Parameterized Complexity News

Newsletter of the Parameterized Complexity Community

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Welcome

Frances Rosamond, Editor, Charles Darwin University
The Parameterized Complexity community is tremendously successful. Since the last newsletter, it has won approximately 1.500.000 Euro for the next 3 - 4 years (The June 2014 newsletter reported almost 1m Euro). There were approx 35 FPT related papers at ESA/IPEC, and many at other conferences (see www.fpt.wikidot.com). This summer saw the successful School. Congratulations to award-winners, graduates and new job holders.

Bedlewo FPT Summer School

Congratulations to organizers **Marek Cygan, Fedor Fomin, Daniel Lokshtanov, Dániel Marx, Marcin Pilipczuk, Michał Pilipczuk**, and **Saket Saurabh** and to all participants (over 90!) for the *School of Parameterized Algorithms and Complexity* that was held Bedlewo, Poland in August. The excellent lectures will result in a book, soon to be available. `http://fptschool.mimuw.edu.pl`.

Bodlaender, Downey, Fellows, Hermelin, Fortnow, Santhanam - Nerode Prize

Congratulations to Nerode Prize winners **Hans Bodlaender, Rodney Downey, Michael Fellows, Danny Hermelin** for *On problems without polynomial kernels*, JCSS 2009, and to **Lance Fortnow, Rahul Santhanam** for *Infeasibility of instance compression and succinct PCPs for NP*, same journal 2011.

Figure 1: Summer School in Bedlewo, Poland.

Figure 2: 2014 Nerode Prize winners Hans Bodlaender, Danny Hermelin, Mike Fellows at IPEC 2014. Hans gave an invited lecture to ESA. More IPEC photos are in an album on Fran's facebook.

Contents of this issue:

Bart Jansen wins Christiaan Huygens Prize, VENI, and a job at Eindhoven!

Congratulations to **Bart Jansen**, Univ. Bergen, for winning the prestigious Christiaan Huygens Prize, awarded once every 5 years in the area of ICT for a PhD thesis that contributes significantly to science and has clear relevance to society. The prize consists of 10,000 Euros and a bronze statue of the Dutch scientist Christiaan Huygens. The award is partly sponsored by IBM, and an interview with Bart is on the IBM weblog: `http://asmarterplanet.com/blog/2014/06/qa-bart-jansen-winner-prestigious-huygens-prize.html`. Bart says: I was really honored, and very happy to meet all these people and share my passion for science with them. During the evening there was an interview with the 4 nominees. They asked us what really helped us in our research; my answer was that the opportunity to travel and meet other people in the field has really helped me grow. During my acceptance speech I told the entire audience about my trip to Australia, surfing and and doing research with Mike and Fran, and about the great and friendly community that I am lucky to be part of. Bart also received a VENI award for *Frontiers in Parameterized Preprocessing* worth 234K Euro over three years, and has accepted a tenure track position at the Univ. Eindhoven.

Henning Fernau - DFG Award

Congratulations to **Henning Fernau**, Univ. Trier, who has won a three-year DFG grant of 326K Euro for *Parameterized approximation - new concepts and new applications*. This includes funding for a PhD position for Katrin Casel and a Mercator fellowship that will allow Ljiljana Brankovic to visit Trier for 5 months.

Serge Gaspers - ARC Future Fellowship

Congratulations to **Serge Gaspers**, UNSW and NICTA for winning an Australian Research Council Future Fellowship for the project, *Algorithms for hard graph problems based on auxiliary data* worth 711 AUD over 4 years.

Danny Hermelin - Israel Science Foundation Award

Congratulations to **Danny Hermelin** who has received an Israel Science Foundation (ISF) grant for *New Directions in Meta-Kernelization*. It is for 500k shekels (roughly 100K Euro) over four years.

Jesper Nederlof - VENI Award

Congratulations to **Jesper Nederlof** for winning a VENI (Netherlands Organization for Scientific Research) award for *Reducing small instances of complex tasks to large instances of simple ones*, worth 231K Euro over three years.

Michał Pilipszuk - Polish NSC Award

Congratulations to **Michał Pilipszuk** for *Optimality in Parameterized Complexity*, funded by the Polish National Science Center starting October for three years. From October 1st Michał will be a postdoc at the Warsaw Center of Mathematics and Computer Science.

