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Mathematical Foundations of Computer Science 2015

40th International Symposium, MFCS 2015
Milan, Italy, August 24–28, 2015
Proceedings, Part I

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Preface

The series of MFCS symposia has a long and well-established tradition of encouraging high-quality research into all branches of theoretical computer science. Its broad scope provides an opportunity to bring together researchers who do not usually meet at specialized conferences. The first symposium was held in 1972. Until 2012 MFCS symposia were organized on a rotating basis in Poland, the Czech Republic, and Slovakia. The 2013 edition took place in Austria, the 2014 edition in Hungary, while in 2015 MFCS was organized for the first time in Italy.

The 40th International Symposium on Mathematical Foundations of Computer Science (MFCS 2015) was held in Milan during August 24–28, 2015. The scientific program of the symposium consisted of five invited talks and 81 contributed papers.

To celebrate the 40th edition of the conference, a special invited talk was given by:

- Zoltán Ésik (University of Szeged, Hungary)

This talk was sponsored by the European Association of Theoretical Computer Science (EATCS). The other invited talks were given by:

- Anindya Banerjee (IMDEA Software Institute, Spain)
- Paolo Boldi (University of Milan, Italy)
- Martin Kutrib (University of Giessen, Germany)
- Yishay Mansour (Microsoft Research, Hertzelia and Tel Aviv University)

We are grateful to all invited speakers for accepting our invitation and for their excellent presentations at the symposium.

The 81 contributed papers were selected by the Program Committee (PC) out of a total of 201 submissions. All submitted papers were peer reviewed and evaluated on the basis of originality, quality, significance, and presentation. To support the selection process, approximately 600 reviews were written by PC members with the help of external experts.

As is the MFCS tradition, a Best Paper Award and a Best Student Paper Award sponsored by EATCS were assigned. The PC decided to assign these awards to the following papers:

- “Strong Inapproximability of the Shortest Reset Word” by Paweł Gawrychowski and Damian Straszak (Best Paper Award)
- “Maximum Minimal Vertex Cover Parameterized by Vertex Cover” by Meirav Zehavi (Best Student Paper Award)

We thank all authors who submitted their work for consideration to MFCS 2015. We wish to thank all PC members and external reviewers for their competent and timely handling of the submissions. The success of the scientific program is due to their hard work. During the selection process and for preparing these proceedings, we used the EasyChair conference management system, which provided excellent support.

Owing to the large number of accepted papers, the proceedings of the conference were divided into two volumes on a thematic basis: *Logic, Semantics, Automata and Theory of Programming* (Vol. I) and *Algorithms, Complexity and Games* (Vol. II).

We gratefully acknowledge the support of the University of Milan (Università degli Studi di Milano, Dipartimento di Informatica) and EATCS. Special thanks for the local organization are due to Violetta Lonati (University of Milan). We also thank Bruno Guillon (University Paris-Diderot, France) for the website design and maintenance.

June 2015

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Invited Contributions

Modular Reasoning for Behavior-Preserving Data Structure Refactorings

Anindya Banerjee

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Abstract. A properly encapsulated data structure can be revised for refactoring without affecting the behaviors of clients of the data structure. Encapsulation ensures that clients are representation independent, that is, their behaviors are independent of particular choices of data structure representations. Modular reasoning about data structure revisions in heap-manipulating programs, however, is a challenge because encapsulation in the presence of shared mutable objects is difficult to ensure for a variety of reasons.

- Pointer aliasing can break encapsulation and invalidate data structure invariants.
- Representation independence is nontrivial to guarantee in a generic manner, without recourse to specialized disciplines such as ownership.
- Mechanical verification of representation independence using theorem provers is nontrivial because it requires relational reasoning between two different data structure representations. Such reasoning lies outside the scope of most modern verification tools.

We address the challenge by reasoning in Region Logic [1, 2], a Hoare logic augmented with state dependent “modifies” specifications based on simple notations for object sets, termed “regions”. Region Logic uses ordinary first order logic assertions to support local reasoning and also the hiding of invariants on encapsulated state, in ways suited to verification using SMT solvers. By using relational assertions, the logic can reason about behavior-preservation of data structure refactorings even in settings where full functional pre/post specifications are absent. The key ingredient behind such reasoning is a new proof rule that embodies representation independence.

