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. Congratulations to award-winners, graduates and new job holders. There were approx 45 FPT related papers at ESA/IPEC, and many at other conferences (See the www.fpt.wikidot.com section on Papers and arXiv compiled by Bart Jansen). Thore Husfeldt and Dániel Marx organized an excellent workshop at the Simons Institute as part of the semester on Fine-Grained Complexity, where one of the topics was *FPT inside of P*, discussed by George Mertzios in this newsletter. In a different direction, a conversation was started about holding an FPT Implementation Challenge. The importance of implementation and appreciation for this work is discussed in the article by Gregory Gutin. Read the *New Ideas* Section by Mike Fellows about *Realistic Modeling*. I will have a new email address starting January: `Frances.Rosamond@uib.no`

Demaine, Fomin, Hajiaghayi, Thilikos - Nerode Prize

Congratulations to Nerode Prize winners **Erik Demaine** (Massachusetts Institute of Technology), **Fedor Fomin** (University of Bergen), **Mohammad T. Hajiaghayi** (University of Maryland Institute for Advanced Computer Studies), and **Dimitrios Thilikos** (LIRMM, Montpellier). The winners introduced a new framework for designing fixed-parameter algorithms. The results can be applied to a broad family of graph problems, called *bidimensional* problems, which includes many domination and covering problems such as vertex cover, feedback vertex set, minimum maximal matching, and more. Dimitrios Thilikos presented the keynote Nerode address at the ALGO/ESA/IPEC Conference in Patras.

Figure 1: IPEC Excellent Student Paper award winners Manuel Sorge and Stefan Kratsch, with IPEC Co-organizers Iyad Kanj and Thore Husfeldt and award presenter Frances Rosamond.

Marek Cygan

Congratulations to **Marek Cygan**, University of Warsaw for a 2015 ERC Starting Grant for the project: *Technology transfer between modern algorithmic paradigms*, funded by approximately 1.48M Euro over 5 years. The project focuses on (a) parameterized complexity, (b) approximation algorithms, and (c) metaheuristics.

Contents of this issue:

Meirav Zehavi - Best Student Paper, more

Congratulations to **Meirav Zehavi** (Technion) for several awards,including the 2016 Women Postdoctoral Fellowship of Israel's Council for Higher Education (awarded to excellent female students). Mirav was also awarded the Best Student Paper Award at IWOCA'15, Best Student Paper Award at ESA'15, and Best Student Paper Award at MFCS'15. Zehavi has a Simons-Berkeley and I-CORE Joint Research Fellowship 08/2015 - 05/2016.


Figure 2: Meirav Zehavi (Technion), Marek Cygan (Univ Warsaw)

Boucher, Lo, Lokshtanov - ESA Best Paper

Congratulations to **Christina Boucher** (Colorado State Univ), **Christine Lo** (UCSD) and **Daniel Lokshtanov** (Univ Bergen) for winning the ESA 2015 Best Paper Award with *Consensus Patterns (Probably) has no EPTAS.*

Sorge and Kratsch - IPEC Excellent Student Paper

Congratulations to **Manuel Sorge** (TU-Berlin) and **Stefan Kratsch** (Univ Bonn) for the IPEC'15 Excellent Student Paper Award with *On Kernelization and Approximation for the Vector Connectivity Problem.*

van Bevern, Komusiewicz, Sorge – ATMOS Best Paper

Congratulations to **Rene van Bevern, Christian Komusiewicz** and **Manuel Sorge** for the ATMOS'15 Best Paper Award with *Approximation algorithms for mixed, windy, and capacitated arc routing problems.*

Jianer Chen – ACM Distinguished

Congratulations to **Jianer Chen** whose ACM Distinguished Membership has been approved.

