

# Lecture Notes in Artificial Intelligence

11481

Subseries of Lecture Notes in Computer Science

Series Editors

Randy Goebel

*University of Alberta, Edmonton, Canada*

Yuzuru Tanaka

*Hokkaido University, Sapporo, Japan*

Wolfgang Wahlster

*DFKI and Saarland University, Saarbrücken, Germany*

Founding Editor

Jörg Siekmann

*DFKI and Saarland University, Saarbrücken, Germany*


More information about this series at <http://www.springer.com/series/1244>

Marcello Balduccini · Yuliya Lierler ·  
Stefan Woltran (Eds.)


# Logic Programming and Nonmonotonic Reasoning

15th International Conference, LPNMR 2019  
Philadelphia, PA, USA, June 3–7, 2019  
Proceedings

*Editors*

Marcello Balduccini   
Saint Joseph's University  
Philadelphia, PA, USA

Yuliya Lierler   
University of Nebraska at Omaha  
Omaha, USA

Stefan Woltran   
TU Wien  
Vienna, Austria

ISSN 0302-9743                      ISSN 1611-3349 (electronic)  
Lecture Notes in Artificial Intelligence  
ISBN 978-3-030-20527-0              ISBN 978-3-030-20528-7 (eBook)  
<https://doi.org/10.1007/978-3-030-20528-7>

LNCS Sublibrary: SL7 – Artificial Intelligence

© Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Preface

This volume contains the papers presented at the 15th International Conference on Logic Programming and Nonmonotonic Reasoning (LPNMR 2019) held June 3–7, 2019, at Saint Joseph’s University in Philadelphia, USA. The conference was co-located with the Datalog 2.0 Workshop, the Workshop on Bidirectional Transformations, and the Workshop on Theory and Practice of Provenance at the Philadelphia Logic Week 2019.

LPNMR 2019 was the 15th in the series of international meetings on logic programming and non-monotonic reasoning. LPNMR is a forum for exchanging ideas on declarative logic programming, non-monotonic reasoning, and knowledge representation. The aim of the conference is to facilitate interactions between researchers and practitioners interested in the design and implementation of logic-based programming languages and database systems, and those working in knowledge representation and nonmonotonic reasoning. LPNMR strives to encompass theoretical and experimental studies that have led or will lead to advances in declarative programming and knowledge representation, as well as their use in practical applications. This year’s edition of the conference attempted to raise submissions discussing the use of LPNMR techniques in emerging applications stemming from such areas as deep learning, robotics, cybersecurity, modeling cyberphysical systems, and human-aware AI. LPNMR 2019 thus brought together researchers from LPNMR core areas and application areas of the aforementioned kind in order to share research experiences, promote collaboration, and identify directions for joint future research.

LPNMR received 45 submissions in three categories: technical papers, system descriptions, and application descriptions. Of these, 22 submissions were accepted as regular papers and three as short papers, yielding an acceptance rate of 55%. Each reviewed paper was examined by at least three experts and discussed amongst them, the Program Committee (PC) members, and the program chairs. This volume contains versions of these articles that have been revised by their authors according to the comments provided in the reviews. Two of the papers were selected for Springer Best Paper Awards: “Pruning External Minimality Checking for ASP Using Semantic Dependencies” by Thomas Eiter and Tobias Kaminski (Best Student Paper Award), and “Splitting Epistemic Logic Programs” by Pedro Cabalar, Jorge Fandinno and Luis Fariñas del Cerro (Best Paper Award).

In addition to the oral presentations of the technical papers, the scientific program featured invited talks by:

- Esra Erdem, Sabanci University, Turkey
- Michael Gelfond, Texas Tech University, USA
- V. S. Subrahmanian, Dartmouth College, USA

The program also included sessions dedicated to the Answer Set Programming Challenge and the Doctoral Consortium of the conference. The conference proceedings

contain abstracts for the invited talks and the Answer Set Programming Challenge. The main conference was preceded by several workshops offering an inspiring start to the event.

The LPNMR 2019 conference received generous support from several organizations. We gratefully acknowledge our sponsors, *Artificial Intelligence* journal, Association for Logic Programming (ALP), Haub School of Business at Saint Joseph's University, European Association for Artificial Intelligence (EurAI), National Science Foundation (NSF), and Potassco Solutions. We also would like to thank Springer for the longstanding, successful cooperation with the LPNMR series. The possibilities for fast-track journal publications in *Artificial Intelligence* and *Theory and Practice of Logic Programming*, as well as the best paper prize offered by Springer, brought additional value and motivation. The conference was managed with the help of EasyChair.

