Welcome

Frances Rosamond, Editor
Welcome to the Parameterized Complexity Newsletter. Congratulations to award winners and graduates. We have excellent articles: Mahdi Parsa writes about game theory, and Uéverton dos Santos Souza writes about answer set programming and bounded treewidth. Please keep the wiki http://fpt.wikidot.com updated with latest results and publications.

IPEC 2012 Call for Papers

The 7th International Symposium on Parameterized and Exact Computation IPEC 2012 http://ipec2012.isoftcloud.gr/ will be co-located with ALGO in Ljubljana, Slovenia. Accepted papers will be published in Springer LNCS.

- **Paper submission**: June 19, 2012
- **Symposium**: September 12-14, 2012
- **Invited Speakers**: Dániel Marx (Computer and Automation Research Institute, Hungarian Academy of Sciences (MTA SZTAKI)), Andreas Björklund (Lund University).
- **Workshop**: Saket Saurabh: Subexponential Parameterised Algorithms.
- **Excellent Student Paper Awards**: A paper is eligible for the award if all authors are students at the time of submission. A student is someone who has not been awarded a PhD.

The AND-Conjecture

Andrew Drucker, MIT, has shown that the AND-conjecture is true (assuming that the polynomial hierarchy doesn’t collapse). A preliminary version of his paper, “New Limits to Classical and Quantum Instance Compression”, is available at http://people.csail.mit.edu/andyd/papers.html. See also, http://intractability.princeton.edu/blog/2012/03/theory-lunch-february-17/. Andy has promised an article for our next newsletter. See the related, “The AND-Conjecture may be Necessary” by Magnus Wahlström, MPI (Nov 2011 Newsletter).

Yiannis Koutis

Congratulations to Yiannis Koutis, Computer Science Dept. at the Univ. Puerto Rico, Rio Piedras. Yiannis has been awarded a prestigious NSF CAREER AWARD for his proposal about spectral graph theory and linear time algorithms. Together with another internal grant, he will be managing about 600K over the next 5 years.

Figure 1: IMSc Short Course Jan 2012

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IMSc January Short Course

A Short Course was held at the Institute for Mathematical Sciences in Chennai (IMSc) in January. This was also the occasion of Neeldhara Misra’s defense lecture.

Morgan Chopin

Congratulations to Morgan Chopin for a DAAD Fellowship to visit Rolf Niedermeier at Technical Univ. Berlin. Morgan is the student of Cristina Bazgan, Univ. Dauphline, Paris.

Papers at Conferences/Online

We appreciate Bart Jansen for maintaining two pages on the FPT Community Wiki. See http://fpt.wikidot.com. One contains FPT-related papers which have appeared online, such as on arXiv or on ECCC. The other is FPT papers at conferences. For example, ten out of the 71 Track A papers at ICALP 2012 are about parameterized complexity. Congratulations, everyone! See the Quick Summary of Parameterized Complexity – 2012 by Bart and Fran at the top of the wiki Welcome Page.

Conferences/Meetings

There are now four Parameterized Complexity International Conferences.

(1) International Symposium on Parameterized and Exact Computation (IPEC), now in its 7th year, is the main conference and focuses on all aspects of parameterized complexity and algorithmics.

(2) Workshop on Kernelization (WorKer) focuses on kernelization. This year, WorKer will take place at Dagstuhl Seminar 12241, “Data Reduction and Problem Kernels.” This event is dedicated to the 60th birthday of Michael Fellows. Please send photos of yourself with Mike to Frances.Rosamond—at–edu.edu.au.

(3) Approximation, Parameterized and Exact Algorithms (APEX) is supported by the French National Agency for Research (ANR). APEX was co-located with STACS 2012 in Paris.

(4) Workshop on Applications of Parameterized Algorithms and Complexity (APAC). APAC 2012 is collocated with ICALP in Warwick, UK.

AMS Special Session on PC

There will be a Special Session on Parameterized Complexity at the American Mathematical Society Annual Meeting in San Diego. The session will take place on Friday and Saturday, 11/12 January 2013. Organizers are Mike Fellows, Anil Nerode and Rod Downey.

Shonan PC, Japan


Pablo Moscato

Keynote speaker at the IX Congress of the Chilean Inst of Operations Research was Pablo Moscato, Univ. Newcastle, Australia. At UoN, Pablo is Co-Director of the Priority Research Centre for Bioinformatics, Biomarker Discovery and Information-based Medicine. He is a Chief Investigator for the ARC Centre of Excellence in Bioinformatics.

Figure 2: Pablo Moscato

At the Congress, Pablo also gave a Tutorial on Memetic Algorithms, including links to parameterized complexity related to the design of local search and recombination operators that prove optimality of the final solution under some restrictions. Pablo’s group has big results in Alzheimer’s Disease. See http://www.skynews.com.au/health/article.aspx?id=735768\&vId=3164045.