Pablo Moscato – Univ Newcastle, AU

Prof. Pablo Moscato was singled out by Australia's Hon Christopher Pyne MP, Minister for Education and Training, and Leader of the House in his speech to launch the Australian Academy of the Humanities. The collaboration between Pablo, researcher in Bioinformatics, and Hugh Craig, Linguistics, was chosen as a case study, *Enlisting Shakespeare to Help Fight Cancer.*

These two researchers set out to identify the molecular 'signatures' for diseases through the application of linguistic methods used in literary research. Working together they used supercomputing systems to analyse literary word markers to identify the authorship of disputed literary works.

The researchers were then able to apply the same approach to identify the molecular signatures for diseases like Cancer, Alzheimers and Multiple Sclerosis. This research has made significant contributions to advances in the diagnosis and treatment of these diseases.

Nominate for the 2016 EATCS-IPEC Nerode Prize

Nominations are due **February 15, 2016** for outstanding papers in the area of multivariate algorithmics meant in a broad sense, and encompassing, but not restricted to, those areas covered by IPEC.

Eligibility: Any research paper or series of research papers by a single author or by a team of authors published in a recognized refereed journal. The year of publication should be at least two years and at most ten years before the year of the award nomination. The Award Committee is solely responsible for the selection of the winner of the award which may be shared by more than one paper or series of papers.

Nominations: Nominations may be made by any member of the scientific community including the members of the Award Committee. A nomination should contain a brief summary of the technical content of each nominated paper and a brief explanation of its significance. Send an email to the Award Committee Chair with copies to the members of the committee. The Subject line of the nomination E-mail should contain the group of words "Nerode Prize Nomination".

The award will be presented at IPEC 2016, which takes place within ALGO 2016, August 22-26, Aarhus, Denmark.

Award Committee
David Eppstein (University of California, Irvine)
Daniel Marx (Hungarian Academy of Sciences)
Jan Arne Telle (University of Bergen, Norway. Chair)

For further information, including former winners, see: `http://www.eatcs.org/index.php/nerode-prize`

New Ideas Column – *Move Hardness into the Modeling* by Mike Fellows

Michael Fellows, Charles Darwin Univ (Univ of Bergen starting January 2016).

Many problems are shown to be NP-hard, where the hardness is only due, for example, to legislating real numbers as input in situations in which such accuracy is impossible. We initiated a novel number-of numbers parameterization yielding FPT when the source of intractability was mitigated by moving approximation concerns into the problem legislation and parameterizing on the size of the relevant finitized arithmetic system.

Along these lines, we predict that in addition to FPT results in scheduling and computational social choice, that in algorithmic game theory it is possible to prove an ultra-finite analog of Nash's Theorem with the following three parameters: (1) quantization of the mixed strategy, (2) quantized uncertainty of the payoffs, (3) quantized reason to shift strategy.

Additionally, in some applied settings, *rough counting* results are all that is needed to predict, for example, physical properties of a material, such as whether it is a *semiconductor, anti-ferromagnetic, etc.* Parameterizing by the number of k-logarithmic qualitative outcomes of the count; such as, *very few, few, many* is not the same as linear-factor (1 + epsilon) – optimal approximate counting, and reasonably more realistic. The suggestion is to target and deconstruct NP-hardness results about counting, seeking FPT results. This may require fresh mathematical approaches, but is generally low risk / high gain, with the intention of pushing counting complexity closer to practical computing.

FPT Implementation Challenge

An emerging conversation asks how to make our field recognized by practitioners who look in Garey and Johnson to see if their problem is NP-complete but never think about checking if it is FPT. Originator of the NSF, Vanebar Bush reminds us that practice informs theory, understanding flows in both directions. At the Simons meeting, an FPT Implementation Challenge was discussed by Thore Husfeldt, Petteri Kaski, Holger Dell, Mike Fellows, Fran Rosamond and others. Interest was expressed also by many at the Banff meeting on Parameterized Complexity and Approximation. Christian Komusiewicz (Jena) and Falk Hüffner (TU-Berlin) have volunteered to help run the competition. At least for the first event, we are looking for problems for which FPT techniques will plausibly beat CPLEX, ILP and other methods. The conversation is being held on SLACK, an easy to use program that keeps a record of all comments. Please join the conversation by sending an email to Holger Dell at `hdell@mmci.uni-saarland.de` or `Frances.Rosamond@uib.no`.

