Lecture Notes in Computer Science 9691

More information about this series at http://www.springer.com/series/7407

Alexander S. Kulikov · Gerhard J. Woeginger (Eds.)

Computer Science – Theory and Applications

11th International Computer Science Symposium in Russia, CSR 2016
St. Petersburg, Russia, June 9–13, 2016
Proceedings

Springer

Editors
Alexander S. Kulikov
St. Petersburg Department of Steklov Institute of Mathematics of Russian Academy of Sciences
St. Petersburg
Russia

Gerhard J. Woeginger
Technische Universiteit Eindhoven
Eindhoven
The Netherlands

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-319-34170-5 ISBN 978-3-319-34171-2 (eBook)
DOI 10.1007/978-3-319-34171-2

Library of Congress Control Number: 2016938395

LNCS Sublibrary: SL1 – Theoretical Computer Science and General Issues

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Preface

This volume contains the 28 papers presented at CSR 2016, the 11th International Computer Science Symposium in Russia, held during June 9–13, 2016, in St. Petersburg, Russia. The symposium was organized by the Steklov Mathematical Institute at St. Petersburg of the Russian Academy of Sciences (PDMI). The first CSR took place in 2006 in St. Petersburg, and this was then followed by meetings in Ekaterinburg (2007), Moscow (2008), Novosibirsk (2009), Kazan (2010), St. Petersburg (2011), Nizhny Novgorod (2012), Ekaterinburg (2013), Moscow (2014), and Listvyanka (2015). CSR covers a wide range of areas in theoretical computer science and its applications.

The opening lecture at CSR 2016 was given by Christos Papadimitriou (Berkeley). Four other invited plenary lectures were given by Herbert Edelsbrunner (IST Austria), Vladimir Kolmogorov (IST Austria), Orna Kupferman (Hebrew University), and Virginia Vassilevska Williams (Stanford).

We received 71 submissions in total, and out of these the Program Committee selected 28 papers for presentation at the symposium and for publication in the proceedings. Each submission was reviewed by at least three Program Committee members. We expect the full versions of the papers contained in this volume to be submitted for publication in refereed journals. The Program Committee also selected the winners of the two Yandex Best Paper Awards.

Best Paper Award: Meena Mahajan and Nitin Saurabh, "Some Complete and Intermediate Polynomials in Algebraic Complexity Theory"
Best Student Paper Award: Alexander Kozachinskiy, "On Slepian–Wolf Theorem with Interaction"

Many people and organizations contributed to the smooth running and the success of CSR 2016. In particular our thanks go to:

- All authors who submitted their current research to CSR
- Our reviewers and subreferees whose expertise flowed into the decision process
- The members of the Program Committee, who graciously gave their time and energy
- The members of the local Organizing Committee, who made the conference possible
- The EasyChair conference management system for hosting the evaluation process
- Yandex
- The Government of the Russian Federation (Grant 14.Z50.31.0030)
- The Steklov Mathematical Institute at St. Petersburg of the Russian Academy of Sciences
- The European Association for Theoretical Computer Science (EATCS)
- Monomax Congresses and Incentives

