New Progress on the (Parameterized?) Circuit Size Problem

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ABSTRACT

The Minimum Circuit Size Problem (MCSP) is a well-known candidate for NP-intermediate status. That is, it is a problem in NP that is believed to neither be in P nor to be NP-complete. MCSP has drawn the attention of researchers, because of strong connections between MCSP and fields such as derandomization, barriers to progress in circuit complexity, cryptography, and Kolmogorov complexity. In recent years, there has been substantial progress toward understanding where MCSP fits in the landscape of complexity classes. These lectures will survey this progress, and highlight some of the most intriguing open questions that remain.

The parameterised complexity of topological problems

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ABSTRACT

In recent years there has been great progress on the parameterised complexity of topological problems, such as the recognition of knots, surfaces and 3-manifolds. We will first survey the state of progress on time complexity, where there are now many positive results backed up by practical mathematical software. We will then move to the less-explored realm of space complexity, where we discuss analysing surfaces in logspace, and solving topological problems on finite state tree automata.

New and Simple FPT Algorithms for Vertex Covers

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ABSTRACT

The classical vertex cover problem requires us to determine whether a graph contains k vertices that cover all edges. In spite of its NP-completeness, the problem can be solved in FPT time for parameter k by various techniques such as bounded search tree and kernelization.

In this talk, we present new and simple FPT algorithms for the vertex cover problem. For this purpose, we explore structural properties of vertex covers and use these properties to obtain FPT algorithms using iterative compression, colour coding, and random separation.

Recent Progress on Maximum Agreement Forest

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ABSTRACT

The problem drew attention about 15 years ago, with many approximation/parameterized algorithms, mostly on two binary trees. Recent progress includes algorithms on non-binary trees and on multiple binary trees. We will summarize the recent results, and report a (not yet published) algorithm on multiple non-binary trees. Our algorithm is better than most previous algorithms on two binary trees.

FPT-inspired approximation algorithms

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ABSTRACT

Standard approaches to cope with NP-hard combinatorial problems include the development of approximation and FPT algorithms. While the former approach dates back in the sixties (and hence even pre-dates the theory of NP completeness), the latter approach was most prominently developed by Rod Downey and Mike Fellows in the nineties, who also wrote the first textbook on the subject, see [3]. One of the core techniques of FPT is kernelization, as kernelizability is equivalent to membership in FPT. Kernelization could be seen as a formal treatment of simple preprocessing rules, so-called reduction rules, that also play a crucial role in many successful (meta-)heuristic strategies to cope with intractability. We will show in our talks that reduction rules can also lead to very good approximation algorithms. We will use variants of well-known graph problems like Dominating Set and Vertex Cover to illustrate our approach, also see [1, 2].

References

[1] F. N. Abu-Khzam, C. Bazgan, M. Chopin, and H. Fernau. Data reductions and combinatorial bounds for improved approximation algorithms. *Journal of Computer and System Sciences*, 82(3):503–520, 2016.

[2] L. Brankovic and H. Fernau. A novel parameterised approximation algorithm for minimum vertex cover. *Theoretical Computer Science*, 511:85–108, 2013.

[3] R. G. Downey and M. R. Fellows. *Parameterized Complexity*. Springer, 1999.

Graph decompositions and algorithms

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ABSTRACT

We overview the recent progress in solving intractable optimization problems on planar graphs as well as other classes of sparse graphs. In particular, we discuss how tools from Graph Minors theory can be used to obtain

- subexponential parameterized algorithms
- approximation algorithms, and
- preprocessing and kernelization algorithms

on these classes of graphs.

Quasi Polynomial and FPT algorithms for Parity Games

Sanjay Jain

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ABSTRACT

It is shown that parity games can be solved in quasipolynomial time. The runtime is improved from the previously best known $n^{O(\sqrt{n})}$ to $O(n^{\log(m)+6})$, where n is the number of nodes and m is the number of colours (priorities).

The parameterised parity game – with n nodes and m distinct colours is proven to be in the class of fixed parameter tractable problems (FPT) when parameterised over m. The corresponding runtime is improved from $O(n^{\Theta(m)})$ for fixed parameter m to an FPT-algorithm with runtime $O(n^5 + g(m))$, where $g(m)$ can be taken to be m^{m+6}.