Should We Care about Huge Imbalance in Parameterized Algorithmics?

by Gregory Gutin*, Royal Holloway University of London*

This short article has been triggered by a recent viewpoint article [1] in Communications of ACM. However, while Michael Mitzenmacher [1] focuses on experimental research in Theoretical Computer Science (TCS) in general, I'd like to discuss a related but different topic: imbalance of theory and applications in Parameterized Algorithmics.

Parameterized Algorithmics was initiated, to a large extend, by the wish of their pioneers, Rod Downey, Mike Fellows, Mike Langston and others, to create an area of TCS which would be useful in solving practical problems. Another important aim was to build an area of complexity theory which would be much more useful than the classical one in providing theoretical lower and upper bounds for complexity of various intractable problems.

While the latter aim has been very successful, possibly even beyond the expectations of the pioneers, the first aim remains largely unfulfilled modulo some sporadic successes. Should we care about this?

I think we should if we are interested in the future of the area beyond a short horizon. Let me first try to argue why should we care and then I'll offer a few suggestions on practical means to address the issue.

One reason we should care is that partially our great success, as a community, in securing research funding and getting promotions was due to the fact we claimed that the area was potentially very useful in practical computing. We cannot continue claiming this for many years, as sooner rather than later some people may start doubting it.

It is not only about funding and promotions. I think if we continue relegating applications to the backseat, interest of many people in our area will fade away starting of course from practitioners but not ending there.

There are several areas of research where a lot of theory is combined with applications in practical computing. One example is mathematical programming, where their great successes are far from limited to theoretical research. They developed several solvers, e.g., the famous CPLEX and CONCORDE, which are used by many practitioners and researchers. And the success of their solvers has a lot to do with their theoretical results.

Mathematical programming became so successful in practical computing because many of its algorithms were implemented and then judged not only by their worst case complexity but by their performance on testbeds. In particular, Simplex Method remains an algorithm of choice in solving moderate-size LP instances as it is more successful than polynomial algorithms on such instances. (The polynomial algorithms win on very large instances though.)

I do understand that many in our community will not want to implement algorithms and study their performance on testbeds, but we certainly need many more who will. To encourage more people to do it, we should appreciate their hard and time-consuming work much more than we do now. In particular, giving weak accept to a conference paper containing a significant body of experimental research, but less impressive theory, is not an encouragement, I am afraid. In my experience, successfully implementing algorithms (including heuristic improvements), running experiments and analyzing experimental results often takes much more time than purely theoretical research.

I'd like to conclude by saying that I agree with many Michael Mitzenmacher's [1] arguments. In particular, we cannot expect practitioners to implement our algorithms without us testing them first.

References.

[1] Michael Mitzenmacher, Theory Without Experiments: Have We Gone Too Far? *Comm. ACM*, 58(9):40–42, 2015.

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). There is a section on the wiki to post jobs. Several PhD and Postdoc positions are available such as: Petr Hlineny `petr.hlineny@googlemail.com`, Masaryk Univ, Brno CZ, `http://www.fi.muni.cz/`, Michael Fellows, `Michael.Fellows@ii.uib.no`, Univ Bergen, Pablo Moscato, `Pablo.Moscato@newcastle.edu.a`, `https://www.newcastle.edu.au/profile/pablo-moscato`, or Blair D. Sullivan (Theory in Practice), currently funded by DARPA and the Moore Foundation. `http://www.csc.ncsu.edu/faculty/bdsullivan`.

Polynomial Fixed-Parameter Algorithms

by George B. Mertzios*, Durham University, UK*

Parameterized complexity analysis is a flourishing field which deals with the exact solvability of NP-hard problems, the key concept being "fixed-parameter tractability (FPT)". But why should this natural and successful approach be limited to intractable (i.e., NP-hard) problems? We are convinced that appropriately parameterizing polynomially solvable problems sheds new light on what makes a problem far from being solvable in *linear* time, in the same way as classical FPT algorithms help in detecting the parameters that make an NP-hard problem far from being solvable in *polynomial* time.

