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Boris Konev · Giles Reger (Eds.)

Frontiers of Combining Systems

13th International Symposium, FroCoS 2021
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Proceedings

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Preface

These proceedings contain the papers selected for presentation at the 13th International Symposium on Frontiers of Combining Systems (FroCoS 2021). The symposium was held during September 8–10, 2021 in Birmingham, UK, at Birmingham University. It was co-located with the 30th International Conference on Automated Reasoning with Analytic Tableaux and Related Methods (TABLEAUX 2021).

FroCoS is the main international event for research on the development of techniques and methods for the combination and integration of formal systems, their modularization and analysis. 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), Sydney (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, co-located with TABLEAUX), Vienna (Austria, 2014, as part of IJCAR), Wrocław (Poland, 2015, co-located with TABLEAUX), Coimbra (Portugal, 2016, as part of IJCAR), Brasilia (Brazil, 2017, co-located with TABLEAUX), Oxford (UK, 2018, as part of IJCAR), London (UK 2019, co-located with TABLEAUX) and Paris (France 2020, as part of IJCAR).

FroCoS 2021 received 23 high-quality paper submissions, which were evaluated by the Program Committee on the basis of their significance, novelty, technical soundness, and appropriateness for the FroCoS audience. Reviewing was single-blind and each paper was subject to at least three reviews, followed by a discussion within the Program Committee. In the end, 16 papers were selected for presentation at the symposium and publication. We have grouped them in this volume according to the following topic classification: (1) calculi and unification, (2) description logics, (3) interactive theorem proving, (4) machine learning, (5) satisfiability modulo theories, and (6) verification.

We were delighted to have four outstanding invited speakers.

- Michael Benedikt, University of Oxford (joint with TABLEAUX 2021)
- Vijay Ganesh, University of Waterloo
- Chantal Keller, Université Paris-Sud
- Renate Schmidt, University of Manchester (joint with TABLEAUX 2021)

We would like to thank all the people who contributed to making FroCoS 2021 a success. In particular, we thank the invited speakers for their inspiring talks, the authors for providing their high-quality contributions, and the Program Committee members and the external reviewers for their careful, competent reviewing and discussion of the submissions on quite a tight schedule. We extend our thanks to the University of Birmingham for hosting FroCoS, especially to Anupam Das.

We gratefully acknowledge financial support from Springer and the University of Birmingham. Finally, we are grateful to EasyChair for allowing us to use their excellent conference management system.

September 2021

Boris Konev
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Abstracts of Invited Talk

The Strange Career of Interpolation and Definability

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Beth Definability, Craig Interpolation, and their variants have long been seen as an important topic in commputational logic, telling us something about logical simplification. But the rationale for their significance has varied over time, and it is not even clear whether they should be best seen as a property of a logic or of a proof system. In this talk I will look back at the somewhat twisty evolution of the topic, highlighting some issues that have been underexplored. I'll also present some current work (joint with Pierre Pradic) aimed at filling some of the gaps. No background on interpolation or definability will be assumed in the talk.

On the Unreasonable Effectiveness of SAT Solvers

Vijay Ganesh

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Over the last two decades, software engineering (broadly construed to include testing, analysis, synthesis, verification, and security) has witnessed a silent revolution in the form of Boolean SAT and SMT solvers. These solvers are now integral to many testing, analysis, synthesis, and verification approaches. This is largely due to a dramatic improvement in the scalability of these solvers vis-a-vis large real-world formulas. What is surprising is that the Boolean satisfiability problem is NP-complete, believed to be intractable, and yet these solvers easily solve industrial instances containing millions of variables and clauses in them. How can that be?

In my talk, I will address this question of why SAT solvers are so efficient through the lens of machine learning (ML) as well as ideas from (parameterized) proof complexity. While the focus of my talk is almost entirely empirical, I will show how we can leverage theoretical ideas to not only deepen our understanding but also to build better SAT solvers. I will argue that SAT solvers are best viewed as proof systems, composed of two kinds of sub-routines, ones that implement proof rules and others that are prediction engines that optimize some metric correlated with solver running time. These prediction engines can be built using ML techniques, whose aim is to structure solver proofs in an optimal way. Thus, two major paradigms of AI, namely machine learning and logical deduction, are brought together in a principled way in order to design efficient SAT solvers. A result of my research is the MapleSAT solver that has been the winner of several recent international SAT competitions and is widely used in industry and academia.

General Automation in Coq Through Modular Transformations and SMT Solving

Chantal Keller

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The subject of the SMTCoq project is to significantly enhance automation in the Coq proof assistant. At the heart of SMTCoq is a Coq plugin that offers a way to use automatic provers with the same degree of trust as Coq itself. On top of it, we define a framework called Sniper to progressively encode Coq's logic into first-order logic, through modular and fine-grained logical transformations that can be composed. Our objective is to obtain automatic while expressive tactics for Coq.

In this talk, I will concisely introduce the communication between Coq and external provers, before presenting the new framework of logical transformations. I will report on work in progress of examples of transformations in this framework.

This is a collaboration with Valentin Blot, Louise Dubois de Prisque, and Pierre Vial.e

Forgetting and Subontology Generation for the Medical Ontology SNOMED CT

Renate A. Schmidt

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In this talk I discuss efforts in developing systems to provide automated support for content extraction for the medical ontology SNOMED CT. SNOMED CT is a large knowledge base of standardised, precise definitions of clinical terms and medical codes for use in electronic health records to allow consistent data capture at the point of care and meaningful processing of data across health care sectors. Since SNOMED CT is so large, it has long been an aim to have the capability to compute smaller extracts of the ontology that are self-contained but restricted to a narrow focus, for example, kidney diseases, dentistry or vocabulary relevant for nursing. Such subontologies would make it easier to reuse and share content, to assist with new ontology creation, quality assurance, ontology update, and debugging. In addition, reasoning tasks such as querying and classification take less time to execute over a smaller extract than over the original ontology.

The aim of our research is to compute extracts that are semantically complete in that they faithfully capture the knowledge in an ontology about a user-specified focus signature. This is a challenging problem, because the knowledge of an ontology is not only given by the explicitly stated axioms in the ontology but also all implicit knowledge that can be inferred from these axioms. Forgetting creates a compact representation of the implicit knowledge of an ontology over specified focus concepts and relations by performing inferences on the non-focus (forgetting) signature. A number of PhD projects in our group have developed a series of forgetting tools and adaptations for use in applications such as logical difference computation and abduction in the context of description logic-based ontologies. These tools provided the basis for a series of industry projects in which we applied and further developed these for use cases of the medical ontology SNOMED CT. A workflow of different modularisation and forgetting methods was devised and thoroughly evaluated. With this workflow, we managed to significantly improve the performance and success rates of our tools and provide a feasible way to compute faithful extracts of SNOMED CT.

Building on these experiences, in a current joint project with SNOMED Intl., we have developed a new bespoke approach and prototype for computing subontologies of SNOMED CT. This approach is definition, driven and returns concise encodings of descriptions of the specified focus concepts in a normal form according to modelling guidelines of SNOMED Intl. These can be efficiently computed and are significantly smaller than both forgetting solutions and subontologies computed by modularisation methods.

The talk will give an overview of this research spanning several years, focussing on key ideas, findings, experiences, and practical challenges encountered.

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