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Fundamentals of Computation Theory

21st International Symposium, FCT 2017
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Proceedings

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Preface

The 21st International Symposium on Fundamentals of Computation Theory (FCT 2017) took place during September 11–13, 2017 in Bordeaux, France.

The Symposium on Fundamentals of Computation Theory (FCT) was established in 1977 for researchers interested in all aspects of theoretical computer science, and in particular algorithms, complexity, and formal and logical methods. FCT is a biennial conference. Previous symposia have been held in Gdansk, Liverpool, Oslo, Wrocław, Budapest, and Lübeck.

The Program Committee (PC) of FCT 2017 received 99 submissions. Each submission was reviewed by at least three PC members and some trusted external referees, and evaluated on its quality, originality, and relevance to the symposium. The PC selected 29 papers, leading to an acceptance rate of 29%.

Four invited talks were given at FCT 2017, by Thomas Colcombet (CNRS, University of Paris-Diderot), Martin Dietzfelbinger (Technische Universität Ilmenau), Juraj Hromkovič (ETH Zürich), and Anca Muscholl (University of Bordeaux). There was also one invited talk in memoriam of Zoltán Ésik given by Jean-Éric Pin (CNRS, University of Paris-Diderot). This volume contains the papers of the five invited talks.

We thank the Steering Committee and its chair, Marek Karpinski, for giving us the opportunity to serve as the program chairs of FCT 2017, and for the responsibilities of selecting the Program Committee, the conference program, and publications.

The Program Committee selected two contributions for the best paper and the best student paper awards, sponsored by Springer and IDEX Bordeaux.

- The best paper award went to Albert Atserias, Phokion Kolaitis, and Simone Severini for their paper "Generalized Satisfiability Problems via Operator Assignments".
- The best student paper award was given to Matthias Bentert, Till Fluschnik, André Nichterlein, and Rolf Niedermeier for their paper "Parameterized Aspects of Triangle Enumeration".

We gratefully acknowledge additional financial support from the following institutions: University of Bordeaux, LaBRI, CNRS, Bordeaux INP, GIS Albatros, EATCS, Région Nouvelle-Aquitaine, and the French National Research Agency (ANR).

We would like to thank all the authors who responded to the call for papers, the invited speakers, the members of the Program Committee, the external referees, and—last but not least—the members of the Organizing Committee.

We would like to thank Springer for publishing the proceedings of FCT 2017 in their ARCoSS/LNCS series and for their support.

Finally, we acknowledge the help of the EasyChair system for handling the submission of papers, managing the review process, and generating these proceedings.

September 2017

Ralf Klasing
Marc Zeitoun

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Abstracts of Invited Papers

Automata and Program Analysis

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Abstract. We show how recent results concerning quantitative forms of automata help providing refined understanding of the properties of a system (for instance, a program). In particular, combining the size-change abstraction together with results concerning the asymptotic behavior of tropical automata yields extremely fine complexity analysis of some pieces of code.

This abstract gives an informal, yet precise, explanation of why termination and complexity analysis are related to automata theory.

Optimal Dual-Pivot Quicksort: Exact Comparison Count

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Abstract. Quicksort, proposed by Hoare in 1961, is a venerable sorting algorithm - it has been thoroughly analyzed, it is taught in basic algorithms classes, and it is routinely used in practice. Can there be anything new about Quicksort today? Dual-pivot quicksort refers to variants of classical quicksort where in the partitioning step two pivots are used to split the input into three segments. Algorithms of this type had been studied by Sedgewick (1975) and by Hennequin (1991), with no further consequences. They received new attention starting from 2009, when a dual-pivot algorithm due to Yaroslavskiy, Bentley, and Bloch replaced the well-engineered quicksort algorithm in Oracle's Java 7 runtime library. An analysis of a variant of this algorithm by Nebel and Wild from 2012, where the two pivots are chosen randomly, showed there are about $1.9n \ln n$ comparisons on average for n input numbers. (Other works ensued. Standard quicksort has $2n \ln n$ expected comparisons. It should be noted that on modern computers parameters other than the comparison count will determine the running time.) In the center of the analysis is the partitioning procedure. Given two pivots, it splits the input keys in "small" (smaller than small pivot), "medium" (between the two pivots), "large" (larger than large pivot). We identify a partitioning strategy with the minimum average number of key comparisons in the case where the pivots are chosen from a random sample. The strategy keeps count of how many large and small elements were seen before and prefers the corresponding pivot. The comparison count is closely related to a "random walk" on the integers which keeps track of the difference of large and small elements seen so far. An alternative way of understanding what is going on is a Pólya urn with three colors. For the fine analysis it is essential to understand the expected number of times this random walk hits zero. The expected number of comparisons can be determined exactly and as a formula up to lower terms: It is $1.8n \ln n + 2.38..n + 1.675 \ln n + O(1)$. Extensions to larger numbers of pivots will be discussed.