Happy Birthday Jianer Chen!

Figure 3: Birthday party for Jianer Chen

A birthday party was held for Jianer Chen in College Station, Texas. More than 10 of his former PhD students joined the party with his wife Rong and children Jenny and Wei. Another party was given by Jianxin Wang and former students of Jianer's at the South-Center Univ of China, where Jianer holds a guest position. The *Tsinghua Science and Technology Journal* Vol. 19 No. 4/August 2014 is a "Special Issue on Parameterized Complexity" in honor of Chen's 60th birthday. Guest edited by Liming Cai, Iyad Kanj, and Frances Rosamond. There are eight articles of recent results and surveys. Congratulations, Jianer!

Nominate! 2015 EATCS-IPEC NERODE PRIZE

The nomination deadline for the EATCS-IPEC Nerode Prize 2015 for outstanding papers in the area of multivariate algorithmics will likely be January 1, 2015. Please send nominations to the 2015 Award Committee: Georg Gottlob, Chair (Oxford University), Jan Arne Telle (University of Bergen) David Eppstein (University of California, Irvine). `http://www.eatcs.org/index.php/nerode-prize`

Keep up-to-date on the wiki

Conference and arXiv papers are maintained on `www.fpt.wikidot.com` at *FPT papers in Conferences* and *FPT papers On-Line* by Bart Jansen. Please let Bart know your papers (or add them yourself).

k-BI-CLIQUE is W[1]-hard

Proved by *Bingkai Lin, Univ. Tokyo, Kawarabayashi Large Graph Project* (Email: lin at is.s.u-tokyo.ac.jp)

The k-BI-CLIQUE problem asks, given a graph G and integer k, whether G contains the complete bipartite graph $K_{k,k}$ as a subgraph. This problem has been long conjectured to be W[1]-hard. This earned k-BI-CLIQUE first place in the open problems of the new textbook by Downey and Fellows, listed among "The Most Infamous". But a W[1]-hardness proof has been found by Bingkai Lin, a PhD student in Tokyo, who gives a parameterized reduction from k-CLIQUE. The crux of the proof is to find bipartite host graphs satisfying certain conditions, that allow a k-clique instance to be embedded in them. Binkai gives a deterministic construction of such host graphs using Weil's character sum theorem, which transforms a k-clique instance into a bi-clique instance whose parameter value is roughly $k!$. There is also a randomized construction that is more efficient, resulting in a parameter value of k^2. It implies that under a randomized version of the ETH, k-BI-CLIQUE cannot be solved in $f(k)n^{o(\sqrt{k})}$ time. Congratulations to Binkai on this great result!

Parameterized logarithmic space and fine-structure of FPT

by Moritz Müller, Univ Vienna

Classical complexity theory offers a rich theory of subclasses of P. These include hierarchies based on circuit families along with classes like L, NL, LOGCFL from the theory of logarithmic space. We ask for a meaningful fine-structure theory of FPT. Such a theory should distinguish natural problems, and furthermore relate this distinction to already established complexity theoretic hypotheses of independent interest.

Today, kernelization theory is well-established as such a theory. Earlier approaches include [7] where parameterized circuit families are studied, and [2] where the class para-L (notation from [9]) is introduced. This is the class of parameterized problems which are for some computable function f decidable in space $O(f(k)+\log n)$ (on instances of size n with parameter k). For example, the parameterized vertex cover problem is in para-L [2]. Some recent work on the theory of parameterized logarithmic space lead itself to the definition of the *tree hierarchy*:

$$\text{para-L} \subseteq \text{PATH} \subseteq \text{TREE} = \text{TREE}[1] \subseteq$$

$$\text{TREE}[2] \subseteq \cdots \subseteq \text{TREE}[*] \subseteq \text{FPT}$$

The hope would be that these classes can be used to capture the complexity of many natural problems in FPT up to parameterized logarithmic space reductions. If true, we would get a doable fine-structure theory as above which, at first glance, seems unrelated to kernelization theory.