Many people played an important role in the success of LPNMR 2019 and deserve our acknowledgment: the PC members and additional reviewers for their timely expertise in carefully reviewing the submissions. The organizers of the Answer Set Programming Challenge, Carmine Dodaro, Christoph Redl, and Peter Schüller dedicated themselves to designing a sequel to the ASP Competition series in order to let LPNMR systems face novel and challenging real-world benchmarks. Fangkai Yang and Jörg Pührer organized an excellent Doctoral Consortium program, guiding young researchers to plan their research and careers. Mario Alviano's contribution was invaluable in coordinating the workshop program and Gregory Gelfond advertised the conference through a number of channels. We also wish to thank all authors who submitted papers and all the conference participants for fruitful discussions. Last but not least, special thanks go to the local organization team and, in particular, to Virginia Miori, Joseph DiAngelo, Lara Guerrini, Jeannine Shantz, Ruixin "Reese" Guo, Andrew Westveer, Elizabeth Angelucci, and Kelsey Neri, for their support and for being our hosts during the wonderful days at Saint Joseph's University.

June 2019

Marcello Balduccini  
Yuliya Lierler  
Stefan Woltran

# Organization

## Program Committee Chairs

Yuliya Lierler	University of Nebraska at Omaha, USA
Stefan Woltran	TU Wien, Austria

## General Chair

Marcello Balduccini	Saint Joseph's University, USA
---------------------	--------------------------------

## Workshops Chair

Mario Alviano	University of Calabria, Italy
---------------	-------------------------------

## Publicity Chair

Gregory Gelfond	University of Nebraska at Omaha, USA
-----------------	--------------------------------------

## Doctoral Consortium Chairs

Fangkai Yang	NVIDIA Corporation, USA
Jörg Pührer	TU Wien, Austria

## Marketing Chairs

Elizabeth Angelucci	Saint Joseph's University, USA
Kelsey Neri	Saint Joseph's University, USA

## Answer Set Programming Challenge 2019

Carmine Dodaro	University of Genoa, Italy
Christoph Redl	TU Wien, Austria
Peter Schüller	TU Wien, Austria

## Program Committee

Chitta Baral	Arizona State University, USA
Bart Bogaerts	Vrije Universiteit Brussel (VUB), Belgium
Martin Brain	University of Oxford, UK
Gerhard Brewka	Leipzig University, Germany
Pedro Cabalar	Corunna University, Spain
Francesco Calimeri	University of Calabria, Italy

Stefania Costantini	University of L'Aquila, Italy
Marina De Vos	University of Bath, UK
James Delgrande	Simon Fraser University, Canada
Agostino Dovier	Università degli Studi di Udine, Italy
Thomas Eiter	Vienna University of Technology, Austria
Esra Erdem	Sabanci University, Turkey
Wolfgang Faber	Alpen-Adria-Universität Klagenfurt, Austria
Johannes K. Fichte	TU Dresden, Germany
Paul Fodor	Stony Brook University, USA
Andrea Formisano	Università di Perugia, Italy
Gerhard Friedrich	Alpen-Adria-Universität Klagenfurt, Austria
Sarah Alice Gaggl	TU Dresden, Germany
Martin Gebser	Alpen-Adria-Universität Klagenfurt, Austria
Michael Gelfond	Texas Tech University, USA
Giovanni Grasso	Oxford University, UK
Amelia Harrison	The University of Texas at Austin, USA
Anthony Hunter	University College London, UK
Giovambattista Ianni	University of Calabria, Italy
Daniela Incezan	Miami University, USA
Tomi Janhunen	Aalto University, Finland
Gabriele Kern-Isberner	Technische Universität Dortmund, Germany
Matthias Knorr	Universidade Nova de Lisboa, Portugal
Joohyung Lee	Arizona State University, USA
Joao Leite	Universidade Nova de Lisboa, Portugal
Nicola Leone	University of Calabria, Italy
Vladimir Lifschitz	The University of Texas at Austin, USA
Fangzhen Lin	Hong Kong University of Science and Technology, SAR China
Marco Maratea	University of Genoa, Italy
Thomas Meyer	University of Cape Town, South Africa
Alessandra Mileo	Dublin City University, Ireland
Emilia Oikarinen	University of Helsinki, Finland
David Pearce	Universidad Politécnica de Madrid, Spain
Axel Polleres	Vienna University of Economics and Business, Austria
Enrico Pontelli	New Mexico State University, USA
Christoph Redl	Vienna University of Technology, Austria
Francesco Ricca	University of Calabria, Italy
Orkunt Sabuncu	TED University Ankara, Turkey
Chiaki Sakama	Wakayama University, Japan
Torsten Schaub	University of Potsdam, Germany
Peter Schüller	Vienna University of Technology, Austria
Guillermo R. Simari	Universidad del Sur in Bahia Blanca, Argentina
Mantas Simkus	Vienna University of Technology, Austria
Tran Cao Son	New Mexico State University, USA
Theresa Swift	Universidade Nova de Lisboa, Portugal
Eugenia Ternovska	Simon Fraser University, Canada



