

Relational and Algebraic Methods in Computer Science

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This special issue showcases the variety and relevance of recent developments in the field of relational and algebraic methods in computer science, from foundations to applications. We invited submissions through an open call. Topics were set to include the theory of semigroups, lattices, semirings, Kleene algebras, relation algebras or quantales, as relevant, for instance, to automata, concurrency, formal languages, games, networks or programming languages. Intended application domains include program verification and correctness, quantitative and qualitative models and semantics for computing systems, the design of algorithms, network protocol analysis, social choice, optimisation and control. Typical benefits of algebraic approaches lie in the compositionality imposed by algebraic operations, the conceptual abstraction and unification they allow in computational modelling and the formal rigour and simplicity of algebraic reasoning. Prominent examples include uses of semigroups and coalgebras in automata theory, those of categories, lattices and Kleene algebras in the semantics and analysis of programs, or those of dioids in optimisation and control.

Algebraic methods belong not only to the core of JLAMP; they are also promoted, with additional emphasis on relations, by the RAMiCS conference series. The sixteenth RAMiCS event, which took place at ENS Lyon in May 2017, was in fact our initial state for organising this special issue. After a thorough and extensive reviewing process that involved at least two reviewers for each article, we are now pleased to have reached an accept state after selecting nine articles out of thirteen initial submissions for publication. We believe that these contributions nicely demonstrate the persisting significance and diversity of this field.

- Marcel Jackson and Szabolcs Mikulás' article on *Domain and Range for Angelic and Demonic Compositions* presents finite axiomatisations of the varieties generated by domain-range algebras, representable as binary relations, and with operations of join, angelic composition and demonic composition. This result stands in a long line of research in semigroup and category theory, which has been well represented within the RAMiCS community.
- Applications of semirings and idempotent mathematics are also the topic of Nikolai Krivulin's article on the *Complete Algebraic Solution of Multidimensional Optimization Problems in Tropical Semifield*. The main results characterise the solution sets for such problems in terms of vector inequalities and provide an algorithm for computing these solutions.
- Very similar algebras, namely modal semirings, are applied by Bernhard Möller to the field of time geography in his work on *Geographic Wayfinders and Space-Time Algebras*. Main contributions lie in abstract algebraic concepts describing how wayfinders can navigate through regions of time in the presence of obstacles.
- Luigi Santocanale shows that *Embeddability into Relational Lattices is Undecidable*. Relational lattices offer a lattice-theoretic alternative to the relational algebras that are traditionally used as query languages for databases. This result has important consequences, including undecidability results for the quasiequational theory of certain relational lattices.
- Relation algebras and Kleene algebras feature prominently in Walter Guttmann's article on *Verifying Minimum Spanning Tree Algorithms with Stone Relation Algebras*, which develops a hierarchy of algebraic methods for verifying Kruskal's algorithm for minimal spanning forests with the Isabelle/HOL proof assistant, after Prim's algorithm has been verified previously with very similar methods.

- Stef Joosten proposes *Relation Algebra as Programming Language using the Ampersand Compiler* and explores its use in a data base application for legal reasoning, in particular argument assistance. Ampersand is an open source requirement specification language for information systems and business processes based on a relational semantics.
- Ampersand is also a starting point for Sebastiaan Joosten’s work on *Finding Models Through Graph Saturation*. He provides a semi-decision procedure for the entailment between sentences in a certain relational language interpreted over graphs, and an undecidability result related to the existence of a graph which is a model for a set of such sentences.
- Inspired by Arbib and Manes’ categorical approach to automata, the article *A (co)algebraic theory of succinct acceptors* by Gerco van Heerdt, Joshua Moerman, Matteo Sammartino and Alexandra Silva studies the reverse question to the determinisation of automata: namely the construction of succinct non-deterministic automata from deterministic ones. Their solution is based on coalgebraic techniques, and illustrated by a series of examples that includes alternating and weighted automata.
- A new algebraic approach to modelling quantitative information flow in the security analysis of programs is presented in Annabelle McIver, Carroll Morgan and Tahiry Rabehaja’s article on an *Algebra for Quantitative Information Flow*. It uses Lawvere and Giry’s monadic framework for probabilistic computation and hidden Markov models to develop a refinement calculus and a compositional transformer semantics for systems in which programs can leak information about their correlated environments.

Annabelle McIver and Alexandra Silva were also invited speakers at RAMiCS 2017. We are particularly grateful that they have submitted extended versions of their presentations to this special issue, yet of course equally indebted to all authors for their submissions and their collaboration during the evaluation process. We wish to thank all referees for their hard work and dedication, without which this volume would not have come together. We are most grateful to Rocco De Nicola and Alberto Lluch Lafuente for supporting yet another special issue on relational and algebraic methods—the eighth so far. Last, but not least, we thank Winky Huang for his support regarding the Elsevier system and organisational matters.