Consider the parameterized homomorphism problem p-HOM($\mathcal{A}$) associated with a class $\mathcal{A}$ of finite relational structures. Here and below, $\mathcal{A}$ ranges over decidable such classes of bounded arity. The problem p-HOM($\mathcal{A}$) asks whether a given structure $\mathbf{A} \in \mathcal{A}$ maps homomorphically into another given structure $\mathbf{B}$; the parameter is the size of $\mathbf{A}$. Grohe [11] proved that p-HOM($\mathcal{A}$) is in FPT if the cores of the structures in $\mathcal{A}$ have bounded treewidth, and otherwise W[1]-complete. As a corollary, based on [6], FPT $\neq$ W[1] implies that the classical problem HOM($\mathcal{A}$) underlying p-HOM($\mathcal{A}$) is in P if and only if the cores of structures in $\mathcal{A}$ have bounded treewidth.

Grohe's classification has been refined in [3]: the bounded treewidth case splits into three degrees up to parameterized logarithmic space reductions. More precisely, let $\mathcal{P}^*$ denote the class of colored paths; each vertex in such a path has its individual color. Similarly, let $\mathcal{T}^*$ denote the class of colored trees. Then the main result of [3] reads as follows. If the cores of structures in $\mathcal{A}$ have bounded treedepth, then p-HOM($\mathcal{A}$) is in para-L; if they have unbounded treedepth and bounded pathwidth, then p-HOM($\mathcal{A}$) is equivalent to p-HOM($\mathcal{P}^*$); if they have unbounded pathwidth and bounded treewidth, then p-HOM($\mathcal{A}$) is equivalent to p-HOM($\mathcal{T}^*$).

This classification has been systematized and further refined in [4]. It gives some interest to the classes PATH and TREE consisting of those parameterized problems reducible (by parameterized logarithmic space reductions) to p-HOM($\mathcal{P}^*$) and p-HOM($\mathcal{T}^*$) respectively. It turns out that PATH coincides with a class introduced earlier by Elberfeld et al. [8]: the class of parameterized problems accepted by nondeterministic Turing machines which run in parameterized logarithmic space and, for some computable f, use a most $f(k) \cdot \log n$ many nondeterministic bits. The class TREE is characterized by allowing the machines to additionally use $f(k)$ many co-nondeterministic bits (see [3]).

The classes PATH and TREE can be viewed as parameterized analogs of NL and LOGCFL respectively. But unlike their classical counterparts (see [1]) they are not known to be closed under complementation. Both classical proofs break under the severe restrictions on nondeterminism in the parameterized setting. The question begs for a better understanding of inductive counting and its limits. One thus has to face the alternation hierarchy TREE[1], TREE[2], ... built upon TREE = TREE[1] with TREE[$*$] arising as a natural limit class. Indeed, p-MC(FO^2), the parameterized model-checking problem for 2-variable first-order logic, is complete for TREE[$*$]; restricting to t quantifier alternations yields a problem complete for TREE[t]. We refer to [5] for definitions and precise statements.

In conlusion, the classes of the tree hierarchy admit natural machine characterizations and capture the complexity of some fundamental problems. For example, the

following problem is TREE-complete [5]: given an (undirected) graph $\mathbf{G}$ and a tree $\mathbf{T}$, decide whether $\mathbf{G}$ contains a subgraph isomorphic to $\mathbf{T}$; the parameter is the size of $\mathbf{T}$. The problems p-DirPath and p-DirCycle (studied e.g. in [10]) are PATH-complete [3]; they ask, given a directed graph $\mathbf{G}$ and a parameter k, whether $\mathbf{G}$ contains a directed path resp. cycle of length k. The undirected version of p-DirPath, the famous problem p-Path, is shown in [5] to be contained in para-L. This is proved using Reingold's algorithm combined with color coding.