Daniele Theseider Dupré	Università del Piemonte Orientale, Italy
Matthias Thimm	Universität Koblenz-Landau, Germany
Hans Tompits	Vienna University of Technology, Austria
Mirek Truszczyński	University of Kentucky, USA
Agustín Valverde	Universidad de Málaga, Spain
Johannes P. Wallner	Vienna University of Technology, Austria
Kewen Wang	Griffith University, Australia
Yisong Wang	Guizhou University, China
Renata Wassermann	University of São Paulo, Brazil
Antonius Weinzierl	Vienna University of Technology, Austria
Jia-Huai You	University of Alberta, Canada
Yuanlin Zhang	Texas Tech University, USA
Yi Zhou	University of Technology Sydney, Australia

## Additional Reviewers

Weronika T. Adrian	Johannes Oetsch
Carmine Dodaro	Francesco Pacenza
Francesco Fabiano	Javier Romero
Jorge Fandinno	Lukas Schweizer
Markus Hecher	Fabio Tardivo
Man Luo	Zhun Yang
Philipp Obermeier	Jessica Zangari

## Sponsors and Collaborators

Artificial Intelligence Journal, Elsevier  
 Association for Logic Programming (ALP)  
 Haub School of Business, Saint Joseph's University  
 European Association for Artificial Intelligence (EurAI)  
 NSF - National Science Foundation  
 Potassco Solutions  
 Theory and Practice of Logic Programming, Cambridge University Press

# **Abstracts of Invited Contributions**

# Logic Programming and Non-monotonic Reasoning from 1991 to 2019: A Personal Perspective

Michael Gelfond

Texas Tech University, Lubbock, Texas, USA  
Michael.Gelfond@ttu.edu

**Abstract.** The field of logic programming and nonmonotonic reasoning was born in 1991, when a number of researchers working in “the theoretical ends” of logic programming and artificial intelligence gathered in Washington D.C. for the first LPNMR workshop, which was organized by Anil Nerode, Wiktor Marek, and V. S. Subrahmanian. I was privileged to attend this meeting; to closely observe the development of the field over the past 28 years; and to witness many remarkable achievements, which in 1991 I would not have believed to be possible. In this talk I plan to discuss some of these achievements and share a number of personal observations on the field’s history, current state, and possible future directions. Among other things, I will comment on the development of powerful knowledge representation languages, the design and implementation of non-monotonic reasoning systems, and use of these languages and systems in formalizing various types of knowledge and reasoning tasks. The talk is not meant to be a survey of the field, rather it is my personal perspective limited to a small, but important, collection of topics I am most familiar with.

# Integrating AI and Robotics Using Answer Set Programming

Esra Erdem

Faculty of Engineering and Natural Sciences, Sabanci University,  
Istanbul, Turkey  
esraerdem@sabanciuniv.edu

**Abstract.** Successful deployment of robotic assistants in social environments necessitates these systems to be furnished with high-level cognitive abilities, such as planning and diagnostic reasoning, to be able to deal with high complexity and wide variability of their surroundings, and perform typical everyday tasks robustly and without sacrificing safety. In the presence of humans, robotic agents need further abilities, such as commonsense reasoning, explanation generation, and epistemic reasoning, to be able to collaborate, communicate and live with humans. We have been investigating the use of Answer Set Programming to endow robotic agents with such cognitive capabilities, considering various robotic domains, such as service robotics, medical robotics, and cognitive factories. In this talk, we will share our experiences of using Answer Set Programming in robotics applications, and discuss its strengths and weaknesses as a knowledge representation and reasoning paradigm to integrate Artificial Intelligence and Robotics.

