

Logics for the new AI spring

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Artificial intelligence is a fuzzy concept. Ever since the term was put forward in the 1956 Dartmouth workshop, no attempt seems to have succeeded in defining its scope and methodology with razor sharp boundaries. This is indeed good news. Science, and hence human intelligence, has advanced significantly owing to AI. This means that AI keeps tackling new challenges and whenever it succeeds, it raises yet again the bar of what human intelligence is capable of. This view, however, is rather new. In the early decades AI researchers focussed on *reasoning* to provide a relatively sharp definition of the natural goals of the field. This owed in part to the obvious prominence of reasoning in human intelligence, and in part on the fact that logicians have been inspired by the goal of mechanising reasoning at least since the times of Leibniz and Boole.

Against this background, classical logic, and then a galaxy of non-classical extensions of it, formed the basis of the symbolic approach to AI. For about half a century this constituted the mainstream approach, and its alternating fortunes correlated almost perfectly with those of the entire AI field.

The fact AI makes the news on a daily basis, not only in the Science, Heath and Technology sections, but also on the Economics and Politics ones, is perhaps the best indication that AI is today living the most spectacular of its springs. But, unlike the previous ones, the blossoming of results and applications is driven by neural networks rather than symbolic AI.

Since logic excelled in pushing forward knowledge representation and reasoning, and neither are playing a central role in the spectacular successes of today's machine learning, the question arises as to what is the role of

logic in the present and near future of AI. This is of course a big question, and one which involves several threads of AI research. Hence, in 2021 we decided to organise a Summer School in the spectacular venue offered by the Lake Como School of Advanced Studies and titled it “Logics for the New Ai Spring”. The school took place from 12 to 16 September 2022 with tutorials Stephanie Dick, Alessandra Palmigiano, Josef Urban, and Mike Wooldridge. It was attended by 40 early stage researchers.¹

We announced this special issue of the *International Journal of Approximate Reasoning* during the call for applications for the Summer School and later opened a call for papers. The following nine papers have been selected.

1. ‘Alien Coding’ by Thibault Gauthier, Miroslav Olšák and Josef Urban [1] presents a self-learning algorithm that aims at explaining numerical sequences of the On-Line Encyclopedia of Integer Sequences (OEIS).
2. ‘A probabilistic analysis of selected notions of iterated conditioning under coherence’ by Lydia Castronovo and Giuseppe Sanfilippo [2]. Conditionals and compound conditionals are the subject of the present paper, where the authors discuss and study iterated conditionals within the probabilistic setting determined by de Finetti’s notion of coherence.
3. ‘MaxSAT Resolution for Regular Propositional Logic by Jordi Colla’ Chu-Min Lib, Felip Manyà and Elifnaz Yangin [3] deals with the computational aspects of knowledge representation. The authors study the MaxSat problem for formulas in regular CNF. Besides defining a sound and complete resolution-style proof system for regular MaxSat, the paper also present a *weighted* extension of it hence resulting in a sound and complete proof system for what the authors name “Weighted Regular MaxSAT”.
4. ‘Moderated Revision’ by Daniel Grimaldi, Maria Vanina Martinez and Ricardo O. Rodriguez [4]. This paper is framed in the logical setting of AGM belief revision; it presents a new kind of operator that the authors call “moderate revision” and that allows to handle those revisions that are made under doubts, or uncertainty.
5. ‘Morpho-Logic from a Topos Perspective – Application to Symbolic AI’ by Marc Aiguier, Isabelle Bloch, Salim Nibouche and Ramón Pino Pérez [5]. The present contribution deals with a toposes-oriented view of modal logic; by that general perspective, the authors propose a new

¹See <https://lais.lakecomoschool.org/past-editions> for more details

way of defining modalities in propositional modal logic. The paper also applies the proposed approach to typical examples in symbolic AI and knowledge representation, namely belief revision, merging, abduction, and spatial reasoning.

