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Coalgebraic Methods in Computer Science

16th IFIP WG 1.3 International Workshop, CMCS 2022
Colocated with ETAPS 2022
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Proceedings

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Preface

The 16th International Workshop on Coalgebraic Methods in Computer Science (CMCS 2022) was held during April 2–3, 2022, in Munich, Germany, as a satellite event of the Joint Conference on Theory and Practice of Software, ETAPS 2022.

The aim of the workshop is to bring together researchers with a common interest in the theory of coalgebras, their logics, and their applications. Coalgebras allow for a uniform treatment of a large variety of state-based dynamical systems, such as transition systems, automata (including weighted and probabilistic variants), Markov chains, and game-based systems. Over the last two decades, coalgebra has developed into a field of its own, presenting a deep mathematical foundation, a growing field of applications, and interactions with various other fields such as reactive and interactive system theory, object-oriented and concurrent programming, formal system specification, modal and description logics, artificial intelligence, dynamical systems, control systems, category theory, algebra, analysis, etc.

Previous workshops have been organized in Lisbon (1998), Amsterdam (1999), Berlin (2000), Genoa (2001), Grenoble (2002) Warsaw (2003), Barcelona (2004), Vienna (2006), Budapest (2008), Paphos (2010), London (2012), Grenoble (2014), Eindhoven (2016), Thessaloniki (2018), and Dublin (2020, held online because of the COVID-19 pandemic). Since 2004, CMCS has been a biennial workshop, alternating with the International Conference on Algebra and Coalgebra in Computer Science (CALCO), which, in odd-numbered years, has been formed by the union of CMCS with the International Workshop on Algebraic Development Techniques (WADT).

The CMCS 2022 program featured a keynote talk by Ana Sokolova (University of Salzburg), an invited talk by Renato Neves (University of Minho), and an invited talk by Sam Staton (University of Oxford). In addition, the program included a special session on data languages featuring invited tutorials by Sławomir Lasota (University of Warsaw) and Mahsa Shirmohammadi (CNRS, University of Paris).

This volume contains the revised regular contributions (9 papers accepted out of 12 submissions) and the abstracts of the three keynote/invited talks and the two invited tutorial talks.

In addition to submissions of full-length regular papers for these post-proceedings, the workshop also solicited short 2-page submissions for presentation of work-in-progress or work published elsewhere that could be of interest to the CMCS community. Submissions and the reviewing process were handled using Easychair. The reviewing of both types of submissions was carried out single-blind, in which each regular submission received three extensive reviews, and each short submission received two short reviews that focused on relevance. PC members had 4 weeks for the reviewing and discussion of one regular and three short submissions, or two regular and zero to one short submissions. We intentionally chose a large PC to keep the review load light, in order to keep up the high quality of reviewing that has been the standard at CMCS. PC members, including PC chairs, were allowed to submit in both categories. To safeguard the integrity of the reviewing process, PC members had to declare conflict with a submission if they were

a co-author, share an affiliation or recent collaboration with one of the co-authors, or if it could be otherwise perceived that the PC member would have a bias towards the decision on the submission. Using an Easychair functionality, PC members were blocked from seeing the reviews and the discussion on submissions for which they had declared a conflict. In particular, one regular submission was co-authored by one of the PC co-chairs, Helle Hvid Hansen, who therefore declared a conflict with this submission, and the discussion and decision on this submission was handled by the other PC co-chair, Fabio Zanasi.

We wish to thank all the authors who submitted to CMCS 2022, and the Program Committee members and external reviewers for their thorough reviewing and help in improving the papers that were accepted for CMCS 2022.

May 2022

Helle Hvid Hansen
Fabio Zanasi

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Abstracts of Invited Talks

Tracing Coalgebras: A Case for Monads

Ana Sokolova

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Trace semantics, also known as linear-time semantics, is the essential semantics of systems, programs, objects, seen as black boxes with some observable behaviour. Unlike its branching-time, step-wise sisters, trace semantics provides the whole observable behaviour of a system. Trace semantics is hard to compute and originally seemed difficult to study coalgebraically. This talk will provide an overview of coalgebraic approaches to trace semantics, over the last fifteen years, focusing on transition systems and automata with effects. Monads play a crucial role in the study of traces, which I will highlight in all approaches using a class of examples. I will also mention some of the context of this exciting line of work that in my view enabled and supported the coalgebraic trace theories.