June 2016

Alexander S. Kulikov
Gerhard J. Woeginger

Organization

Program Committee

Eric Allender	Rutgers University, USA
Maxim Babenko	Moscow State University, Russia
Marek Chrobak	University of California, Riverside, USA
Volker Diekert	University of Stuttgart, Germany
Leah Epstein	University of Haifa, Israel
Fedor Fomin	University of Bergen, Norway
Lane Hemaspaandra	University of Rochester, USA
Kazuo Iwama	Kyoto University, Japan
Juhani Karhumaki	University of Turku, Finland
Stephan Kreutzer	Technical University of Berlin, Germany
Andrei Krokhin	University of Durham, UK
Piotr Krysta	University of Liverpool, UK
Alexander Kulikov	Steklov Mathematical Institute at St. Petersburg, Russia
Yuri Matiyasevich	Steklov Mathematical Institute at St. Petersburg, Russia
Elvira Mayordomo	Universidad de Zaragoza, Spain
Rolf Niedermeier	Technical University of Berlin, Germany
Vladimir Podolskii	Steklov Mathematical Institute, Russia
Don Sannella	University of Edinburgh, UK
Miklos Santha	CNRS-LRI, UMR 8623, Universitè Paris-Sud, France
Thomas Schwentick	Technical University of Dortmund, Germany
Tatiana Starikovskaya	University of Bristol, UK
Wolfgang Thomas	RWTH Aachen, Germany
Ryan Williams	Stanford University, USA
Gerhard J. Woeginger	Technical University Eindhoven, The Netherlands

Organizing Committee

Asya Gilmanova
Alexandra Novikova
Ekaterina Ipatova
Alexander Smal
Alexander S. Kulikov

External Reviewers

Akhmedov, Maxim
Alman, Joshua
Anastasiadis, Eleftherios
Artamonov, Stepan
Aumüller, Martin
Averbakh, Igor
Baier, Christel
Bauwens, Bruno
Beliakov, Gleb
Bensch, Suna
Bevern, René Van
Bliznets, Ivan
Brattka, Vasco
Braverman, Mark
Brazdil, Tomas
Buergisser, Peter
Carton, Olivier
Chalopin, Jérémie
Chatzistergiou, Andreas
Chen, Xujin
Chistikov, Dmitry
Chrzaszcz, Jacek
Davydow, Alex
De Paris, Alessandro
de Wolf, Ronald
Duedder, Boris
Durand, Arnaud
Elder, Murray
Escoffier, Bruno
Filiot, Emmanuel
Froese, Vincent
Fukunaga, Takuro
Gairing, Martin
Gastin, Paul
Gawrychowski, Pawel
Geck, Gaetano
Geuvers, Herman
Godin, Thibault
Golovach, Petr
Golovnev, Alexander
Grochow, Joshua
Harju, Tero
Harks, Tobias
Hirvensalo, Mika
Iwamoto, Chuzo
Jancar, Petr
Johnson, Matthew
Kannan, Sampath
Kara, Ahmet
Karpov, Dmitri
Karpov, Nikolay
Kashin, Andrei
Katoen, Joost-Pieter
Kawamura, Akitoshi
Klimann, Ines
Knop, Alexander
Kociumaka, Tomasz
Kolesnichenko, Ignat
Komusiewicz, Christian
Kulkarni, Raghav
Kumar, Mrinal
Kuske, Dietrich
Kutten, Shay
Kuznetsov, Stepan
Laekhanukit, Bundit
Lange, Klaus-Joern
Libkin, Leonid
Löding, Christof
Mahajan, Meena
Maneth, Sebastian
Manquinho, Vasco
Maslennikova, Marina
Mayr, Ernst W.
Mnich, Matthias
Mundhenk, Martin
Nichterlein, André
Nishimura, Harumichi
Nutov, Zeev
Obua, Steven
Okhotin, Alexander
Oliveira, Rafael
Oparin, Vsevolod
Pasechnik, Dmitrii
Pastor, Alexei
Petersen, Holger
Pilipczuk, Michał

Pin, Jean-Eric
Pouzyrevsky, Ivan
Qiao, Youming
Randall, Dana
Reynier, Pierre-Alain
Riveros, Cristian
Romashchenko, Andrei
Rosén, Adi
Saarela, Aleksi
Savchenko, Ruslan
Schnoor, Henning
Shen, Alexander
Sokolov, Dmitry
Souto, André
Talmon, Nimrod
Tamaki, Suguru
Terekhov, Andrey
Thielen, Clemens
van Rooijen, Lorijn
Vassilevska Williams, Virginia
Vegh, Laszlo
Vildhøj, Hjalte Wedel
Volkovich, Ilya
Vortmeier, Nils
Vyalyi, Mikhail
Wahlström, Magnus
Walter, Tobias
Watrous, John
Weinzierl, Tobias
Wächter, Jan Philipp
Zanetti, Luca
Zimand, Marius
Zivny, Standa