This work is in collaboration with David A. Naumann and Mohammad Nikouei (Stevens Institute of Technology).

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Minimal and Monotone Minimal Perfect Hash Functions

Paolo Boldi

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Abstract. A minimal perfect hash function (MPHF) is a (data structure providing a) bijective map from a set S of n keys to the set of the first n natural numbers. In the static case (i.e., when the set S is known in advance), there is a wide spectrum of solutions available, offering different trade-offs in terms of construction time, access time and size of the data structure. MPHFs have been shown to be useful to compress data in several data management tasks. In particular, *order-preserving* minimal perfect hash functions have been used to retrieve the position of a key in a given list of keys: however, the ability to preserve any given order leads to an unavoidable $\Omega(n \log n)$ lower bound on the number of bits required to store the function. Recently, it was observed that very frequently the keys to be hashed are sorted in their intrinsic (i.e., lexicographical) order. This is typically the case of dictionaries of search engines, list of URLs of web graphs, etc. MPHFs that preserve the intrinsic order of the keys are called *monotone* (MMPHF). The problem of building MMPHFs is more recent and less studied (for example, no lower bounds are known) but once more there is a wide spectrum of solutions available, by now. In this paper, we survey some of the most practical techniques and tools for the construction of MPHFs and MMPHFs.

Equational Properties of Fixed Point Operations in Cartesian Categories: An Overview

Zoltán Ésik

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Abstract. Several fixed point models share the equational properties of iteration theories, or iteration categories, which are cartesian categories equipped with a fixed point or dagger operation subject to certain axioms. After discussing some of the basic models, we provide equational bases for iteration categories and offer an analysis of the axioms. Although iteration categories have no finite base for their identities, there exist finitely based implicational theories that capture their equational theory. We exhibit several such systems. Then we enrich iteration categories with an additive structure and exhibit interesting cases where the interaction between the iteration category structure and the additive structure can be captured by a finite number of identities. This includes the iteration category of monotonic or continuous functions over complete lattices equipped with the least fixed point operation and the binary supremum operation as addition, the categories of simulation, bisimulation, or language equivalence classes of processes, context-free languages, and others. Finally, we exhibit a finite equational system involving residuals, which is sound and complete for monotonic or continuous functions over complete lattices in the sense that it proves all of their identities involving the operations and constants of cartesian categories, the least fixed point operation and binary supremum, but not involving residuals.

Reversible and Irreversible Computations of Deterministic Finite-State Devices

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Abstract. Finite-state devices with a read-only input tape that may be equipped with further resources as queues or pushdown stores are considered towards their ability to perform reversible computations. Some aspects of the notion of logical reversibility are addressed. We present some selected results on the decidability, uniqueness, and size of minimal reversible deterministic finite automata. The relations and properties of reversible automata that are equipped with storages are discussed, where we exemplarily stick with the storage types queue and pushdown store. In particular, the computational capacities, decidability problems, and closure properties are the main topics covered, and we draw attention to the overall picture and some of the main ideas involved.

Robust Inference and Local Algorithms

Yishay Mansour

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Abstract. We introduce a new feature to inference and learning which we call *robustness*. By robustness we intuitively model the case that the observation of the learner might be corrupted. We survey a new and novel approach to model such possible corruption as a zero-sum game between an adversary that selects the corruption and a learner that predict the correct label. The corruption of the observations is done in a worse-case setting, by an adversary, where the main restriction is that the adversary is limited to use one of a fixed know class of modification functions. The main focus in this line of research is on *efficient* algorithms both for the inference setting and for the learning setting. In order to be efficient in the dimension of the domain, one cannot hope to inspect all the possible inputs. For this, we have to invoke local computation algorithms, that inspect only a logarithmic fraction of the domain per query.

