

# Secondary Publication



Steen, Alexander; Benz Müller, Christoph

## Non-Classical Reasoning for Contemporary AI Applications

Date of secondary publication: 15.10.2025

Version of Record (Published Version), Article

Persistent identifier: urn:nbn:de:bvb:473-irb-110813x

### Primary publication

Steen, Alexander; Benz Müller, Christoph (2024): Non-Classical Reasoning for Contemporary AI Applications, in: Künstliche Intelligenz : KI, Berlin: Springer Science and Business Media LLC, Vol. 38, Nr. 1–2, pp. 3.5, doi: 10.1007/s13218-024-00857-6.

### Legal Notice

This work is protected by copyright and/or the indication of a licence. You are free to use this work in any way permitted by the copyright and/or the licence that applies to your usage. For other uses, you must obtain permission from the rights-holders.

This document is made available under a Creative Commons license.



The license information is available online:

<https://creativecommons.org/licenses/by/4.0/legalcode>



# Non-Classical Reasoning for Contemporary AI Applications

Alexander Steen<sup>1</sup> · Christoph Benzmüller<sup>2</sup>

Published online: 16 July 2024  
© The Author(s) 2024

The two main visions that the second author remembers well from his early days as a computer science student at Saarland University more than three decades ago were: (i) We're entering a very interesting period of history where AI systems will become more intelligent than humans in various challenging domains, or perhaps even in general, and (ii) using formal methods, we should be able to develop computer programs whose correctness can be guaranteed by formal verification. The first idea was discussed a lot, especially in Jörg Siekmann's AI lectures, and formal verification was a core topic in Jacques Loeckx's teaching portfolio. At the time, AI was often seen as being about symbolic techniques, especially rule-based and logic-based systems, both in popular understanding and in course syllabi. It seemed like the two visions weren't really at odds with each other. But today, it feels, with AI technology focusing predominantly on subsymbolic, deep learning-based AI, the gap between these two visions couldn't be wider.

Neuro-symbolic AI, or hybrid, may be a potential avenue for integrating the two visions once again. It seems that identifying an optimal combination of techniques from subsymbolic AI (data-driven learning) and symbolic AI (explicit reasoning within well-defined and well-understood formal languages) within an appropriate methodological framework could eventually help in addressing and resolving some of the open questions and challenges related to (self-)control, abstraction, reflection and potentially even consciousness. This special issue does not seek to identify a specific combination of hybrid AI techniques that would facilitate this goal. Several contributions of this special issue are, however, motivated by this idea and therefore focus on advancing the state of the art in normative, doxastic, causal

and regulatory symbolic reasoning. This could be employed, for instance, to regulate and control the operation of AI systems or to enable them to provide a more detailed rationale for their beliefs and decisions and to align them with regulatory and normative objectives.

## 1 Content of the Special Issue

We are pleased to present a collection of contributions on different aspects of non-classical logics and non-classical reasoning for applications in AI. First, a brief overview of relevant fields of research in logic in AI is presented in an overview article by the editors, in particular highlighting what we think the current challenges in this field are; followed by an inspiring interview with Dov Gabbay and Leon van der Torre that elaborates on the relevance of non-classical logics in AI. Then, two technical contributions are presented, one of the use of theorem proving methods for learning normative behaviour, and one about a novel family of logics for reasoning about goals. The technical contributions are complemented by three system descriptions on a repository of conditional logic resources, an automated reasoning-based AI planner, and an implementation of a deontic logic reasoner. We continue with three dissertation abstracts on belief change, computer-assisted reasoning in metaphysics, and on logical foundations of randomized computation. We conclude with a project report on conditional normative reasoning.

### 1.1 Introduction

- Challenges for Non-Classical Reasoning in Contemporary AI Applications [1].  
Alexander Steen and Christoph Benzmüller.

---

✉ Alexander Steen  
alexander.steen@uni-greifswald.de

✉ Christoph Benzmüller  
christoph.benzmueller@uni-bamberg.de

<sup>1</sup> Universität Greifswald, Greifswald, Germany

<sup>2</sup> Otto-Friedrich-Universität Bamberg, Bamberg, Germany

## 1.2 Interview

- What are Non-classical Logics and Why Do We Need Them? An Extended Interview with Dov Gabbay and Leon van der Torre [2].  
Alexander Steen and Christoph Benzmüller.

## 1.3 Technical Contributions

- Learning Normative Behaviour through Automated Theorem Proving [3].  
Emery A. Neufeld.
- Modeling C0 Family Logics for Artificial Intelligence: Doxastic-Temporal Logics for Reasoning About Goals [4].  
James T. Oswald, Brandon Rozek, and Thomas M. Ferguson.