The known results fitting under this leitmotif "FPT inside P" are somewhat scattered around in the literature and do not systematically refer to or exploit the toolbox of parameterized algorithm design. This should change and "FPT inside P" should be more broadly investigated, using parameterized algorithm design techniques such as data reduction and kernelization. As a simple proof-of-concept example, consider the Maximum Matching problem. By following a "Buss-like" kernelization (as is standard knowledge in parameterized algorithmics) and then applying a known polynomial-time matching algorithm, it is not difficult to derive an efficient algorithm which, given a graph G with n vertices, computes a matching of size at least k in $O(kn + k^3)$ time [8].

More formally, and somewhat more generally, in a recent joint work with Archontia C. Giannopoulou and Rolf Niedermeier [8], we proposed the following scenario. Given a problem with instance size n for which an $O(n^c)$-time algorithm is already known, our aim is to identify appropriate parameters k and to derive algorithms with time complexity $f(k) \cdot n^{c'}$ such that $c' < c$, where $f(k)$ depends only on k. It is important to note here that, in strong contrast to FPT algorithms for NP-hard problems, now $f(k)$ may also become *polynomial* in k. Motivated by this, we refine the complexity class P by introducing, for every polynomial function $p(n)$, the class *P-FPT*$(p(n))$ *(Polynomial Fixed-Parameter Tractable)*, containing the problems solvable in $O(k^t \cdot p(n))$ time for some constant $t \geq 1$, i.e., the dependency of the complexity on the parameter k is at most polynomial. Within this framework it is worth focusing our attention in particular on the (practically most attractive) subclass *PL-FPT (Polynomial-Linear Fixed-Parameter Tractable)*, where PL-FPT = P-FPT(n). For example, the algorithm we sketched above for Maximum Matching, parameterized by solution size k, belongs to the class PL-FPT.

In an attempt to systematically follow the leitmotif "FPT inside P", we put forward three desirable algorithmic properties:

1. The running time should have a *polynomial* dependency on the parameter.
2. The running time should be as close to *linear* as possible if the parameter value is constant, improving upon an existing "high-degree" polynomial-time (unparameterized) algorithm.
3. The parameter value, or a *constant-factor* approximation of it, should be *computable efficiently* (preferably in linear time) for any parameter value.

In addition, as this research direction is still only little explored, we suggest to focus first on problems for which the best known upper bounds of the time complexity are polynomials of high degree, e.g., $O(n^4)$ or higher.

To illustrate the potential algorithmic challenges posed by this "FPT inside P" framework, we focused in [8] on Longest Path on Interval Graphs, which was proved a few years ago to be solvable in $O(n^4)$ time. In wide contrast, a longest path in a *proper interval* graph can be computed by a *trivial* linear-time algorithm, since every connected proper interval graph has a Hamiltonian path. Consequently, as the classes of interval graphs and of proper interval graphs seem to behave quite differently, it is natural to parameterize the problem by the size k of a *minimum proper interval (vertex) deletion set*, i.e., by the minimum number of vertices that need to be deleted to obtain a proper interval graph. We provided a parameterized algorithm that runs in $O(k^9 n)$ time, where n is the number of vertices, thus LONGEST PATH ON INTERVAL GRAPHS belongs to the class *PL-FPT* when parameterized by the size of a minimum proper interval deletion set [8]. Our algorithm satisfies all three desirable algorithmic properties described above. In particular, it turns out that a 4-approximation of the minimum proper interval deletion number k of an interval graph can be easily computed in $O(n+m)$ time (by carefully scanning the given interval representation from left to right). It is worth noting here that, to the best of our knowledge, it is unknown whether a minimum proper interval deletion set of an interval graph G can be computed in polynomial time.

