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Frontiers of Combining Systems

10th International Symposium, FroCoS 2015
Wroclaw, Poland, September 21–24, 2015
Proceedings

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ISSN 0302-9743

ISSN 1611-3349 (electronic)

Lecture Notes in Artificial Intelligence

ISBN 978-3-319-24245-3

ISBN 978-3-319-24246-0 (eBook)

DOI 10.1007/978-3-319-24246-0

Library of Congress Control Number: 2015948707

LNCS Sublibrary: SL7 – Artificial Intelligence

Springer Cham Heidelberg New York Dordrecht London

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Printed on acid-free paper

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(www.springer.com)

Preface

These proceedings contain the papers selected for presentation at the *10th International Symposium on Frontiers of Combining Systems*, FroCoS 2015, held during September 21-24, 2015 in conjunction with the *International Conference on Automated Reasoning with Analytic Tableaux and Related Methods*, Tableaux 2015, in Wrocław, Poland. Previous FroCoS meetings were organized in Munich (Germany, 1996), Amsterdam (The Netherlands, 1998), Nancy (France, 2000), Santa Margherita Ligure (Italy, 2002), Cork (Ireland, 2004, as part of the International Joint Conference on Automated Reasoning, IJCAR), Vienna (Austria, 2005), Seattle (USA, 2006, as part of IJCAR), Liverpool (UK, 2007, co-located with the International Workshop on First-Order Theorem Proving, FTP), Sidney (Australia, 2008, as part of IJCAR), Trento (Italy, 2009), Edinburgh (UK, 2010, as part of IJCAR), Saarbrücken (Germany, 2011), Manchester (UK, 2012, as part of IJCAR), Nancy (France, 2013, in conjunction with Tableaux), and Vienna (Austria, 2014, as part of IJCAR).

Like previous events in the FroCoS series, FroCoS 2015 offered a common forum for research in the general area of combination, modularization, and integration of systems, with an emphasis on logic-based ones, and on their practical use. The development of techniques and methods for the combination and integration of dedicated formal systems, as well as for their modularization and analysis, is crucial to the development of systems in logic, computation, program development and verification, artificial intelligence, knowledge representation, and automated reasoning.

FroCoS 2015 received 34 submissions, which were evaluated on the basis of their significance, novelty, technical quality, and appropriateness to the FroCoS audience. After intensive reviewing and electronic discussions, 20 papers were selected for presentation at the symposium. Their topics include description logics, theorem proving and model building, decision procedures as well as their combination and application to verification, rewriting and constraint solving, reasoning in large theories, and transformations between symbolic systems. The symposium program included three invited talks:

- Andreas Herzig (Université Paul Sabatier, Toulouse, France): “*Knowledge and Action: How Should We Combine Their Logics?*”
- Philipp Rümmer (Uppsala University, Sweden): “*Free Variables and Theories: Revisiting Rigid E-unification*”, and
- Thomas Sturm (Max-Planck-Institut für Informatik, Saarbrücken, Germany): “*From Complete Elimination Procedures to Subtropical Decisions over the Reals*”.

It also shared Tableaux 2015’s invited speaker, Oliver Ray, featured two shared sessions with Tableaux 2015, and the following tutorials:

- Till Mossakowski (University of Magdeburg, Germany): “The Distributed Ontology, Modeling, and Specification Language (DOL): Networks of Theories, Languages, and Logics”
- Cesare Tinelli (University of Iowa, USA): “A Taste of CVC4”
- Christoph Weidenbach (Max-Planck-Institut für Informatik, Saarbrücken, Germany): “Automated Reasoning Building Blocks.”

We would like to thank all the people who invested their time and energy to make this year’s symposium happen. In particular, we thank the authors for submitting their manuscripts and the attendees for contributing to the symposium discussion. We are also very grateful to the members of the Program Committee and to the external reviewers for carefully reviewing and discussing the submissions, and for their commitment to meet the strict deadlines.