What can we say about the hypotheses that the classes of the tree hierarchy are pairwise distinct? On the upper end, the hypothesis TREE[$*$] $\neq$ FPT is equivalent to L $\neq$ P. Note that by [3, 11] p-Hom($\mathcal{A}$) is W[1]-complete or in TREE, a class presumably smaller than FPT. On the lower end the hypothesis para-L $\neq$ PATH implies L $\neq$ NL. More interestingly, it is implied by the classical hypothesis NL $\not\subseteq$ DSPACE($o(\log^2 n)$) stating that Savitch's Theorem is optimal [5]. These results are not meant to foster some "belief" in the hypothesis para-L $\neq$ PATH, but rather some interest in its investigation. As shown in [4], para-L $\neq$ PATH implies that Hom($\mathcal{A}$) is in L if and only if $\mathcal{A} \in$ L and the cores of structures in $\mathcal{A}$ have bounded treedepth.

References.

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[11] M. Grohe. The complexity of homomorphism and constraint satisfaction problems seen from the other side. *Journal of the ACM*, 54(1):1:1–1:24, 2007.

This has been a very busy summer with the Summer School on PC held in Bedlewo, the *2nd workshop on PC of Computational Reasoning* at the Vienna Summer of Logic, Dagstuhl Seminar 14341 *Resource-bounded Problem Solving* applying PC to cognitive modeling, the Bertinoro workshop on PC and Approximation, the Shonan seminar *Towards the ground truth: Exact algorithms for bioinformatics research*, and many other activities.

IPEC 2014 - September

An excellent 9th IPEC 2014 was held with ALGO/ESA in beautiful Wroclaw, Poland (`http://algo2014.ii.uni.wroc.pl/ipec`). Many thanks to co-Chairs Pinar Heggernes, U. Bergen and Marek Cygan, U. Warsaw.

PCCR 2014 Report

Serge Gaspers, UNSW Australia and NICTA

The 2nd Workshop on the Parameterized Complexity of Computational Reasoning (PCCR), took place in Vienna, Austria, 17-18 July 2014, as part of FLoC and the Vienna Summer of Logic, which hosted 12 conferences and over 80 workshops and attracted over 2,000 researchers, `http://vsl2014.at/pccr/`. It was organized by Mike Fellows, Serge Gaspers, and Toby Walsh.

Among the highlights of PCCR 2014, were three fabulous invited talks:

- Georg Gottlob (University of Oxford, UK *and* Vienna University of Technology, Austria), Structural Decomposition Methods: How They Matter;
- Dániel Marx (Hungarian Academy of Sciences, Hungary), CSPs and fixed-parameter tractability;
- Stefan Szeider (Vienna University of Technology, Austria), Fixed-Parameter Algorithms for Reasoning Problems in NP and Beyond.

Interesting talks by Robert Ganian, Jan Johannsen, Martin Kronegger, Johann Makowsky, Sebastian Ordyniak, Andreas Pfandler, and R. Ramanujam, spanned topics such as answer set programming, backdoors, computational social choice, constraint satisfaction, intuitionistic modal logic, new parameterized complexity hierarchies, planning, and the satisfiability of propositional formulas. There was also a panel where Mike Fellows, Dániel Marx,

and Stefan Szeider outlined their favourite open problems and research directions in the field.

The exciting Open Problem session is described on the wiki `www.fpt.wikidot.com` on the Conferences/Workshops page.

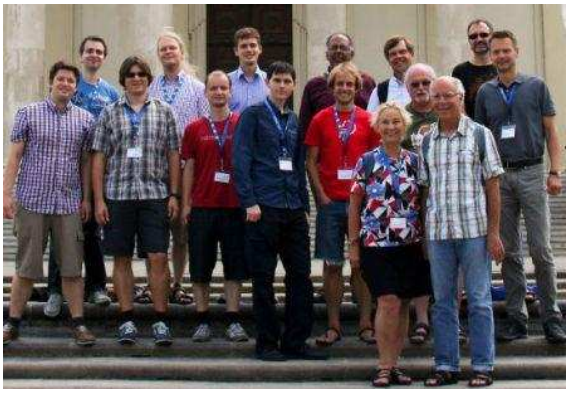

Figure 4: PCCR 2014 Vienna

The workshop was hosted by CSL-LICS and was also affiliated with IJCAR and SAT.

Algorithmic Social Choice - Eisenhardt Castle - October

Workshop on Challenges in Algorithmic Social Choice (CASC 2014) Eisenhardt Castle, Bad Belzig (near Berlin), Germany, 8-11 October, 2014. Invited speakers are Edith Elkind (U. Oxford), Ariel Procaccia (Carnegie Mellon U.), Clemens Puppe (KIT), Arkadii Slinko (U. Auckland), Toby Walsh (NICTA and UNSW) Gerhard J Woeginger (Eindhoven U. of Technology).