# Logic for Machine Learning Based Security

V. S. Subrahmanian

Dartmouth College, Hanover, New Hampshire, USA  
vs@dartmouth.edu

**Abstract.** The talk will cover 2 broad areas: (i) the role of logic in providing human-understandable explanations of forecasts produced by complex machine learning models, (ii) the use of logic based methods for reasoning about deception in cybersecurity. In the first part, I will describe BEEF, a framework that generates logic-based “balanced” explanations (which explain both why a forecast might be correct and why it might be incorrect). BEEF is capable of operating “on top” of any binary classifier. In the second part, I will describe logic-based methods to lead an attacker astray when he successfully penetrates a system by providing him fake results in response to scan requests. I will conclude with suggestions on how the LPNMR community may build upon these ideas.

# The ASP Challenge 2019

Carmine Dodaro<sup>1</sup>, Christoph Redl<sup>2</sup>, and Peter Schüller<sup>2</sup>

<sup>1</sup> Department of Informatics, Robotics and Systems Engineering (DIBRIS),  
University of Genova  
dodaro@dibris.unige.it

<sup>2</sup> Institut für Logic and Computation, Technische Universität Wien  
{redl,ps}@kr.tuwien.ac.at

The Answer Set Programming Challenge 2019 is run jointly among the Technische Universität Wien (Austria) and the University of Genoa (Italy), in Spring 2019. The event is the sequel to the ASP Competition series, which was held biannually since 2007. Unlike the previous ASP Competitions, the ASP Challenge 2019 focuses on challenging persons and teams rather than systems. To this end, five real problems from research and industry have been collected and are to be solved by researchers and students using arbitrary available systems, which do not necessarily have to be developed by the participants. Indeed, participants are encouraged to use any available system(s) and to combine ASP with other formalisms, as long as ASP or an extension thereof plays a crucial role. Submissions are expected to comprise the used systems and an encoding.

The challenge benefits the ASP community as challenging real-world research and industrial benchmarks become available, and it also benefits the problem providers as they get solutions to their problems.

Differently from previous editions, we host the challenge on the StarExec platform at <https://www.starexec.org/> with two aims: (i) attracting expert and non-expert participants, and (ii) providing timely feedback to solutions and permitting participants to adjust solutions instead of collecting encodings and solvers, running the competition offline, and publishing the results afterwards.

We use the following problem domains:

- The *House Reconfiguration Problem* is an abstract version of (re-)configuration problems occurring in practice. The task is, given a legacy configuration, to find an (optimal) reconfiguration satisfying various constraints.
- The industrial *Insurance Referees Assignment Problem* is a scheduling problem from the insurance domain, where referees are to be assigned to insurance cases according to various hard and soft constraints.
- The *Automated Warehouse Scenario* is a planning problem where robots have to deliver products to picking stations to fulfill orders.
- In the *Fastfood Problem*, given a set of restaurants, the task is to select a number of them as depots such that the sum of distances from each restaurant to the closest depot is minimized.

- The problem of *Checking Policies for Reactive Agents* comes from the planning domain. An agent in a grid environment has to find a goal, where the environment and obstacles are only partially observable.

For details we refer to <https://sites.google.com/view/aspcomp2019/>.

# Contents

## Applications

Train Scheduling with Hybrid ASP . . . . .	3
<i>Dirk Abels, Julian Jordi, Max Ostrowski, Torsten Schaub, Ambra Toletti, and Philipp Wanko</i>	
Telco Network Inventory Validation with NoHR. . . . .	18
<i>Vedran Kasalica, Ioannis Gerochristos, José Júlio Alferes, Ana Sofia Gomes, Matthias Knorr, and João Leite</i>	
An ASP-Based Framework for the Manipulation of Articulated Objects Using Dual-Arm Robots . . . . .	32
<i>Riccardo Bertolucci, Alessio Capitanelli, Carmine Dodaro, Nicola Leone, Marco Maratea, Fulvio Mastrogiovanni, and Mauro Vallati</i>	
C-ASP: Continuous ASP-Based Reasoning over RDF Streams . . . . .	45
<i>Thu-Le Pham, Muhammad Intizar Ali, and Alessandra Mileo</i>	
Internet Routing and Non-monotonic Reasoning . . . . .	51
<i>Anduo Wang and Zhijia Chen</i>	