## 1.4 System Descriptions

- CLKR - Conditional Logic and Knowledge Representation [5].  
Christoph Beierle.
- Spectra: An Expressive STRIPS-Inspired AI Planner Based on Automated Reasoning [6].  
Brandon Rozek and Selmer Bringsjord.
- An ASP Implementation of Defeasible Deontic Logic [7].  
Guido Governatori.

## 1.5 Dissertation Abstracts

- Semantics of Belief Change Operators for Intelligent Agents [8].  
Kai Sauerwald.
- Computer-Verified Foundations of Metaphysics [9].  
Daniel Kirchner.
- Towards a Logical Foundation of Randomized Computation: Doctoral Thesis Abstract [10].  
Melissa Antonelli.

## 1.6 Project Report

- Report on “Axiomatizing Conditional Normative Reasoning” [11].  
Xavier Parent.

## 2 Service

### 2.1 Conferences and Workshops

Major AI conferences like IJCAI, ECAI, and AAAI cover topics related to non-classical logics and their automation. The conferences in the following (incomplete) list more specifically address the topic of (non-classical) logics, their automation, and/or their use in Artificial Intelligence. Some of the following conferences are moreover dedicated to specific application domains (like normative reasoning in the case of DEON).

- European Conference on Logics in Artificial Intelligence resp. Journées Européennes sur la Logique en Intelligence Artificielle (JELIA).
- Deutsche Jahrestagung für Künstliche Intelligenz (KI).
- International Joint Conference on Automated Reasoning (IJCAR).
- International Conference on Automated Deduction (CADE).
- International Conference on Automated Reasoning with Analytic Tableaux and Related Methods (TABLEAUX).
- International Conference on Logic for Programming, Artificial Intelligence and Reasoning (LPAR).
- International Conference on Principles of Knowledge Representation and Reasoning (KR).
- International Conference on Principles and Practice of Multi-Agent Systems (PRIMA).
- Advances in Modal Logic (AiML).
- International Conference on Legal Knowledge and Information Systems (JURIX).
- International Conference on Deontic Logic and Normative Systems (DEON).
- Non-Classical Logics: Theory and Applications (NCL).
- International Workshop on Description Logics (DL).
- International Workshop on Non-Monotonic Reasoning (NMR).
- International Workshop on Automated Reasoning in Quantified Non-Classical Logics (ARQNL).
- Deduktionstreffen (DT).
- Workshop on Formal and Cognitive Reasoning (FCR).

## 2.2 Journals

- Elsevier: Artificial Intelligence.
- Cambridge University Press: Review of Symbolic Logic.
- Cambridge Universität Press: Theory and Practice of Logic Programming.
- College Publications: Journal of Applied Logics.
- College Publications: Journal of Logic and Computation.
- MDPI: Logics.
- Morgan Kaufman: Journal of Artificial Intelligence Research.
- Oxford University Press: Logic Journal of the IGPL.
- Taylor and Francis: Journal of Applied Non-Classical Logics.
- Springer: Artificial Intelligence and Law.
- Springer: Journal of Automated Reasoning.
- Springer: Journal of Philosophical Logic.
- Springer: KI - Künstliche Intelligenz.

**Funding** Open Access funding enabled and organized by Projekt DEAL.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References

1. Steen A, Benz Müller C (2024) Challenges for non-classical reasoning in contemporary AI applications. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00855-8>
2. Steen A, Benz Müller C (2024) What are non-classical logics and why do we need them? An extended interview with Dov Gabbay and Leon Van Der Torre. *Künstl Intell.* <https://doi.org/10.1007/s13218-023-00824-7>
3. Neufeld EA (2024) Learning normative Behaviour through Automated Theorem Proving. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00844-x>
4. Oswald JT, Rozek B, Ferguson TM (2024) Modeling Family Logics for Artificial Intelligence: doxastic-temporal logics for reasoning about goals. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00848-7>
5. Beierle C, Haldimann J, Schwarzer LCLKR (2024) Conditional logic and knowledge representation. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00842-z>
6. Rozek B, Bringsjord S, Spectra (2024) An expressive STRIPS-Inspired AI planner based on automated reasoning. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00847-8>
7. Guido Governatori (2024) An ASP implementation of Defeasible Deontic Logic. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00854-9>
8. Sauerwald K (2024) Semantics of belief change operators for Intelligent agents. *Künstl Intell.* <https://doi.org/10.1007/s13218-023-00830-9>
9. Kirchner D (2024) Computer-verified foundations of Metaphysics. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00834-z>
10. Antonelli M (2024) Towards a Logical Foundation of Randomized Computation: Doctoral Thesis Abstract. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00843-y>
11. Parent X (2024) Report on axiomatizing conditional normative reasoning. *Künstl Intell.* <https://doi.org/10.1007/s13218-024-00832-1>

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.