6. ‘A probabilistic modal logic for context-aware trust based on evidence’ by Alessandro Aldini, Gianluca Curzi, Pierluigi Graziani, and Mirko Tagliaferri [6] introduces a logical setting to deal with the notion of *trust*. To this end the authors proposes an interpretation of a probabilistic modal language to capture a context-aware quantitative notion of trust based on evidence. The so arising logic is axiomatized and proved to be sound, complete and decidable.
7. ‘Reasoning about Knowledge and Conditional Probability’ by Šejla Dautović, Dragan Doder and Zoran Ognjanović [7]. The authors of this contribution present a proof-theoretical and model-theoretical approach to knowledge and uncertainty; precisely a logic that merges epistemic logic and a logic for conditional probabilities. The paper presents a propositional and a first-order version of the formalisms; both versions are proved to be sound and complete, and the propositional logic is also proved to be decidable.
8. ‘Spatial Unity for the Apperception Engine’ by Arie Soeteman and Michiel van Lambalgen [8]. The contribution presents a logical approach for computational agents to spatially explore their environment, extending on the Kant-inspired logical unification methods of the Apperception Engine.
9. ‘From Undecidability of Non-Triviality and Finiteness to Undecidability of Learnability’ by Matthias C. Caro [9]. The article presents a logical perspective on machine learning to address the issue of determining if it can be decide whether “learning si possible”. The authors presents an analysis for this general question and presents two possible meanings for the above question. Then, it is proved that in both these variants, the answer is generally negative.

The variety of themes and their cumulative breadth suggest that there is much which logic can contribute to help tackle many pressing issues in AI, even if they originate from the sub-symbolic track. This convinced us to run a second edition of the Logics for the New AI Spring school, to be held on 2-6 September 2024 ² which in addition to the history of

²<https://lais.lakecomoschool.org>

AI and its logical underpinnings, will devote particular attention to the neuro-symbolic integration. We will edit another IJAR special issue for that too and we invite warmly anyone who is interested in furthering or complementing the view emerging from the present special issue to submit their contributions, see <https://www.sciencedirect.com/journal/international-journal-of-approximate-reasoning/about/call-for-papers>

We would like to thank Thierry Denoeux, Editor-in-Chief of IJAR, for the opportunity and his support in preparing this Special Issue. We are also grateful to the reviewers, whose constructive comments helped the authors to substantially improve their papers. And of course our gratitude goes to the authors for their extremely interesting contributions.

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References

- [1] Thibault Gauthier, Miroslav Olšák and Josef Urban. Alien Coding.
- [2] Lydia Castronovo and Giuseppe Sanfilippo. A probabilistic analysis of selected notions of iterated conditioning under coherence. *International Journal of Approximate Reasoning*, 165: 109088, 2024.
- [3] Jordi Colla, Chu-Min Lib, Felip Manyà and Elifnaz Yangin. MaxSAT Resolution for Regular Propositional Logic. *International Journal of Approximate Reasoning*, 162: 109010, 2023.
- [4] Daniel Grimaldi, Maria Vanina Martinez and Ricardo O. Rodriguez. Moderated Revision. *International Journal of Approximate Reasoning*, 166: 109126, 2024.

- [5] Marc Aiguier, Isabelle Bloch, Salim Nibouche and Ramón Pino Pérez. Morpho-Logic from a Topos Perspective – Application to Symbolic AI. *International Journal of Approximate Reasoning*, 161: 109011, 2023.
- [6] Alessandro Aldini, Gianluca Curzi, Pierluigi Graziani, and Mirko Tagliaferri. A probabilistic modal logic for context-aware trust based on evidence. *International Journal of Approximate Reasoning*, 169: 109167, 2024.
- [7] Šejla Dautović, Dragan Doder and Zoran Ognjanović. Reasoning about Knowledge and Conditional Probability. *International Journal of Approximate Reasoning*, 163: 109037, 2023.
- [8] Arie Soeteman and Michiel van Lambalgen. Spatial Unity for the Apperception Engine. *International Journal of Approximate Reasoning*, 165: 109106, 2024.
- [9] Matthias C. Caro. From Undecidability of Non-Triviality and Finiteness to Undecidability of Learnability. *International Journal of Approximate Reasoning*, 163: 109057, 2023.