Parameterized Complexity-News

The Newsletter of the Parameterized Complexity Community Volume 1, May 2005

Welcome

Frances Rosamond, Editor

Welcome to the first issue of the Parameterized Complexity Newsletter. Our aim is to be provocative and informative, suggesting new problems while keeping the community abreast of the rapidly expanding list of applications and techniques. Parameterized Complexity is well represented at conferences including ACiD organized by Stefan Szeider, WADS, Cocoon, Dagstuhl, as well as at meetings such the University of Queensland's Institute for Molecular Bioscience (keynote speakers included F. Dehne, M. Langston, M. Fellows). I predict that within a few years this small newsletter will transform into a powerful website, referenced by researchers worldwide–much as the stunning success of string theory, with its commensurate elaborate website, evolved from enthusiastic beginnings with a simple, modest newsletter.

We provide reviews of Fernau's Habilitationsschrift and van Rooij's dissertation, the latter introducing parameterized complexity as a new theory for psychology. The world records of FPT races (as we know them)are summarized. The newsletter has a Problem Corner and a section of research ideas, for which Mike Fellows has made many contributions. There are sections for recent papers and manuscripts, for conferences, and one to keep us up-to-date on new positions and occasions. Grant successes are mentioned for inspiration. We extend congratulations to new graduates.

Contributions, suggestions or requests to add or delete a name from my mailing list may be sent to the email address: (`fptnews@yahoo.com`). Suggestions for a logo for the newsletter are welcome. Copies of the newsletter will be archived at (`http://www.geocities.com/retreat4artscience/`).

Reviews: Fernau and van Rooij

Parameterized Algorithmics: A Graph-Theoretic Approach

by Henning Fernau. This comprehensive 540-page Habilitationsschrift is filled with examples that address the interest of practitioners as well as algorithm developers. Algorithms are presented as pseudo-code, easily translatable into real programs, and applications come from concrete case studies. As Henning says, "We hope that this style of the Habilitationsschrift helps proliferate the ideas of parameterizd algorithmics into real-world programs, a step that is mostly still lacking (as is the fate also for many clever algorithmic ideas according to our experience and according to talks with people that write "everyday pieces" of software)." A sense of the vast range of problems can be obtained from the summary in Chapter 12: Cover problems and their relatives (17 problems), Dominating problems and their relatives (19 problems), Graph modification problems (13), Further graph-theoretic problems (7), Graph drawing problems (15), Hypergraph problems (4), Network problems (5), Automata problems (5), Logical problems (4), Miscellaneous and applications (13 problems). Chapter 3 classifies parameters as internal or external, standard, multiple, dual and alterative parameterizations. Other chapters include Kernels, Search Trees, Graph Parameters, Limitations to Parameterized Algorithms, and Further Approaches which includes parameterized enumeration and non-standard methods and applications. (`http://www-fs.informatik.uni-tuebingen.de/~fernau/habil.pdf`). (Reviewed by Frances Rosamond.)

Contents of this issue:

Tractable Cognition: Complexity Theory in Cognitive Psychology

by Iris van Rooij, Ph.D. Dissertation, University of Victoria, 2004. One can point to two main functions of computational complexity theory in science, generally considered. The first of these is by far the most familiar: the role of complexity analysis in sharpening algorithm design as the tandem toolkits, the "negative" toolkit of methods for identifying intractability and establishing lower bounds, and the "positive" toolkit of algorithmic methods, interact to hopefully produce the best possible computational tools for realistic input distributions. The second pricipal role of computational complexity theory is in theory-formation and theory-critique in sciences that are concerned in one way or another with natural computational processes — such fields as Linguistics and Cognitive Psychology. (Perhaps areas of Economics and Biology are also ripe for this sort of consideration.) The general idea is that if your theory of, say, natural language processing, requires our heads to be computing noncomputable or totally infeasible functions, then there might be something wrong with your theory! This role for computational complexity theory in sciences concerned with natural forms of computing may have a very big future ahead. I am only aware of two efforts to apply parameterized complexity theory in this direction. Half of Todd Wareham's dissertation at the University of Victoria in 1999 was concerned with precisely this issue in Linguistics. The dissertation under review is an important first effort in this direction in Cognitive Psychology. As computational brain science develops over the next decades, this could be a very prescient piece of work. The philosophical grounds for the effort are very carefully handled, as is the account of previous work applying classical complexity to these ends. There are also quite a lot of interesting concrete analyses of combinatorial problems relevant to the area. This is an eloquent and I think important dissertation and well worth getting a copy of. It should become a monograph, and it would be great to see a Dagstuhl meeting at some point that explores this and related directions. (Reviewed by Mike Fellows.)