To develop our algorithm in [8], we first introduce two data reduction rules on interval graphs. Each of these reductions shrinks the size of specific vertex subsets, called *reducible* and *weakly reducible* sets, respectively. Then, given any proper interval deletion set D of size k in an interval graph G, we appropriately decompose the graph $G \setminus D$ into two collections $\mathcal{S}_1$ and $\mathcal{S}_2$ of reducible and weakly reducible sets, respectively, on which we apply our two reduction rules. The resulting interval graph $\widehat{G}$ is *weighted* (with weights on its vertices) and has some special properties; we call $\widehat{G}$ a *special weighted interval graph* with *parameter* κ, where in this case $\kappa = O(k^3)$. Notably, although $\widehat{G}$ has reduced size, it still has $O(n)$ vertices. Finally we present a fixed-parameter algorithm (parameterized by κ) computing in $O(\kappa^3 n) = O(k^9 n)$ time the maximum weight of a path in a special weighted interval graph, which can be directly mapped back to a longest path in the original interval graph.

Our work heads at stimulating a general research program which systematically exploits the concept of fixed-parameter tractability for polynomially solvable problems. We conclude with three related topics that may lead to further interactions:

1. Design of efficient P-FPT($p(n)$) algorithms: In classical parameterized complexity analysis there is a growing awareness concerning the polynomial-time factors that often have been neglected [4]. Notably, there are some prominent fixed-parameter tractability results giving *linear-time* factors in the input size (but quite large exponential factors in the parameter); these include Bodlaender's famous "linear-time" algorithm for computing treewidth [5] and the more recent "linear-time" algorithm for computing the crossing number of a graph [11]. Interestingly, these papers emphasize "linear time" in their titles, instead of "fixed-parameter tractability". In this spirit, our result for LONGEST PATH IN INTERVAL GRAPHS is a "linear-time" algorithm where the dependency on the parameter is not exponential [5, 11] but *polynomial*. In this line of research, an interesting work by Fomin et al. appeared very recently [7], shortly after the conference version of our paper [8]. In this paper, Fomin et al. studied graph and matrix problems on instances with small treewidth. In particular the authors presented, among other results, an $O(k^3 n \log n)$-time randomized algorithm for computing the cardinality of a maximum matching and an $O(k^4 n \log^2 n)$-time randomized algorithm for actually constructing a maximum matching, where k is an upper bound for the treewidth of the graph [7].

2. Parameterized conditional lower bounds: Polynomial-time solvability and the corresponding *lower bounds* have been of long-standing interest, e.g., it is believed that the famous 3SUM problem is only solvable in quadratic time and this conjecture has been employed for proving relative lower bounds for other problems. Very recently, there was a significant push in this research direction with many new relative lower bounds [1, 2, 6]. The "FPT inside P" approach might help in "breaking" these nonlinear relative lower bounds by introducing useful parameterizations and striving for PL-FPT results. In this direction an interesting negative result by Abboud et al. appeared very recently [3]. They proved that, unless some plausible complexity assumptions fail, for any $\varepsilon > 0$ there does not exist any algorithm with running time $2^{o(k)} n^{2-\varepsilon}$ for $(\frac{3}{2} - \delta)$-approximating the diameter or the radius of a graph, where k is an upper bound for the treewidth. In contrast, the authors proved that both the diameter and the radius can be computed in $2^{O(k \log k)} n^{1+o(1)}$ time [3].

3. Programming by optimization: Coming back to a practical motivation for "FPT inside P", it has been very recently observed that identifying various parameterizations for the same problem may help in designing meta-algorithms that (dynamically) select the most appropriate solution strategy (also specified by respective parameters) —this approach is known as "programming by optimization" [10]. Note that so far this line of research is still in its infancy with only one known study [9] for NP-hard problems; following this approach might also be promising within our "FPT inside P" framework.

References.

[1] A. Abboud, F. Grandoni, and V. V. Williams. Subcubic equivalences between graph centrality problems, APSP and diameter. *SODA 2015*, pages 1681–1697.

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and diameter. *SODA 2016*. Techn. Report available at arxiv.org/abs/1506.01799.