## Argumentation

Assessing Arguments with Schemes and Fallacies . . . . .	61
<i>Pierre Bisquert, Florence Dupin de Saint-Cyr, and Philippe Besnard</i>	
Simple Contrapositive Assumption-Based Frameworks. . . . .	75
<i>Jesse Heyninck and Ofer Arieli</i>	
Argumentation-Based Explanations for Answer Sets Using ADF. . . . .	89
<i>Lena Rolf, Gabriele Kern-Isberner, and Gerhard Brewka</i>	

## Foundations and Complexity

Treewidth and Counting Projected Answer Sets . . . . .	105
<i>Johannes K. Fichte and Markus Hecher</i>	
Splitting Epistemic Logic Programs. . . . .	120
<i>Pedro Cabalar, Jorge Fandinno, and Luis Fariñas del Cerro</i>	



Founded World Views with Autoepistemic Equilibrium Logic . . . . .	134
<i>Pedro Cabalar, Jorge Fandinno, and Fariñas del Cerro Luis</i>	
Towards Dynamic Answer Set Programming over Finite Traces . . . . .	148
<i>Pedro Cabalar, Martín Diéguez, and Torsten Schaub</i>	
A Sequent-Type Calculus for Three-Valued Default Logic, Or: Tweety Meets Quantum Non Datur . . . . .	163
<i>Sopo Pkhakadze and Hans Tompits</i>	
<b>Knowledge Representation and Reasoning</b>	
Diagnosing Data Pipeline Failures Using Action Languages . . . . .	181
<i>Jori Bomanson and Alex Brik</i>	
Repair-Based Degrees of Database Inconsistency . . . . .	195
<i>Leopoldo Bertossi</i>	
Elect: An Inconsistency Handling Approach for Partially Preordered Lightweight Ontologies . . . . .	210
<i>Siheem Belabbes, Salem Benferhat, and Jan Chomicki</i>	
Elaboration Tolerant Representation of Markov Decision Process via Decision-Theoretic Extension of Probabilistic Action Language $p\mathcal{BC}+$ . . . . .	224
<i>Yi Wang and Joohyung Lee</i>	
<b>Systems</b>	
Evaluation of Disjunctive Programs in WASP . . . . .	241
<i>Mario Alviano, Giovanni Amendola, Carmine Dodaro, Nicola Leone, Marco Maratea, and Francesco Ricca</i>	
<i>telingo</i> = ASP + Time . . . . .	256
<i>Pedro Cabalar, Roland Kaminski, Philip Morkisch, and Torsten Schaub</i>	
Verifying Strong Equivalence of Programs in the Input Language of GRINGO . . .	270
<i>Vladimir Lifschitz, Patrick Lühne, and Torsten Schaub</i>	
The Return of <i>xorro</i> . . . . .	284
<i>Flavio Everardo, Tomi Janhunen, Roland Kaminski, and Torsten Schaub</i>	
Degrees of Laziness in Grounding: Effects of Lazy-Grounding Strategies on ASP Solving . . . . .	298
<i>Richard Taupe, Antonius Weinzierl, and Gerhard Friedrich</i>	

<b>Enhancing DLV for Large-Scale Reasoning . . . . .</b>	<b>312</b>
<i>Nicola Leone, Carlo Allocca, Mario Alviano, Francesco Calimeri, Cristina Civili, Roberta Costabile, Alessio Fiorentino, Davide Fuscà, Stefano Germano, Giovanni Labocetta, Bernardo Cuteri, Marco Manna, Simona Perri, Kristian Reale, Francesco Ricca, Pierfrancesco Veltri, and Jessica Zangari</i>	
<b>Pruning External Minimality Checking for ASP Using Semantic Dependencies . . . . .</b>	<b>326</b>
<i>Thomas Eiter and Tobias Kaminski</i>	
<b>Declarative Local Search for Predicate Logic . . . . .</b>	<b>340</b>
<i>Tu-San Pham, Jo Devriendt, and Patrick De Causmaecker</i>	
<b>Author Index . . . . .</b>	<b>347</b>