Vienna Center

The Vienna Center for Logic and Algorithms http://www.VCLA.at. Faculty of Informatics, Vienna Univ of Technology (TU Vienna), held its official opening in January. Stefan Szeider was Co-chair. Fedor V. Fomin, Univ. Bergen, was an invited speaker.
Parameterized Complexity and Nash Equilibrium

by Vlad Estivill-Castro and Mahdi Parsa, Griffith Univ, Australia.

One of the key solution concepts in game theory is the Nash equilibrium, a set of strategies, one for each player (two or more), such that no player has anything to gain by changing only his or her own strategy unilaterally.

Nash proved that every finite game has an equilibrium (Nash equilibrium) maybe with mixed strategies. But Nash’s existence proof does not suggest how to compute an equilibrium. This fact motivates the question: when can we compute Nash equilibria efficiently?

Since Nash’s paper was published, many researchers developed algorithms for finding Nash equilibria [4, and references therein]. However, all of them are known to have worst-case running times that are exponential.

So, the question that naturally arises is: what is the inherent complexity of finding Nash equilibria in $n$-player games?

Attempts to turn the Nash problem into a decision problem, either by imposing restrictions on the kind of Nash equilibrium that is desired, or by asking questions about properties of potential Nash equilibria, resulted in variants of Nash problems that are computationally hard [3], [4, and references therein].

A review of the literature in game theory reveals that many decision problems regarding the computation of Nash equilibria can be answered in $n^{O(k)}$ time, where $n$ is the size of the game (input size) and $k$ is a parameter that is related to a property of the Nash equilibria in the problem. The $n^{O(k)}$ time complexity indicates these problems are in the class XP. Thus, applying parameterized complexity techniques may result in tractability.

An important class of decision problems are related to the support of Nash equilibria. The support of a mixed strategy is the set of strategies assigned positive probability. It is an important concept, because if we know the support, then the corresponding Nash equilibrium can be found in polynomial time for two-player games. Therefore, we focus on whether we can achieve fixed-parameter tractability in these classes of problems.

**Computation of Nash equilibria in two-player games**

Our first attempt is to determine the parameterized complexity of finding Nash equilibria where all the strategies in the support are played with the same probability. These are called uniform Nash equilibria. It seems that a uniform mixed strategy is probably the simplest way of mixing pure strategies.

$k$-Uniform Nash

**Instance**: A two-player game $G$.

**Parameter**: An integer $k$.

**Question**: Does there exist a uniform Nash equilibrium with support size $k$?

$k$-Minimal Nash support

**Instance**: A two-player game $G$. A subset of strategies $E_1 \subseteq \{1, \ldots, m\}$ for the row player and a subset of strategies $E_2 \subseteq \{1, \ldots, n\}$ for the column player.

**Parameter** $k = \max(\{|E_1|, |E_2|\})$

**Question**: Does there exist a Nash equilibrium of $G$ where all strategies not included in $E_1$ and $E_2$ are played with probability zero?

Nash Equilibrium In A Subset is fixed parameter tractable [4].

**Computation of dominant strategies**

A strategy for a player is (strictly) dominant if, regardless of what any other player does, the strategy earns a better payoff than any other, but if it is simply not worse, then it is called weakly dominant. This is a more elementary notion than Nash equilibrium and it can be used as a preprocessing technique for computing Nash equilibria.

Many decision problems regarding computation of domination are NP-complete [2]. We studied these problems in the parameterized framework. We first tried to find the smallest mixed strategy that dominates a given strategy. A strategy may fail to be dominated by a pure strategy, but may be dominated by a mixed strategy.

Minimum Mixed Dominating Strategy Set

**Instance**: The row player’s payoffs of a two-player game $G$ and a distinguished pure strategy $i$ of the row player.

**Parameter**: An integer $k$.

**Question**: Is there a mixed strategy $x$ for the row player that places positive probability on at most $k$ pure strategies, and dominates the pure strategy $i$?

Minimum Mixed Dominating Strategy Set is $W[2]$-hard [1]. It can be solved in polynomial time in games where the payoffs are limited to 0 and 1 [4]. It is FPT for games where the payoff matrices have at most $r$ nonzero entries in each row and each column [4].
Our next problem is related to the concept of iterated domination. It is well-known that iterated strict dominance is path-independent, that is, the elimination process will always terminate at the same point, and the elimination procedure can be executed in polynomial time [2]. In contrast, iterated weak dominance is path-dependent. It is known that testing whether a given strategy is eliminated in some path is \( \text{NP-complete} \) [1].