Contents – Part I

Invited Contributions

Minimal and Monotone Minimal Perfect Hash Functions	3
<i>Paolo Boldi</i>	
Equational Properties of Fixed Point Operations in Cartesian Categories: An Overview	18
<i>Zoltán Ésik</i>	
Reversible and Irreversible Computations of Deterministic Finite-State Devices	38
<i>Martin Kutrib</i>	
Robust Inference and Local Algorithms	53
<i>Yishay Mansour</i>	

Logic, Semantics, Automata and Theory of Programming

Uniform Generation in Trace Monoids.	63
<i>Samy Abbes and Jean Mairesse</i>	
When Are Prime Formulae Characteristic?	76
<i>L. Aceto, D. Della Monica, I. Fábregas, and A. Ingólfssdóttir</i>	
Stochastization of Weighted Automata	89
<i>Guy Avni and Orna Kupferman</i>	
Algebraic Synchronization Criterion and Computing Reset Words.	103
<i>Mikhail Berlinkov and Marek Szykula</i>	
Recurrence Function on Sturmian Words: A Probabilistic Study	116
<i>Valérie Berthé, Eda Cesaratto, Pablo Rotondo, Brigitte Vallée, and Alfredo Viola</i>	
Exponential-Size Model Property for PDL with Separating Parallel Composition.	129
<i>Joseph Boudou</i>	
A Circuit Complexity Approach to Transductions	141
<i>Michaël Cadilhac, Andreas Krebs, Michael Ludwig, and Charles Paperman</i>	

Locally Chain-Parsable Languages	154
<i>Stefano Crespi Reghizzi, Violetta Lonati, Dino Mandrioli, and Matteo Pradella</i>	
Classes of Languages Generated by the Kleene Star of a Word.	167
<i>Laure Daviaud and Charles Paperman</i>	
Relating Paths in Transition Systems: The Fall of the Modal Mu-Calculus . . .	179
<i>Cătălin Dima, Bastien Maubert, and Sophie Pinchinat</i>	
Weighted Automata and Logics on Graphs.	192
<i>Manfred Droste and Stefan Dück</i>	
Longest Gapped Repeats and Palindromes	205
<i>Marius Dumitran and Florin Manea</i>	
Quasiperiodicity and Non-computability in Tilings	218
<i>Bruno Durand and Andrei Romashchenko</i>	
The Transitivity Problem of Turing Machines.	231
<i>Anahí Gajardo, Nicolas Ollinger, and Rodrigo Torres-Avilés</i>	
Strong Inapproximability of the Shortest Reset Word.	243
<i>Paweł Gawrychowski and Damian Straszak</i>	
Finitary Semantics of Linear Logic and Higher-Order Model-Checking	256
<i>Charles Grellois and Paul-André Melliès</i>	
Complexity of Propositional Independence and Inclusion Logic	269
<i>Miika Hannula, Juha Kontinen, Jonni Virtema, and Heribert Vollmer</i>	
Modal Inclusion Logic: Being Lax is Simpler than Being Strict	281
<i>Lauri Hella, Antti Kuusisto, Arne Meier, and Heribert Vollmer</i>	
Differential Bisimulation for a Markovian Process Algebra.	293
<i>Giulio Iacobelli, Mirco Tribastone, and Andrea Vandin</i>	
On the Hardness of Almost-Sure Termination	307
<i>Benjamin Lucien Kaminski and Joost-Pieter Katoen</i>	
Graphs Identified by Logics with Counting	319
<i>Sandra Kiefer, Pascal Schweitzer, and Erkal Selman</i>	
Synchronizing Automata with Extremal Properties	331
<i>Andrzej Kisielewicz and Marek Szykuła</i>	
Ratio and Weight Quantiles	344
<i>Daniel Krähmann, Jana Schubert, Christel Baier, and Clemens Dubsclaff</i>	

