation. MIT Press (2008)
- Darwiche, P.A.: Modeling and Reasoning with Bayesian Networks, 1st edn. Cambridge University Press, New York, NY, USA (2009)
- Halpern, J.Y.: Reasoning about Uncertainty. MIT Press (2005)
- Jensen, F.V., Nielsen, T.D.: Bayesian Networks and Decision Graphs, 2nd edn. Springer (2007)
- Koller, D., Friedman, N.: Probabilistic Graphical Models: Principles and Techniques — Adaptive Computation and Machine Learning. MIT Press (2009)
- Paris, J.B.: The Uncertain Reasoner’s Companion: A Mathematical Perspective. Cambridge University Press, New York, NY, USA (1994)
- Pearl, J.: Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference. Morgan Kaufmann, San Francisco, CA, USA (1988)
- Pearl, J.: Causality: Models, Reasoning, and Inference. Cambridge University Press, New York, NY, USA (2000)
- Suciu, D., Olteanu, D., Christopher, R., Koch, C.: Probabilistic Databases, 1st edn. Morgan & Claypool (2011)