**Iterated Weak Dominance (IWD)**

**Instance:** A two-player game and a distinguished pure strategy \( i \).

**Parameter:** An integer \( k \).

**Question:** Is there a path of at most \( k \)-step of iterated weak dominance that eliminates the pure strategy \( i \)?

**Iterated Weak Dominance** is \( \text{W}[2] \)-hard [4]. Our last problem is related to the sub-game problem. Finding the smallest sub-game of a given game \( G = (A, B) \) using iterated elimination of strict dominated strategies can be performed in polynomial time. However, whether a distinguished sub-game of \( G = (A, B) \) can be reached (using strict domination) is \( \text{NP-complete} \) [2].

**Sub-game**

**Instance:** Games \( G = (A_{n \times n}, B_{n \times n}) \) and \( G' = (A'_{k \times k}, B'_{k \times k}) \).

**Parameter:** An integer \( k \).

**Question:** Is there a path of iterated strict dominance that reduces the game \( G \) to the game \( G' \)?

**Sub-game** is \( \text{W}[1] \)-hard [2].


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**A Parameterized Approach for And-Or Graphs and X-of-Y graphs**

by Uéverton dos Santos Souza, Fábio Protti and Maise Dantas da Silva, Federal University of Rio de Janeiro, Brazil. Uéverton recently completed his Master’s thesis with Supervisors Protti and Dantas da Silva, and is now working towards the Ph.D. with them.

We study and/or graphs and x-y graphs, two data structures that have been used to model problems in computer science. An and/or graph is an acyclic digraph containing a source (a vertex that reaches all other vertices by directed paths). Every vertex \( v \) has a label \( f(v) \in \{ \text{and}, \text{or} \} \), (weighted) edges represent dependency relations between vertices. A vertex labeled and depends on all of its out-neighbors (conjunctive dependency), while a vertex labeled or depends on only one of its out-neighbors (disjunctive dependency). X-y graphs are defined as a natural generalization of and/or graphs: every vertex \( v_i \) of an x-y graph has a label \( x_i - y_i \) to mean that \( v_i \) depends on \( x_i \) of its \( y_i \) out-neighbors.

And/or graphs have modeled problems in AI [11, 13], and other fields to model cutting problems [10], interference tests [7], failure dependencies [2], robotic task plans [3], assembly/disassembly sequences [5], game trees [8], software versioning [4], and evaluation of boolean formulas [9]. With respect to x-y graphs, they correspond to the x-out-of-y model of resource sharing in distributed systems [1].

Special directed hypergraphs \( F \)-graphs are equivalent to and/or graphs [6]. An \( F \)-graph is a directed hypergraph where hyperarcs are called \( F \)-arcs (for forward arcs), which are of the form \( E_i = (S_i, T_i) \) with \( |S_i| = 1 \). An \( F \)-graph \( H \) can be easily transformed into an and/or graph.

We analyze the complexity of Min-AND/OR and Min-X-Y, which consist of finding solution subgraphs of optimal weight for and/or and x-y graphs, respectively. A solution subgraph \( H \) of an and/or graph must contain the source and obey the following rule: if an and-vertex (resp. or-vertex) is included in \( H \) then all (resp. one) of its out-edges must also be included in \( H \). Analogously, if a vertex \( v_i \) is included in a solution subgraph \( H \) of an x-y graph then \( x_i \) of its \( y_i \) out-edges must also be included in \( H \).

In 1974, Sahni [12] showed that Min-AND/OR is NP-hard via a reduction from 3-SAT. Therefore, Min-X-Y is also NP-hard. We prove that Min-AND/OR remains NP-hard even for a very restricted family of and/or graphs where edges have weight one and or-vertices have out-degree at most two (apart from other property related to some in-degrees), and that deciding whether there is a solution subtree with weight exactly \( k \) of a given x-y tree is also NP-hard. We also show that: (i) the parameterized problem Min-AND/OR\((k, r)\), which asks whether there is a solution subgraph of weight at most \( k \) where every or-vertex has at most \( r \) out-edges with the same weight, is FPT; (ii) the parameterized problem Min-AND/OR\((k)\), whose domain includes and/or graphs allowing zero-weight edges, is \( \text{W}[2] \)-hard; (iii) the parameterized problem Min-X-Y\((k)\) is \( \text{W}[1] \)-hard. The question of classifying the parameterized problem Min-AND/OR\((k)\) for and/or graphs whose edges have positive weights remains open.
parameterized complexity news


9. Laber, E. S., A randomized competitive algorithm for evaluating priced and/or trees, Theoretical Computer Science, v. 401, n. 1, p. 120-130, 2008.


The Theory Blogosphere

by Neeldhara Misra, Column Editor, Institute for Mathematical Sciences, Chennai, India.

We continue our journey into the theory blogosphere.