Abstracts of Invited Talks

Topological Data Analysis with Bregman Divergences

Herbert Edelsbrunner
(joint work with Hubert Wagner)

IST Austria (Institute of Science and Technology Austria),
Am Campus 1, 3400 Klosterneuburg, Austria

Given a finite set in a metric space, the topological analysis assesses its multi-scale connectivity quantified in terms of a 1-parameter family of homology groups. Going beyond Euclidean distance and really beyond metrics, we show that the basic tools of topological data analysis also apply when we measure distance with Bregman divergences. While these violate two of the three axioms of a metric, they have been found more effective for high-dimensional data. Examples are the Kullback–Leibler divergence, which is commonly used for text and images, and the Itakura–Saito divergence, which is popular for speech and sound.

Complexity Classifications of Valued Constraint Satisfaction Problems

Vladimir Kolmogorov

IST Austria, Am Campus 1, 3400 Klosterneuburg, Austria
vnk@ist.ac.at

Classifying complexity of different classes of optimization problems is an important research direction in Theoretical Computer Science. One prominent framework is Valued Constraint Satisfaction Problems (VCSPs) in which the class is parameterized by a "language" Γ, i.e. a set of cost functions over a fixed discrete domain D. A instance of VCSP(Γ) is an arbitrary sum of functions from Gamma (possibly with overlapping variables), and the goal is to minimize the sum. The complexity of VCSP (Γ) depends on how "rich" the set Γ is. If, for example, Γ contains only submodular functions then any instance in VCSP(Γ) can be solved in polynomial time. If, on the other hand, Γ contains e.g. the "not-equal" relation then VCSP(Γ) can express the $|D|$-coloring problem and thus is NP-hard when $|D| > 2$.

I will show that establishing complexity classification for plain CSPs (i.e. when functions in Γ only take values in $\{0, \infty\}$) would immediately give the classification for general VCSPs. The key algorithmic tool that we use is a certain LP relaxation of the problem combined with the assumed algorithm for plain CSPs.

In the second part of the talk I will consider a version where we additionally restrict the structure of the instance to be *planar*. More specifically, I will describe a generalization of the Edmonds's blossom-shrinking algorithm from "perfect matching" constraints to arbitrary "even Δ-matroid" constraints. As a consequence of this, we settle the complexity classification of planar Boolean CSPs started by Dvořák and Kupec.

Based on joint work with Alexandr Kazda, Andrei Krokhin, Michal Rolínek, Johann Thapper and Stanislav Živný [1–3].

References

1. Kazda, A., Kolmogorov, V., Rolínek, M.: Even Delta-matroids and the complexity of planar Boolean CSPs (2016). arXiv: 1602.03124v2
2. Kolmogorov, V., Krokhin, A., Rolínek, M.: The complexity of general-valued CSPs. In: IEEE 56th Annual Symposium on Foundations of Computer Science. FOCS 2015, pp. 1246–1258 (2015)
3. Kolmogorov, V., Thapper, J., Živný, S.: The power of linear programming for general-valued CSPs. SIAM J. Comput. **44**(1), 1–36 (2015)

On High-Quality Synthesis

Orna Kupferman(✉)

School of Computer Science and Engineering,
The Hebrew University, Jerusalem, Israel
orna@cs.huji.ac.il

Abstract. In the synthesis problem, we are given a specification ψ over input and output signals, and we synthesize a system that realizes ψ: with every sequence of input signals, the system associates a sequence of output signals so that the generated computation satisfies ψ. The above classical formulation of the problem is Boolean. First, correctness is Boolean: a computation satisfies the specification ψ or does not satisfy it. Then, other important and interesting measures like the size of the synthesized system, its robustness, price, and so on, are ignored. The paper surveys recent efforts to address and formalize different aspects of quality of synthesized systems. We start with multi-valued specification formalisms, which refine the notion of correctness and enable the designer to specify quality, and continue to the quality measure of sensing: the detail in which the inputs should be read in order to generate a correct computation. The first part is based on the articles [1–3]. The second part is based on [4, 5].