Workshop chairs: Piotr Faliszewski (AGH U. of Science and Technology, Krakow) and Rolf Niedermeier (TU Berlin). `www.akt.tu-berlin.de/nenue/casc14`.

Dagstuhl Optimality - Nov 2014

Dagstuhl Seminar 14451: *Optimality and tight results in parameterized complexity* takes place 2–7 November. Organizers are Stefan Kratsch (TU Berlin), Daniel Lokshtanov (U. Bergen), Daniel Marx (Hungarian Academy of Sciences), Peter Rossmanith (RWTH Aachen).

LAW Cliques - Brazil - Nov 2014

The *Sixth Latin-American Workshop on Cliques in Graphs* will take place 9–12 November in Pirenopolis, Brazil. Invited speakers are Marcia Cerioli (Federal U. of Rio de Janeiro), Mike Fellows and Frances Rosamond (Charles Darwin U.), Vadim Lozin (U. Warwick), and Claudio Lucchesi (U. Campinas).

FPT New Ideas Workshop - December 2014

An *FPT New Ideas Workshop* will take place 8 Dec 2014 at IMSC, Chennai immediately preceding the computer science outreach conf (CMSC) taking place 9 –12 Dec. Note FST-TCS follows 15–17 Dec. Venkatesh Raman (IMSC) and S. P. Suresh (CMI, Chennai) are co-chairs of the FST-TCS Program Committee.

Creative Mathematical Sciences Communication (CMSC) - Chennai - December

Second Int'l Conf. on Creative Mathematical Sciences Communication (CMSC) takes place 9–12 Dec 2014 at IMSC, Chennai. The conference aims to engage research mathematical scientists in outreach and communication. Bringing together researchers, educators and communicators committed to bringing exploration and discovery into classrooms and among the educated public, the conference hopes to explore new ways of thinking initiated by *Computer Science Unplugged* and other similar efforts.

The main theme of the conference is popularizing the rich mathematics underlying computer science, and to attract children to open problems, to dare reach for gold. We believe that combinatorics and computer science mathematics offer extensive opportunities in this regard.

`http://www.imsc.res.in/~cmsc2014/index.html`
Co-organizers are R. Ramanujam (jam@imsc.res.in) and Fran Rosamond(Frances.Rosamond@cdu.edu.au). The first conf. was a huge success and this one will be even better! `www.cdu.edu.au/conference/csmaths`.

Multivariate Algorithmics and Approximation - Banff - Nov 2015

Banff Seminar on *Approximation Algorithms and Parameterized Complexity*:15w5118. Arriving Sunday, Nov 29 and departing Friday Dec 4, 2015. Organizers: Michael Fellows (Charles Darwin Univ), Shachnai Hadas (Technion), Klaus Jansen (Univ Kiel), Roberto Solis-Oba (Univ Western Ontario).

Fine-Grained Complexity at Simons

From August 2015, the Simons Institute in Berkeley is supporting a semester-long program on "Fine-Grained Complexity and Algorithm Design". *Fine-grained complexity analysis* is a codeword for parameterized/multivariate algorithmics that seems to have been first used in the Foreword to the *Computer Journal* double special issue on parameterized complexity [1], which also first articulated the *FPT-optimality* and *XP-optimality* programs, generalizing early results of Cai and Juedes [2] and Chen et al. [3] (later articulated by Dániel Marx into a successful ERC Starting Grant proposal.)

The optimality programs will be the subject of a workshop during the semester. The program is organized by R. Paturi (Chair), R. Impagliazzo, D. Marx, V. Williams, and R. Williams, and presumably those interested in participating should contact the organizers.

1. Rodney Downey, Michael Fellows, and Michael A. Langston: *Foreword by the Guest Editors.* The Computer Journal 51 (1) (2008).

2. Liming Cai, David W. Juedes: *On the existence of subexponential parameterized algorithms.* J. Comput. Syst. Sci. 67(4): 789-807 (2003).