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IPEC 2015 Report

An excellent 10th IPEC 2015 was held with ALGO/ESA in beautiful Patras, Greece. Many thanks to Co-Organizers Thore Husfeldt and Iyad Kanj. It was a well-attended meeting with excellent papers. There were 51 submissions, 32 acceptances, and 155 reviews. The acceptance rate was 63%. There also were several FPT papers in other ALGO workshops.

WG - Istanbul

42nd International Workshop on Graph-Theoretic Concepts in Computer Science
June 22-24, Istanbul, Turkey
Submission Deadline: Feb 27, 2016
http://www.ie.boun.edu.tr/ wg2016/ Pinar Heggernes, Univ of Bergen, Norway is an organizer.

Algorithmic Social Choice - NZ-Feb

The Centre for Mathematical Social Science (CMSS) invites to its 7th Summer Workshop at the Univ Auckland, 18-20 February 2016. http://cmss.auckland.ac.nz/. This meeting is rich and diverse. The three themes are Mathematical Psychology, Mathematics of Social Choice and Mathematical Politics with a particular emphasis on the following topics:

multi-winner voting rules; stochastic choice; complexity in social choice and political science; proportional representation; comparative analysis of existing electoral systems; experiments in political science and social choice.

Confirmed workshop speakers include:

Charles R. Plott (California Institute of Technology), Bernard N. Grofman (Univ California, Irvine), Jean-Francois Laslier (Paris School of Economics), Simon Grant (Australian National Univ), Pavlo Blavatskyy (Murdoch Univ, Perth), Rolf Niedermeier (Technical Univ Berlin), Piotr Faliszewski (AGH Krakow Institute of Technology).

In the afternoons of 18th and 19th there will be tutorials on:

Basics of experimental research in economics (Valery Pavlov, Univ of Auckland) PREFLIB: An online Library for Preferences (Nick Mattei, NICTA, Australia)

The workshop will be concluded with a discussion panel on the role of exact sciences and experimental methods in social choice and political science chaired by Keith Dowding (ANU, Australia).

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 are 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.

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

Michael Fellows has been invited *by call* to join the Faculty of Mathematics and Information Sciences at the University of Bergen starting January 1, 2016. See the announcement here `http://www.uib.no/en/news`. Mike's new email is [Michael.Fellows@uib.no]

Mark Jones has accepted a Postdoc position with Christophe Paul and Celine Scornavacca at LIRMM, Montpellier.

George B. Mertzios, Durham Univ, UK has been promoted to Senior Lecturer since October 2015.

Andre Nichterlein, TU-Berlin has accepted a Postdoc position with George B. Mertzios, Durham Univ for 1 year, starting in February.

Geevarghese Philip has joined the Chennai Mathematical Institute (CMI) as faculty. He is teaching a Parameterized Algorithms course at CMI this semester.

CONGRATULATIONS New PhDs

Mark Blokpoel, *Understanding understanding: A computational-level perspective*, 2015, Radboud University Nijmegen, The Netherlands. Advisors: Prof. Ivan Toni, Prof. Iris van Rooij, Prof. Pim Haselager, and Prof. Todd Wareham. Congratulations, Dr. Blokpoel.

Yongjie Yang, *Complexity of Strategic Voting: Face the Real-World Settings*, 2015, Saarland University, Germany. Advisor: Prof. Jiong Guo. Congratulations, Dr. Yang.

Felix Reidl, *Structural Sparseness and Complex Networks*, 2015, RWTH–Aachen, Germany. Advisor: Prof. Peter Rossmanith. The co-examiner was Jaroslav Neŝetr̂il. Congratulations, Dr. Reidl. Felix has accepted a Post-doc starting January, with Blair Sullivan in Raleigh, North Carolina.

Sigve H. Saether, *Choice of Parameter for DP-based FPT Algorithms: four case studies*, 2015, University of Bergen, Norway. Advisor: Prof. Jan Arne Telle. Congratulations, Dr. Saether.