Established FPT Races

The results for some problems gradually keep improving, and the latest best results are summarized here. The table is not complete and we are awaiting information on your favorite problem for the next issue.

Established FPT Races

Problem	*f(k)*	**kernel**	**Sources**
Vertex Cover	1.2738^k	$2k$	1
FVS	10.567^k	8	2
Planar DS	$2^{16.472\sqrt{k}}$	$67k$	3
1-Sided Crossing Min	1.4656^k	8	4
Max Leaf	9.4815^k	$5.75k$	5
Set Splitting	2.6494^k	$2k$	6
Nonblocker	2.5154^k	$5k/3$	7
$k-$Path	33^k	None	1

1) J. Chen. Manuscript. May 2005 email.
2) F. Dehne, M. Fellows, M. Langston, F. Rosamond, K. Stevens. An $O^*(2^{O(k)})$ FPT Algorithm for the Undirected Feedback Vertex Set Problem. in *COCOON 2005 proceedings*, LNCS. Springer, 2005.
3) H. Fernau. Parameterized Algorithmics: A Graph-Theoretic Approach. *HabSchrift, Wilhelm-Schickard Institut fr Informatik, Universitt Tbingen, 2005.*
4) V. Dujmovic, H. Fernau, and M. Kaufmann. Fixed parameter algorithms for one-sided crossing minimization revisited. in G. Liotta-editor, *Graph Drawing, 11th International Symposium GD 2003*, volume 2912 of LNCS, pages 332-334. Springer, 2004.
5) E. Prieto-Rodriguez. Systematic Kernelization in FPT Algorithm Design, *Dissertation, University of Newcastle, Australia, 2005.*
6) D. Lokshtanov and C. Sloper. *ACiD 2005.*
7) F. Dehne, M. Fellows, H. Fernau, E. Prieto, and F. Rosamond. Nonblocker: Parameterized Algorithms for Minimum Dominating Set. Manuscript.
8) No known poly(k) kernel.

Exercise Corner

Exercise Corner: The Problem.
Stefan Szeider asked the following question, which makes an interesting exercise. The parameterized Hitting Set problem takes as input a family $\mathcal{F} \subseteq 2^X$ of a base set X, and k, and asks if there is a k-element subset of X, $H \subseteq X$, such that $\forall A \in \mathcal{F}$, A has nonempty intersection with the hitting set H. This is well-known to be complete for $W[2]$. Show that the following special case of the problem is fixed-parameter tractable: suppose that $\forall A, B \in \mathcal{F}$, $|A \cap B| \leq r$. Parameterize by (k, r).

Exercise Corner: The Solution. Observe that for a yes-instance, among any $k+1$ sets of $\mathcal{F}$, there must be at least two sets $A, B \in \mathcal{F}$ hit by the same element a. Thus, if $\mathcal{F}$ contains at least $k+1$ sets, then we can identify a pool of at most $r\binom{k+1}{2}$ elements of X, at least one of which must belong to any solution H. Branch on all these possibilities, and on each branch reduce the instance in the obvious way (e.g., deleting any sets that are hit). The total cost of the branching for the entire algorithm (since each branch decreases k by one) is at most $O^*((r\binom{k+1}{2}))^k)$. But one detail is missing: what do we do if $\mathcal{F}$ contains at most k sets? (Left to the reader.)

Research Ideas

For Further Research: Some Possibly Interesting Story Lines (contributed by Mike Fellows).

1. The Ultimate Parameterization for VERTEX COVER. VERTEX COVER is clearly the most popular parameterized problem of all time, and it would be extremely sad if fundamental investigation of its parameterized complexity should ever cease to produce new insights. There has been steady progress. The problem, parameterized by the number of vertices in a solution, has been shown to be solvable in time $O^*(1+\epsilon)^k$ for ever-decreasing ϵ. The question naturally arises about how far this can go. Can we get a result of this sort for ϵ arbitrarily small? It has recently become fashionable in parameterized complexity circles to parameterize on $k = 1/\epsilon$ especially because it so much fun to show that the good news about a lot of PTASs is not so good after all (even if the neighbors don't always agree about how much fun this is). Following fashion, we can so parameterize here, and confront:

THE ULTIMATE VERTEX COVER CHALLENGE

Input: A graph G, and k and $\epsilon > 0$.