3. Jianer Chen, Benny Chor, Mike Fellows, Xiuzhen Huang, David W. Juedes, Iyad A. Kanj, Ge Xia: *Tight Lower Bounds for Certain Parameterized NP-Hard Problems.* IEEE Conference on Computational Complexity 2004: 150-160.

New Resource - www.CSMaths.org

New blog (`www.CSMaths.org`) with new *CS Unplugged* activities, and research into computer science outreach. It is an outcome of the **Creative Mathematical Sciences Communication Conference**. Moderator `Frances.Rosamond@cdu.edu.au`.

Parameterized Complexity Blog

by Neeldhara Misra, IIS, Bangalore, BLOG Editor

Enjoy the FPT blog at `http://fptnews.org`. Sign up at `http://www.fptnews.org/contribute`. The blog offers open problems, event announcements, expositions, reports, and so forth. Post your overviews, anecdotes, pictures, updates, and announcements to keep the blog an up-to-date, active resource.

Moving Around – Congratulations to ALL.

Haris Aziz has been promoted to Senior Researcher at NICTA, Australia.

Holger Dell has started a five-year position as Independent Research Group Leader at Saarland University and the Cluster of Excellence, MMCI. The group is *Foundations of Exact Algorithms.* Contact Holger if you would like to work with him as a postdoc or as a PhD student on challenging problems.

Serge Gaspers has been promoted to Senior Lecturer at UNSW Australia.

Jiong Guo is now Full Professor and chairs a research group at School of Computer Science and Technology, Shandong Univ.

Pim van 't Hof has accepted mathematics teaching position at Rotterdam University of Applied Sciences (Hogeschool Rotterdam) within the Bachelor programme "Logistics and Economics". (pimvanthof@gmail.com)

Bart Jansen has accepted a tenure track position at the Univ. Eindhoven.

Luke Mathieson has joined Pablo Moscato at the University of Newcastle (Australia) as a Research Associate.

Marcin Pilipczuk moved in August to Warwick where he holds a postdoc position. Formally it is called U. of Warwick - Queen Mary U. of London Alliance Postdoc.

Michał Pilipszuk has accepted a postdoc position at the Warsaw Center of Mathematics and Computer Science.

Iddo Tzameret is moving to Royal Holloway, Univ London from the Institute of Theoretical CS, Tsinghua Univ. He starts 1st Oct 2014.

CONGRATULATIONS New PhDs

Rajesh Chitnis, *Directed Graphs: Fixed-Parameter Tractability and Beyond*, 2014, University of Maryland, College Park, USA. Advisor: Prof. MohammadTaghi Hajiaghayi. Dr. Chitnis has accepted a postdoc at Weizmann Institute, Israel where he plans to work with Prof. Robi Krauthgamer and Prof. Uri Feige. Congratulations, Dr. Chitnis.

Uėverton dos Santos Souza, *Multivariate Investigation of NP-Hard Problems: Boundaries Between Parameterized Tractability and Intractability*, 2014, Fluminense Federal University, Brazil. Advisors: Prof. Fábio Protti, Prof. Maise Dantas da Silva, and Prof. Dieter Rautenbach. Dr. Souza has accepted a teaching position in a Federal College. Congratulations, Dr. Souza. (ueverton-ssouza@yahoo.com.br)

René van Bevern, *Fixed-Parameter Linear-Time Algorithms for NP-Hard Graph and Hypergraph Problems Arising in Industrial Applications*, 2014, TU-Berlin. Advisor: Prof. Dr. Rolf Niedermeier. Congratulations, Dr. van Bevern.

Gabriele Muciaccia, *Polynomial Kernels for Graph and Hypergraph Optimisation Problems*, 2014, Royal Holloway, Univ of London. Advisors: Prof. Gregory Gutin and Prof. Anders Yeo. Congratulations, Dr. Muciaccia.

Best wishes to families

Best wishes to **René van Bevern** and Galina on their new daughter, Polina.

Best wishes to **Frederick** and **Marianne Dorn**. Their son Johannes has a new little brother, David.

Figure 5: Marianne, David and Johannas Dorn

Figure 6: Galina, Polina, Rene van Bevern