My Brain is Open is the blog of Shiva Kintali http://kintali.wordpress.com. The latest posts include coverage of the Turing Centennial Celebration — a 3-day event hosted by Princeton Univ, celebrating Turing’s time there. Snippets from the film Breaking The Code are posted.


Simultaneously Satisfying Linear Equations Over $F_2$ by R. Crowston, M. Fellows, G. Gutin, M. Jones, F. Rosamond, S. Thomasse, A. Yeo. Input is a set of $m$ equations containing $n$ variables $x_1, \ldots, x_n$, of the form $\prod_{i \in I} x_i = b$. The $x_i$s and $b$ take values from $\{-1, 1\}$. Each equation has a positive weight. The objective is to find an assignment of variables such that the total weight of the satisfied equations is maximized. There is always an assignment satisfying half the equations, so the above guarantee version of the question is addressed. The authors show that the problem MAX-LIN[$k$] is FPT and admits a kernel of size $O(k^2 \log k)$, and give an $O(2^{O(k \log k)(nm)^c})$ algorithm.

Rainbow Connectivity: Hardness and Tractability by P. Ananth, M. Nasre, and K. K. Sarpatwar. A path in an edge colored graph is a rainbow path if no two edges on the path have the same color. Rainbow connected means there exists a (geodesic) rainbow path between every pair of vertices. The rainbow connectivity of a graph is the smallest number of colors required to edge color the graph such that $G$ is rainbow connected. The following problem is shown to be FPT: Given $G$, determine the maximum number of pairs of vertices that can be rainbow connected using two colors. The authors also address the more direct question of finding (strong) rainbow connectivity numbers, and derive hardness results in almost all cases.

Obtaining a Bipartite Graph by Contracting Few Edges by P. Heggernes, P. van’t Hof, D. Lokshtanov, C. Paul. Given a graph $G$, can we obtain a bipartite graph by contracting $k$ edges? This is a variant of the much-studied OCT problem, and it is established that the contraction variant is FPT, parameterized by $k$. The question of whether the problem has a polynomial kernel remains open.

Shtetl-Optimized. Towards the end of last year, the blog covered two recent improvements in the time required to multiply two $n$-by-$n$ matrices. The Coppersmith and Winograd algorithm required $O(n^{2.376})$. While being the best known for a couple of decades,
this has been improved twice in the space of two years, first in a PhD thesis by Andrew Stothers (2010), and then in a paper by Virginia Vassilevska Williams (2011), to $O(n^{2.374})$ and $O(n^{2.373})$ respectively: 

http://www.scottaaronson.com/blog/?p=839

**The Geomblog** This is the blog of Suresh Venkat, and his latest piece is about the *multiplicative weight update method*. He makes a case for why it should be taught as a standard algorithm tool that naturally follows from divide and conquer and prune-and-search, instead of being treated as an “advanced” method. The post begins by motivating randomized splitting for prune-and-search, and leads up to the intriguing conclusion that the MWU method can be thought of as a zombie binary search... and the post wraps up with the hope that you think of zombies whenever you think of MWU! More at http://geomblog.blogspot.com/2012/05/multiplicative-weight-updates-as-zombie.html.

**Elsevier and The Cost Of Knowledge.** Not strictly speaking a blog, http://thecostofknowledge.com/ is a protest against Elsevier’s business practices. A number of popular bloggers express their support. The website has a blog for updates and a list of 11503 signatures (and counting).

For those who would like to keep track of new blog posts, the content from nearly forty active blogs is conveniently “aggregated” at one central place, and can be found at http://feedworld.net/toc/.

**Celebrating our Colleagues in Industry**

Siamak Tazari has accepted an engineering position in the NYC office of Google. He says, “It was a very tough decision for me (to leave academia) and a very long process.”

While at MIT, Siamak co-taught, “Algorithms for Planar Graphs and Beyond.” The lectures are online at http://courses.csail.mit.edu/6.889/fall11/lectures/. In particular, Lectures 5-7, 9, 10, 16, 17, 22 and 24 are by Siamak. siamak.tazari--at--googlemail.com.

Siamak has been an important part of our parameterized community and we look forward to seeing him at future conferences and workshops. We would like to hear more from Siamak and others who have moved into industry about what the transition is like, how our community can better serve them, and what we can do to enhance the academia-industry relationship.

**Positions Available**

Univ. of Siegen. A PhD position at the interface of Computational Social Choice and Scheduling. Contact Gabor Erdélyi (erdelyi@wiwi.uni-siegen.de).

**Wedding Saket Saurabh**

Congratulations to Saket and Sushmita on their beautiful wedding. It was attended by Mike Fellows and Frances Rosamond, Serge Gaspers, Daniel Lokshtanov, Venkatesh Raman, and about 600 other people. It was marvelous.
Figure 3: Sushmita and Saket