Based on joint work with Martin Aumüller, Daniel Krenn, Clemens Heuberger, and Helmut Prodinger.

What One Has to Know When Attacking P vs. NP (Extended Abstract)

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Abstract. Mathematics was developed as a strong research instrument with fully verifiable argumentations. We call any consistent and sufficiently powerful formal theory that enables to algorithmically verify for any given text whether it is a proof or not algorithmically verifiable mathematics (AV-mathematics for short). We say that a decision problem $L \subseteq \Sigma^*$ is almost everywhere solvable if for all but finitely many inputs $x \in \Sigma^*$ one can prove either "$x \in L$" or "$x \notin L$" in AV-mathematics.

First, we formalize Rice's theorem on unprovability, claiming that each nontrivial semantic problem about programs is not almost everywhere solvable in AV-mathematics. Using this, we show that there are infinitely many algorithms (programs that are provably algorithms) for which there do not exist proofs that they work in polynomial time or that they do not work in polynomial time. We can prove the same also for linear time or any time-constructible function.

Note that, if $\mathsf{P} \neq \mathsf{NP}$ is provable in AV-mathematics, then for each algorithm A it is provable that "A does not solve SATISFIABILITY or A does not work in polynomial time". Interestingly, there exist algorithms for which it is neither provable that they do not work in polynomial time, nor that they do not solve SATISFIABILITY. Moreover, there is an algorithm solving SATISFIABILITY for which one cannot prove in AV-mathematics that it does not work in polynomial time.

Furthermore, we show that $\mathsf{P} = \mathsf{NP}$ implies the existence of algorithms X for which the true claim "X solves SATISFIABILITY in polynomial time" is not provable in AV-mathematics. Analogously, if the multiplication of two decimal numbers is solvable in linear time, one cannot decide in AV-mathematics for infinitely many algorithms X whether "X solves multiplication in linear time".

Finally, we prove that if P vs. NP is not solvable in AV-mathematics, then P is a proper subset of NP in the world of complexity classes based on algorithms whose behavior and complexity can be analyzed in AV-mathematics. On the other hand, if $\mathsf{P} = \mathsf{NP}$ is provable, we can construct an algorithm that provably solves SATISFIABILITY almost everywhere in polynomial time.

A Tour of Recent Results on Word Transducers

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Abstract. Regular word transductions extend the robust notion of regular languages from acceptors to transformers. They were already considered in early papers of formal language theory, but turned out to be much more challenging. The last decade brought considerable research around various transducer models, aiming to achieve similar robustness as for automata and languages.

In this talk we survey some recent results on regular word transducers. We discuss how classical connections between automata, logic and algebra extend to transducers, as well as some genuine definability questions. For a recent, more detailed overview of the theory of regular word transductions the reader is referred to the excellent survey of E. Filiot and P.-A. Reynier (Siglog News 3, July 2016).

Based on joint work with Félix Baschenis, Olivier Gauwin and Gabriele Puppis. Work partially supported by the Institute of Advance Studies of the Technische Universität München and the project DeLTA (ANR-16-CE40-0007).

Some Results of Zoltán Ésik on Regular Languages

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Abstract. Zoltán Ésik published 2 books as an author, 32 books as editor and over 250 scientific papers in journals, chapters and conferences. It was of course impossible to survey such an impressive list of results and in this lecture, I will only focus on a very small portion of Zoltán's scientific work. The first topic will be a result from 1998, obtained by Zoltán jointly with Imre Simon, in which he solved a twenty year old conjecture on the shuffle operation. The second topic will be his algebraic study of various fragments of logic on words. Finally I will briefly describe some results on commutative languages obtained by Zoltán, Jorge Almeida and myself.

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