This is joint work with C. Calude, B. Khoussainov, W. Li and F. Stephan

Towards a parameterised analogue of Toda's theorem

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ABSTRACT

Toda's theorem states that the ability to count solutions to instances of NP-complete problems allows one to solve any decision problem in the polynomial-time hierarchy PH. This theorem came as a surprise when it first appeared in 1989, because it showed that the power to count solutions was much stronger than previously thought. In 2017, a parameterised analogue of Toda's theorem still remains elusive. It is even somewhat unclear what such an analogue might look like. We discuss the barriers to obtaining a parameterised analogue of Toda's theorem and the work of Montoya, Müller, and others, towards this end.

References

[1] Montoya J A. (2007) On Parameterized Counting. Thesis, University of California, Freiburg.

[2] Müller M. (2006) Randomized Approximations of Parameterized Counting Problems. In: Bodlaender H.L., Langston M.A. (eds) Parameterized and Exact Computation. IWPEC 2006. Lecture Notes in Computer Science, vol 4169. Springer, Berlin, Heidelberg

[3] Montoya J A. and Müller M. (2013) Parameterized random complexity. In Theory of Computing Systems 52.2 (2013): 221-270.

[4] Downey R. and Fellows M. (2013) Fundamentals of Parameterized Complexity. Texts in Computer Science, Springer 2013.

Effective fractal dimension theory: exploring the extreme cases

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ABSTRACT

Effective fractal dimension theory was introduced by Lutz with the initial purpose of quantitatively analyzing complexity classes, while strong connections and consequences for algorithmic randomness and back to classical geometry quickly appeared. In this mini course I will introduce effective dimension focusing on the resource bounded cases and in particular covering small bounds below polynomial time, including recent results on Borel normality.

Efficient Algorithms for Hard Problems on Structured Electorates

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ABSTRACT

Computational social choice [1] is a rapidly evolving research trend concerned with the design and analysis of methods for collective decision making. In this talk, we will focus mostly on voting-inspired scenarios, where we have multiple agents (voters) expressing their preferences over a fixed set of alternatives (candidates), and the goal is to find a consensus (a winner or a committee or a ranking) that, as far as possible, reflects the collective opinions of all the agents.

We will survey some algorithmic developments in the context of problems like winner determination, committee formation, and manipulation, all of which are fundamental to voting scenarios. In particular, we will survey various restricted domains, both in the context of rankings and dichotomous preferences. We will consider examples that demonstrate how the structure in these domains can be exploited to make otherwise hard problems tractable. We will also describe some ideas for detecting whether a given instance belongs to these domains, and more generally, if the instance is close to a structured domain. In the context of the latter, the notion of closeness will usually be based on candidate or voter deletion.[a]

[a]Some results that will be described here are based on joint work with Palash Dey.

References

[1] Felix Brandt, Vincent Conitzer, Ulle Endriss, Jérôme Lang, and Ariel Procaccia. *Handbook of computational social choice*, Cambridge University Press, 2016.

Disjoint NP Pairs and Propositional Proof Systems

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ABSTRACT

This talk surveys results on disjoint NP-pairs, propositional proof systems, function classes, and promise classes—including results that demonstrate close connections that bind these topics together. We illustrate important links between the questions of whether these classes have complete objects and whether optimal proof systems may exist.

A parameterized approach to the analysis of Otitis Media data

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ABSTRACT

A multi-parameterized formulation of correlation clustering is applied to the analysis of interactions between viruses and bacteria in the nasopharynx of young children at high risk of otitis media (OM) and acute lower respiratory infection (ALRI) in a remote region in Australia. The multi-parameterized approach [1] takes into consideration some constraints that better-model the problem. By setting realistic bounds on the number of tolerated false positives and false negatives per data elementit is able to filter out meaningless clusters and reveal clusters, that other known techniques could not detect

Our method is the first to provide a network-based model of the interactions between the pathogens in the nasopharyngeal carriage data. This approach reveals a $K_{4,2}$ bi-clique structure that links strong interactions between Otitis Media and both viruses and bacterial pathogens. The observed interaction has not been previously reported and suggest that virus-bacterial interactions play a substantial role in this context.

In addition, a speedup of over 700 times was obtain though the use of a combination of Abu-Kzhams Hybrid Graph Structure [2] and the use of multiparameterization [1].

References

[1] Faisal N Abu-Khzam. On the complexity of multi-parameterized cluster editing. *Journal of Discrete Algorithms*, 2017.

[2] Faisal N. Abu-Khzam, Karim A. Jahed, and Amer E. Mouawad. A hybrid graph representation for exact graph algorithms. *CoRR*, abs/1404.6399, 2014.