We thank the people at Springer for their assistance with publishing these proceedings and for the generous financial support that allowed us to offer several student travel grants. Last but certainly not least, our thanks go to everybody who contributed to the organization of the event, most notably to Hans de Nivelle, General Chair of Tableaux 2015 and FroCoS 2015, for taking care of all the details of local organization.

September 2015

Carsten Lutz
Silvio Ranise

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Abstracts of Invited Talks

Knowledge and Action: How Should we Combine Their Logics?

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The design of logical systems accounting for both knowledge and action is an important issue in AI and MAS. While there are fairly well-established logics of knowledge—essentially the modal logics S5 and S4.2—, there is much less consensus about logical formalisms for actions: there exists a plethora of rather expressive formal systems, including situation calculus, event calculus, fluent calculus, and dynamic logic. When one combines these formal systems with epistemic logic then one typically supposes that knowledge and actions are related through the principles of perfect recall and no miracles. The resulting many-dimensional logics often have high complexity or are undecidable.

In this talk, building on previous work with several colleagues [6, 2, 4, 5] I will advocate a combination that is based on a simple, STRIPS-like account of action: a dialect of Propositional Dynamic Logic PDL whose atomic programs are assignments of propositional variables. Its epistemic extension generalises the notion of visibility of a propositional variable by an agent, as proposed by van der Hoek, Wooldridge and colleagues [9, 8]. The model checking, satisfiability and validity problems of the resulting logic are all PSPACE complete. The logic allows to capture in a natural way several concepts that were studied in the literature, including logics of propositional control [3, 7] and epistemic boolean games [1].

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Free Variables and Theories: Revisiting Rigid E -Unification*

Peter Backeman and Philipp Rümmer

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Abstract. The efficient integration of theory reasoning in first-order calculi with free variables (such as sequent calculi or tableaux) is a long-standing challenge. For the case of the theory of equality, an approach that has been extensively studied in the 90s is rigid E -unification, a variant of equational unification in which the assumption is made that every variable denotes exactly one term (rigid semantics). The fact that simultaneous rigid E -unification is undecidable, however, has hampered practical adoption of the method, and today there are few theorem provers that use rigid E -unification.

One solution is to consider incomplete algorithms for computing (simultaneous) rigid E -unifiers, which can still be sufficient to create sound and complete theorem provers for first-order logic with equality; such algorithms include rigid basic superposition proposed by Degtyarev and Voronkov, but also the much older subterm instantiation approach introduced by Kanger in 1963 (later also termed minus-normalisation). We introduce bounded rigid E -unification (BREU) as a new variant of E -unification corresponding to subterm instantiation. In contrast to general rigid E -unification, BREU is NP-complete for individual and simultaneous unification problems, and can be solved efficiently with the help of SAT; BREU can be combined with techniques like congruence closure for ground reasoning, and be used to construct theorem provers that are competitive with state-of-the-art tableau systems. We outline ongoing research how BREU can be generalised to other theories than equality.

* This work was partly supported by the Microsoft PhD Scholarship Programme and the Swedish Research Council.

From Complete Elimination Procedures to Subtropical Decisions over the Reals

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Effective quantifier elimination procedures for first-order theories provide a powerful tool for generically solving a wide range of problems based on logical specifications. In contrast to general first-order provers, quantifier elimination procedures are based on a fixed set of admissible logical symbols with an implicitly fixed semantics. This admits the use of sub-algorithms from symbolic computation. We focus here on quantifier elimination for the reals and its applications giving examples from geometry [1, 6], verification [9], and the sciences [10, 11]. Beyond quantifier elimination we are going to discuss recent results on an incomplete decision procedure for the existential fragment of the reals [8], which has been successfully applied to the analysis of reaction systems in chemistry and in the life sciences [2]. We conclude with an overview on further quantifier-eliminable theories [7, 12, 5, 4, 3] that have been realized in our open-source computer logic software Redlog (www.redlog.eu).

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