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Nicolas Behr · Daniel Strüber (Eds.)

Graph Transformation

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Preface

This volume contains the proceedings of ICGT 2022, the 15th International Conference on Graph Transformation, held during July 7–8, 2022, in Nantes, France. ICGT 2022 was affiliated with STAF (Software Technologies: Applications and Foundations), a federation of leading conferences on software technologies. ICGT 2022 took place under the auspices of the European Association of Theoretical Computer Science (EATCS), the European Association of Software Science and Technology (EASST), and the IFIP Working Group 1.3, Foundations of Systems Specification.

The ICGT series aims at fostering exchange and the collaboration of researchers from different backgrounds working with graphs and graph transformation, either by contributing to their theoretical foundations or by applying established formalisms to classic or novel areas. The series not only serves as a well-established scientific publication outlet but also as a platform to boost inter- and intra-disciplinary research and to stimulate for new ideas. The use of graphs and graph-like structures as a formalism for specification and modeling is widespread in all areas of computer science as well as in many fields of computational research and engineering. Relevant examples include software architectures, pointer structures, state-space and control/data flow graphs, UML and other domain-specific models, network layouts, topologies of cyber-physical environments, quantum computing, and molecular structures. Often, these graphs undergo dynamic change, ranging from reconfiguration and evolution to various kinds of behavior, all of which may be captured by rule-based graph manipulation. Thus, graphs and graph transformation form a fundamental universal modeling paradigm that serves as a means for formal reasoning and analysis, ranging from the verification of certain properties of interest to the discovery of fundamentally new insights.

ICGT 2022 continued the series of conferences previously held in Barcelona (Spain) in 2002, Rome (Italy) in 2004, Natal (Brazil) in 2006, Leicester (UK) in 2008, Enschede (The Netherlands) in 2010, Bremen (Germany) in 2012, York (UK) in 2014, L'Aquila (Italy) in 2015, Vienna (Austria) in 2016, Marburg (Germany) in 2017, Toulouse (France) in 2018, Eindhoven (The Netherlands) in 2019, and online in 2020 and 2021, following a series of six International Workshops on Graph Grammars and Their Application to Computer Science from 1978 to 1998 in Europe and in the USA.

This year, the conference solicited research papers describing new unpublished contributions in the theory and applications of graph transformation as well as tool presentation papers that demonstrate main new features and functionalities of graph-based tools. All papers were reviewed thoroughly by at least three Program Committee members and additional reviewers. We received 19 submissions, and the Program Committee selected 10 research papers and one tool presentation paper for publication in these proceedings, after careful reviewing and extensive discussions. The topics of the accepted papers cover a wide spectrum, including theoretical approaches to graph transformation, logic and verification for graph transformation, and model transformation, as well as the application of graph transformation in some areas. In addition to these paper presentations, we were delighted to host an invited talk by Christian Doczkal (Max Planck Institute for Security and Privacy, Bochum, Germany).

A special focus of ICGT 2022 consisted of new approaches to formalizing the knowledge in the research field of graph transformation theory via proof assistants such as Coq. A long-term goal of this kind of approach consists of establishing a Coq-enriched wiki for this research field akin to the nLab. This platform will serve as a sustainable mechanism for curating applied and mathematical knowledge in graph transformation research, and eventually as a research tool in its own right, notably through the provision of interactive database-supported proof construction. Another avenue of research concerns executable applied category theory (ExACT), i.e., code extraction from formalized categorical structures, with the perspective of curating a database of correct-by-construction reference prototype algorithms for various forms of graph transformation semantics and graph-like data structures. To introduce the initiative, facilitate the broad involvement of the ICGT community, and collect feedback from participants regarding the scope and format of such a wiki project, a peer-reviewed brainstorming session was conducted as one of the events at the conference. Results of this session as well as further information on this initiative are available via the GReTA ExACT working group website (https://www.irif.fr/%7Egreta/gretaexact/).

We would like to thank all who contributed to the success of ICGT 2022, the invited speaker Christian Doczkal, the authors of all submitted papers, and the members of the Program Committee, as well as the additional reviewers, for their valuable contributions to the selection process. We are grateful to Reiko Heckel, the chair of the Steering Committee of ICGT, for his valuable suggestions; to Massimo Tisi and Gerson Sunye, the general chair and the local chair, respectively, of STAF 2022; and to the STAF federation of conferences for hosting ICGT 2022. We would also like to thank EasyChair for providing support for the review process.

May 2022

Nicolas Behr
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Graph Theory in Coq: Axiomatizing Isomorphism of Treewidth-Two Graphs (Abstract of Invited Talk)

Christian Doczkal

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Despite the importance of graph theory in mathematics and computer science, there are relatively few machine-checked proofs of graph theory results and even fewer general purpose libraries. After the formalization of some basic concepts in HOL [1] and a formalization of Euler's theorem in Mizar [12] during the 90s, the 2000s saw several results on planar graphs: Gonthier's celebrated formal proof of the four-color theorem [9] in Coq, the formalization of tame graphs as part of the Flyspeck project [13] in Isabelle/HOL, and a study on Delaunay triangulations [8] by Dufourd and Bertot. More recently, Noschinski developed a library for both simple and multigraphs in Isabelle/HOL [14].

Over the past couple of years, Damien Pous and I have developed a graph theory library[1,2] for the interactive theorem prover Coq[3] based on the Mathematical Components Library[4].

The initial goal was to formalize soundness and completeness of a finite axiomatization of isomorphism for the class of labeled treewidth-two multigraphs [10], a new result answering positively – for this particular class of graphs – a question posed by Courcelle [2, p. 118]. Since none of the available libraries suited our needs, we started to develop a new graph theory library [3, 6, 7]. Since then, there has been some renewed interest in the formalization of graph theory, both in Coq [15, 16] and in other systems [11].

The development of our library and the aforementioned axiomatizability result that guided the development process highlight the fruitful interplay between the development of pen-and-paper proofs and the development of machine-checked mathematical libraries. While the initial design of the library allowed us to formally verify [4] parts of the original proofs, formalizing the full proof seemed out of reach. This prompted us to develop a new pen-and-paper proof [5] that was significantly simpler and written with formalization in mind. In addition, we revised and extended the library [7], allowing us to overcome those difficulties that could not be sidestepped using the new proof. This allowed us to finally verify [6] the completeness result we initially set out to prove.

Despite the use of a graph rewrite system, the completeness proof and its formalization in Coq are elementary in the sense that we do not employ results from graph transformation theory. This is due, at least in part, to us not being familiar with these

[1] https://coq-community.org/graph-theory/.

[2] With contributions from Daniel Severín, Guillaume Combette and Guillaume Ambal.

[3] https://coq.inria.fr.

[4] https://math-comp.github.io.

techniques and there not being any preexisting graph transformation libraries, in particular none that would interface well with the Mathematical Components library. Further, our simple 4-rule rewrite system could still be reasoned about directly, However, for reasoning about more complex graph rewrite systems, using a more abstract approach appears necessary.

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