Precise Upper and Lower Bounds for the Monotone Constraint Satisfaction Problem	357
<i>Victor Lagerkvist</i>	
Definability by Weakly Deterministic Regular Expressions with Counters is Decidable	369
<i>Markus Latte and Matthias Niewerth</i>	
On the Complexity of Reconfiguration in Systems with Legacy Components	382
<i>Jacopo Mauro and Gianluigi Zavattaro</i>	
Eliminating Recursion from Monadic Datalog Programs on Trees	394
<i>Filip Mazowiecki, Joanna Ochremiak, and Adam Witkowski</i>	
Computability on the Countable Ordinals and the Hausdorff-Kuratowski Theorem (Extended Abstract)	407
<i>Arno Pauly</i>	
Emergence on Decreasing Sandpile Models	419
<i>Kévin Perrot and Éric Rémila</i>	
Lost in Self-Stabilization	432
<i>Damien Regnault and Éric Rémila</i>	
Equations and Coequations for Weighted Automata.	444
<i>Julian Salamanca, Marcello Bonsangue, and Jan Rutten</i>	
Author Index	457

Contents – Part II

Near-Optimal Asymmetric Binary Matrix Partitions	1
<i>Fidaa Abed, Ioannis Caragiannis, and Alexandros A. Voudouris</i>	
Dual VP Classes	14
<i>Eric Allender, Anna Gál, and Ian Mertz</i>	
On Tinhofer’s Linear Programming Approach to Isomorphism Testing	26
<i>V. Arvind, Johannes Köbler, Gaurav Rattan, and Oleg Verbitsky</i>	
On the Complexity of Noncommutative Polynomial Factorization	38
<i>V. Arvind, Gaurav Rattan, and Pushkar Joglekar</i>	
An Algebraic Proof of the Real Number PCP Theorem	50
<i>Martijn Baartse and Klaus Meer</i>	
On the Complexity of Hub Labeling (Extended Abstract).	62
<i>Maxim Babenko, Andrew V. Goldberg, Haim Kaplan, Ruslan Savchenko, and Mathias Weller</i>	
On the Complexity of Speed Scaling	75
<i>Neal Barcelo, Peter Kling, Michael Nugent, Kirk Pruhs, and Michele Scquizzato</i>	
Almost All Functions Require Exponential Energy	90
<i>Neal Barcelo, Michael Nugent, Kirk Pruhs, and Michele Scquizzato</i>	
On Dynamic DFS Tree in Directed Graphs	102
<i>Surender Baswana and Keerti Choudhary</i>	
Metric Dimension of Bounded Width Graphs	115
<i>Rémy Belmonte, Fedor V. Fomin, Petr A. Golovach, and M.S. Ramanujan</i>	
Equality, Revisited	127
<i>Ralph Bottesch, Dmitry Gavinsky, and Hartmut Klauck</i>	
Bounding the Clique-Width of H -free Chordal Graphs.	139
<i>Andreas Brandstädt, Konrad K. Dabrowski, Shenwei Huang, and Daniël Paulusma</i>	

New Bounds for the CLIQUE-GAP Problem Using Graph Decomposition Theory	151
<i>Vladimir Braverman, Zaoxing Liu, Tejasvam Singh, N.V. Vinodchandran, and Lin F. Yang</i>	
QMA with Subset State Witnesses	163
<i>Alex Bredariol Grilo, Iordanis Kerenidis, and Jamie Sikora</i>	
Phase Transition for Local Search on Planted SAT	175
<i>Andrei A. Bulatov and Evgeny S. Skvortsov</i>	
Optimal Bounds for Estimating Entropy with PMF Queries	187
<i>Cafer Caferov, Barış Kaya, Ryan O’Donnell, and A.C. Cem Say</i>	
Mutual Dimension and Random Sequences	199
<i>Adam Case and Jack H. Lutz</i>	
Optimal Algorithms and a PTAS for Cost-Aware Scheduling	211
<i>Lin Chen, Nicole Megow, Roman Rischke, Leen Stougie, and José Verschae</i>	
Satisfiability Algorithms and Lower Bounds for Boolean Formulas over Finite Bases	223
<i>Ruiwen Chen</i>	
Randomized Polynomial Time Protocol for Combinatorial Slepian-Wolf Problem	235
<i>Daniyar Chumbalov and Andrei Romashchenko</i>	
Network Creation Games: Think Global – Act Local	248
<i>Andreas Cord-Landwehr and Pascal Lenzner</i>	
Oblivious Transfer from Weakly Random Self-Reducible Public-Key Cryptosystem	261
<i>Claude Crépeau and Raza Ali Kazmi</i>	
Efficient Computations over Encrypted Data Blocks	274
<i>Giovanni Di Crescenzo, Brian Coan, and Jonathan Kirsch</i>	
Polynomial Kernels for Weighted Problems	287
<i>Michael Etscheid, Stefan Kratsch, Matthias Mnich, and Heiko Röglin</i>	
A Shortcut to (Sun)Flowers: Kernels in Logarithmic Space or Linear Time . . .	299
<i>Stefan Fafianie and Stefan Kratsch</i>	
Metastability of Asymptotically Well-Behaved Potential Games: (Extended Abstract)	311
<i>Diodato Ferraioli and Carmine Ventre</i>	