Coalgebra Meets Hybrid Systems

Renato Neves

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A main challenge of the 21st century is to engineer software systems that tightly interact with physical processes such as velocity, movement, energy, and time. Such systems are qualified as 'hybrid' to emphasise this cyber-physical interaction—which remarkably forces a shift from standard software practices to a more multifaceted view that combines computer science, control theory, and analysis.

In this talk, I will discuss how Coalgebra can help advance hybrid systems theory. In particular, I will describe previous applications of Coalgebra to tackle two central problems in the field: the lack of a uniform framework for hybrid automata (currently, the standard formalism for hybrid systems) and the lack of suitable semantics for interpreting hybrid while-loops. As alluded above, we will see that hybrid systems deviate from standard notions of computer science in many aspects. For example, whilst classical while-loops give rise to a single divergence point, hybrid while-loops give rise to a whole continuum of divergence points. Nonetheless, we will see that Coalgebra can still properly guide us in providing a semantics for the latter kind of loop.

I will conclude with a brief mention of other significant challenges in the field of hybrid systems and possible uses of Coalgebra to tackle them.

Coalgebraic Methods in Probability

Sam Staton

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I will discuss some of the roles that coalgebra can play in probability theory and statistics. Infinite dimensional systems are often described as generative models, and these are often like coalgebras, as I will explain. I will look at some recent statistical models that involve symmetries, such as the "Chinese Restaurant process" and "Indian Buffet process". Since these use names implicitly, I will connect this to nominal techniques. I will also discuss our probabilistic programming library "lazyppl", which uses coinductive structures extensively. I will not assume much familiarity with probability, statistics, nominal techniques, or probabilistic programming.

The talk will draw on joint work with Ackerman, Dash, Freer, Jacobs, Kaddar, Paquet, Roy, Sabok, Stein, Wolman, Yang, and others.

Some Recent Advances in Register Automata

Sławomir Lasota

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I shall recall the model of register automata (RA), and relate it to the setting of orbit-finite automata. Then I will mention two recent advances concerning language expressivity of different types of RA, together with remaining open problems.

First, two complementing languages of nondeterministic RA are recognized by a deterministic RA. For two such languages which are disjoint but not necessarily complementing, one may ask if there is a deterministic (resp. unambiguous) RA whose language separates the two. It is not known if existence of a deterministic separator is decidable, and it is not known if (but conjectured that) an unambiguous separator always exists.

The second advance considers orbit-finite rational expressions (with orbit-finite unions in place of finite ones). While languages of nondeterministic RA are not definable by such rational expressions, their Parikh (commutative) images are conjectured to be so. This has been recently confirmed for automata (and grammars) with 1 register, but is still open in case of 2 registers.

Learning Weighted Automata over Fields and Principal Ideal Domains

Mahsa Shirmohammadi

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In this talk, I will discuss learning algorithms for weighted automata over principal ideal domains (PIDs). An example is $\mathbb{Z}$-automata which can be seen as register automata with affine integer updates over integers. I start with discussing properties of the Hankel matrix of a weighted automaton. Then I reiterate briefly the idea behind learning weighted automata over fields. For automata over PIDs, I recall an existing algorithm (Heerdt et al., FoSSaCS 2020) for exact learning that has no complexity bounds (but only termination). I will recall a classical result of Fatou, and, inspired by its proof, draft a simpler learning algorithm for learning weighted automata over PIDs. I also briefly talk about learning algorithms for polynomial automata. I will conclude with mentioning that the automata I talk about can be seen as coalgebras. It will be interesting to see whether the learning algorithms can be simulated by general coalgebraic learning approaches.

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