The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013)/ERC grant agreement no. 278410, and from The Israel Science Foundation (grant no. 1229/10).

Algorithm as a Scientific Weltanschauung

Christos Papadimitriou

UC Berkeley, Berkeley, USA
christos@berkeley.edu

The idea of the algorithm, present in the work of Euclid, Archimedes, and Al Khorizmi, and formalized by Alan Turing only eight decades ago, underlies much of the realm of science — physical, life, or social. Algorithmic processes are present in the great objects of scientific inquiry — the cell, the universe, the market, the brain — as well as in the models developed by scientists over the centuries for studying them. During the past quarter century this algorithmic point of view has helped make important progress in science, for example in statistical physics through the study of phase transitions in terms of the convergence of Markov chain Monte carlo algorithms, and in quantum mechanics through the lens of quantum computing.

In this talk I will recount a few more instances of this mode of research. Algorithmic considerations, as well as ideas from computational complexity, revealed a conceptual flaw in the solution concept of Nash equilibrium ubiquitous in economics. In the study of evolution, a new understanding of century-old questions has been achieved through purely algorithmic ideas. Finally, current work in theoretical neuroscience suggests that the algorithmic point of view may be invaluable in the central scientific question of our era, namely understanding how behavior and cognition emerge from the structure and activity of neurons and synapses.

Fine-Grained Algorithms and Complexity

Virginia Vassilevska Williams

Stanford University, Stanford, USA
virgi@cs.stanford.edu

A central goal of algorithmic research is to determine how fast computational problems can be solved in the worst case. Theorems from complexity theory state that there are problems that, on inputs of size n, can be solved in $t(n)$ time but not in $t(n)^{1-\varepsilon}$ time for $\varepsilon > 0$. The main challenge is to determine where in this hierarchy various natural and important problems lie. Throughout the years, many ingenious algorithmic techniques have been developed and applied to obtain blazingly fast algorithms for many problems. Nevertheless, for many other central problems, the best known running times are essentially those of the classical algorithms devised for them in the 1950s and 1960s.

Unconditional lower bounds seem very difficult to obtain, and so practically all known time lower bounds are conditional. For years, the main tool for proving hardness of computational problems have been NP-hardness reductions, basing hardness on P$\neq$NP. However, when we care about the exact running time (as opposed to merely polynomial vs non-polynomial), NP-hardness is not applicable, especially if the running time is already polynomial. In recent years, a new theory has been developed, based on *"fine-grained reductions"* that focus on exact running times. The goal of these reductions is as follows. Suppose problem A is solvable in $a(n)$ time and problem B in $b(n)$ time, and no $a(n)^{1-\varepsilon}$ and $b(n)^{1-\varepsilon}$ algorithms are known for A and B respectively. The reductions are such that whenever A is fine-grained reducible to B (for $a(n)$ and $b(n)$), then a $b(n)^{1-\varepsilon}$ time algorithm for B (for any $\varepsilon > 0$) implies an $a(n)^{1-\varepsilon'}$ algorithm for A (for some $\varepsilon' > 0$). Now, mimicking NP-hardness, the approach is to (1) select a key problem X that is conjectured to require $t(n)^{1-o(1)}$ time, and (2) reduce X in a fine-grained way to many important problems. This approach has led to the discovery of many meaningful relationships between problems, and even sometimes to equivalence classes.

In this talk I will give an overview of the current progress in this area of study, and will highlight some new exciting developments.

Contents