The Shifted Partial Derivative Complexity of Elementary Symmetric Polynomials	324
<i>Hervé Fournier, Nutan Limaye, Meena Mahajan, and Srikanth Srinivasan</i>	
Parameterized Algorithms for Parity Games	336
<i>Jakub Gajarský, Michael Lampis, Kazuhisa Makino, Valia Mitsou, and Sebastian Ordyniak</i>	
Algorithmic Applications of Tree-Cut Width	348
<i>Robert Ganian, Eun Jung Kim, and Stefan Szeider</i>	
Log-Concavity and Lower Bounds for Arithmetic Circuits	361
<i>Ignacio García-Marco, Pascal Koiran, and Sébastien Tavenas</i>	
Easy Multiple-Precision Divisors and Word-RAM Constants	372
<i>Torben Hagerup</i>	
Visibly Counter Languages and the Structure of NC^1	384
<i>Michael Hahn, Andreas Krebs, Klaus-Jörn Lange, and Michael Ludwig</i>	
The Price of Connectivity for Cycle Transversals	395
<i>Tatiana R. Hartinger, Matthew Johnson, Martin Milanič, and Daniël Paulusma</i>	
Upper and Lower Bounds on Long Dual Paths in Line Arrangements	407
<i>Udo Hoffmann, Linda Kleist, and Tillmann Miltzow</i>	
A Numbers-on-Foreheads Game	420
<i>Sune K. Jakobsen</i>	
Faster Lightweight Lempel-Ziv Parsing	432
<i>Dmitry Kosolobov</i>	
Parallel Identity Testing for Skew Circuits with Big Powers and Applications	445
<i>Daniel König and Markus Lohrey</i>	
On Probabilistic Space-Bounded Machines with Multiple Access to Random Tape	459
<i>Debasis Mandal, A. Pavan, and N.V. Vinodchandran</i>	
Densest Subgraph in Dynamic Graph Streams	472
<i>Andrew McGregor, David Tench, Sofya Vorotnikova, and Hoa T. Vu</i>	
The Offline Carpool Problem Revisited	483
<i>Saad Mneimneh and Saman Farhat</i>	

On Sampling Simple Paths in Planar Graphs According to Their Lengths	493
<i>Sandro Montanari and Paolo Penna</i>	
Degree-Constrained Subgraph Reconfiguration is in P	505
<i>Moritz Mühlenthaler</i>	
Generalized Pseudoforest Deletion: Algorithms and Uniform Kernel	517
<i>Geevarghese Philip, Ashutosh Rai, and Saket Saurabh</i>	
Efficient Equilibria in Polymatrix Coordination Games	529
<i>Mona Rahn and Guido Schäfer</i>	
Finding Consensus Strings with Small Length Difference Between Input and Solution Strings	542
<i>Markus L. Schmid</i>	
Active Linking Attacks	555
<i>Henning Schnoor and Oliver Woizekowski</i>	
On the Complexity of Master Problems	567
<i>Martijn van Ee and René Sitters</i>	
Efficient Algorithm for Computing All Low s - t Edge Connectivities in Directed Graphs	577
<i>Xiaowei Wu and Chenzi Zhang</i>	
Maximum Minimal Vertex Cover Parameterized by Vertex Cover.	589
<i>Meirav Zehavi</i>	
Fast Dynamic Weight Matchings in Convex Bipartite Graphs.	601
<i>Quan Zu, Miaomiao Zhang, and Bin Yu</i>	
Author Index	613