

Introduction to the 40th International Conference On Logic Programming Special Issue

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This issue contains the regular papers of the 40th International Conference on Logic Programming (ICLP), held in Dallas, Texas October 14–17, 2024 (ICLP 2024). Before describing the papers in this issue, it is worthwhile to note how remarkable it is that ICLP continues to be a top conference 42 years after the first in the series was held in Marseilles, France, in 1982. Forty conferences over 42 years evidences a long journey for any computation-related activity. In 1982, the first IBM PC was less than a year old but had started to revolutionize the impact of computers on everyday life. Prolog (ASP had not been invented yet) ran slowly on the hardware of the time, but the new field of Logic Programming looked toward the future.

Although several of the attendees of the first ICLP are still active today, the field of computing is vastly different than in 1982 and the papers in this issue reflect contemporary topics. We can roughly classify the contributions into the following categories:

Theoretical foundations

Presentation of research on theoretical foundations of logic programming has been a constant feature of the previous 39 editions of ICLP, and this year's conference was not different. Two invited talks concerned theory: Moshe Vardi's talk *Logic Programming and Logical Algorithmics* and Markus Hecher's talk *How Structure Shapes Logic Programming and Counting-Based Reasoning*. Semantics was also the focus of Annie Liu's invited tutorial *Commonsense in Uncertain Times: A Simple Unified Semantics for Reasoning with Assurance and Agreement*. Finally, a paper on algorithmic complexity won the Best Paper award for 2024.

- *On Lower Bounding Minimal Model Counting* by Mohimenu Kabir and Kuldeep S. Meel. (ICLP 2024 Best Paper Award)

Neuro-symbolic approaches

The remarkable success of large language models such as Chat-GPT, Gemini, and Llama, together with the success of neural models in computer vision and other areas is surely the most striking advance in computer science over the last several years. However, while neural models are excellent at recognizing and generating patterns, they are far from reliable when performing reasoning. One approach to addressing this deficit is to design architectures and algorithms that combine neural models with symbolic AI approaches such as logic programming. Katsumi Inoue's invited talk *Linear Algebraic Approaches to Logic Programming* discussed one aspect of supporting neuro-symbolic architectures. Several papers in this volume discuss other aspects, such as:

- *A Reliable Common-Sense Reasoning Socialbot Built Using LLMs and Goal-Directed ASP* by Yankai Zeng, Abhiramon Rajasekharan, Kinjal Basu, Huaduo Wang, Joaquín Arías, and Gopal Gupta.
- *Towards Probabilistic Inductive Logic Programming with Neuro-symbolic Inference and Relaxation* by Fieke Hillerström and Gertjan Burghouts.
- *A Neuro-symbolic Framework for Bias Correction in Convolutional Neural Networks* by Parth Padalkar, Natalia Slusarz, Gopal Gupta, and Ekaterina Komendantskaya.

Probabilistic reasoning and machine learning

The ability to probabilistically reason and to learn rules and probabilistic parameters are important constituents to neuro-symbolic approaches as well as other applications of logic programming. Several of the papers in this issue address these topics:

- *CON-FOLD Explainable Machine Learning with Confidence* by Lachlan McGinness and Peter Baumgartner. (ICLP 2024 Best Student Paper award)
- *Fast Inference for Probabilistic Answer Set Programs via the Residual Program* by Damiano Azzolini and Fabrizio Riguzzi.
- *Symbolic Parameter Learning in Probabilistic Answer Set Programming* by Damiano Azzolini, Elisabetta Gentili and Fabrizio Riguzzi.

Answer set programming (ASP)

Inspired by a translation of logic programs into autoepistemic logic, the stable model semantics was introduced back in 1988 and eventually gave rise to the ASP logic programming paradigm, an active area of research and the topic of many contributions to this issue. Some papers related to ASP comprise theoretical results:

- *Quantifying over Optimum Answer Sets* by Giuseppe Mazzotta, Francesco Ricca, and Mirek Truszczyński.

- *The Stable Model Semantics for Higher-Order Logic Programming* by Bart Bogaerts, Angelos Charalambidis, Giannos Chatziagapis, Babis Kostopoulos, Samuele Pollaci, and Panos Rondogiannis.

However, most of the ASP papers are focused on applications that rely on novel techniques and/or partnership with researchers in industry:

ASP applications

- *Dominating Set Reconfiguration with Answer Set Programming* by Masato Kato, Torsten Schaub, Takehide Soh, Naoyuki Tamura, and Mutsunori Banbara.
- *Winning Snake: Design Choices in Multi-Shot ASP* by Elisa Böhl, Stefan Ellmauthaler and Sarah Alice Gaggl.
- *Reasoning about Study Regulations in Answer Set Programming* by Susana Hahn, Cedric Martens, Amadé Nemes, Henry Otunuya, Javier Romero, Torsten Schaub, and Sebastian Schellhorn.
- *Automating Semantic Analysis of System Assurance Cases Using Logic Programming and Commonsense Reasoning* by Anitha Murugesan, Isaac Wong, Srivatsan Varadarajan, Joaquín Ariás, Gopal Gupta, Robert Stroud, Robin Bloomfield, John Rushby, and Elmer Salazar.
- *Optimising Dynamic Traffic Distribution for Urban Networks with Answer Set Programming* by Cardellini Matteo, Carmine Dodaro, Marco Maratea, and Mauro Vallati.
- *Early Validation of High-level System Requirements with Event Calculus and Answer Set Programming* by Ondřej Vašíček, Jan Fiedor, Bohuslav Krena, Tomas Vojnar, Joaquín Ariás, Gopal Gupta, Brendan Hall, Brian Larson, and Sarat Chandra Varanasi.

Prolog and constraint-based reasoning

Prolog was a central topic in the first ICLP, and Prolog-related topics such as constraint-based reasoning and program analysis continue to be areas of active research. This was reflected in ICLP 24 by Mats Carlsson's invited talk *The Anatomy of the SICStus Finite-Domain Constraint Solver* and by Neng-Fa Zhou's tutorial *Encoding High-Level Constraints into SAT and MIP*. Related papers in this issue include:

- *Abstract Environment Trimming* by Daniel Jurjo-Rivas, Jose F. Morales, Pedro Lopez-Garcia, and Manuel V. Hermenegildo.
- *The Semantics of Metaprogramming in Prolog* by David S. Warren.

Non-monotonic reasoning (NMR)

One of the surprising connections of logic programming to other Artificial Intelligence areas was the correspondence, unveiled by Nicole Bidoit and Christine Froidevaux in

1987, between logic programs with negation as failure and Reiter's Default Logic theories, one of the best-known non-monotonic formalisms. Nowadays, the connection between logic programming and NMR is well established; in fact, ICLP 2024 was co-located with the 17th *International Conference on Logic Programming and Non-Monotonic Reasoning* which focused on the overlap of both areas. Still, it is not uncommon for papers exploring the relation to NMR to be published in ICLP conferences. Two papers in this issue especially address this topic:

- *On the Foundations of Conflict-Driven Solving for Hybrid MKNF Knowledge Bases* by Riley Kinahan, Spencer Killen, Kevin Wan, and Jia-Huai You.
- *Cyclic Supports in Recursive Bipolar Argumentation Frameworks: Semantics and LP Mapping* by Gianvincenzo Alfano, Sergio Greco, Francesco Parisi, and Irina Trubitsyna.

Finally, we note that technical communications, Doctoral Consortium papers, and abstracts of all invited talks are available from *Proceedings of the 40th International Conference on Logic Programming*. In: Electronic Proceedings in Computer Science, 2024.

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