Parameter: ϵ

Challenge: Determine whether the graph G has a k-element vertex cover in time $O^*((1+\epsilon)^k)$ for fixed ϵ.

The THE CHALLENGE is in XP if and only if the FPT algorithms for the ordinary parameterized VERTEX COVER problem can be improved with ϵ as small as we like, however with running times of the form $f(\epsilon)(1+\epsilon)^k n^{c_\epsilon}$ where the polynomial exponents c_ϵ may be increasing as ϵ gets smaller. Whether THE CHALLENGE is in XP is an interesting question. Could THE CHALLENGE be in FPT? It's not hard to show that if THE CHALLENGE is in FPT, then FPT = M[1]. (You have to tie k to n in a way that depends on f. E.g., if $f(\epsilon) = 2^{2^{1/\epsilon}}$ then something like $k = \log\log n$ works.) A consequence is that if you fix an acceptable polynomial exponent, such as $c = 3$, and ask how far we can improve FPT running times of the form $f(\epsilon)(1+\epsilon)^k n^c$ for VERTEX COVER, then the hardness result shows that there is a positive limit ϵ_c that we cannot get beyond. Can we show any actual positive lower bound on ϵ_3 now that we know it exists? How would we hope to do that? Furthermore, now that we know that the ULTIMATE CHALLENGE is hard for $M[1]$, can we show it is in XP, or would membership in XP somehow imply P=NP or something else improbable?

2. Parameters: Good, Bad and Ugly. I recently read a paper that offered the following disingenuous definition: a parameterized problem is *parameterized tractable* it said, if it is solvable in polynomial time for every fixed k. (Grumble, grumble.) (The paper is by Cohen, Jeavons and Gyssens, if you must know.) It is easy to discern the motivation to dissemble: the paper defines a number of new ("tractable") structural parameters, and shows good news results when these structural parameters are bounded. As for the issue of whether these new structural parameters are FPT or not — the authors don't seem to want to go there. A *good* parameter is FPT, and a *bad* parameter is W-hard. We know that. But even though these new parameters (somewhat akin to hypergraph hypertreewidth, which is bad) are probably bad — *all hope is not lost* because they might have been doing business with the wrong parameter! We know that "parameter identification" and "parameter selection" are monster categories. For example, for planar graphs, *the right parameter* is not treewidth, but branchwidth, because: (1) they are basically the same thing, up to a constant factor — a planar graph has bounded branchwidth if and only if it has bounded treewidth, while, (2) branchwidth of planar graphs is miraculously in P, while treewidth remains NP-hard. For another example, topological bandwidth is the wrong parameter, because it is hard for $W[t]$ for all t (Bodlaender, unpublished). The right parameter in this case is cutwidth, since cutwidth is FPT, and a graph has (up to a factor of 2 difference in the bound) bounded cutwidth if and only if it has bounded topological bandwidth. A parameter might be **bad**, but that doesn't mean it's **ugly**!

Definition. A parameter $\alpha(x)$ is *ugly* if and only if there is no FPT parameter β and constant c such that $\alpha(x) \leq k$ implies $\beta(x) \leq ck$ and $\beta(x) \leq k$ implies $\alpha(x) \leq ck$. Does anyone know any ugly parameters yet?

3. What About Quantum FPT? After several productive decades of showing the world that almost all interesting problems are NP-hard, and can't be approximated, exporting these vital messages to economics and social science, and pulling the PTAS routine where you announce "good news" (finally) but forget to tell the customer that for a 20% error that'll be an exponent of 90,000 — it has recently become extremely fashionable in normal theoretical computer science to prove theorems about what probably can't be done on machines you probably can't build: the great white hope of *quantum computing*. Shouldn't parameterized complexity be paying attention and joining this new bandwagon? After all, the physicists are talking about *maybe* getting one of these things up and running with 20 or 30 qubits, which is in the normal range of concern of parameterologists. Furthermore, what you get from k qubits is along the lines of $2^{O(k)}$ computing power, so altogether this looks like a match made in heaven, if not Fantasyland. So far, the field of parameterized complexity has been slow to rise to this opportunity. But how to get started? If you've thought about it for a minute, you probably thought: "FPT on a quantum computer is ... FPT," and it doesn't look so interesting. But wait a minute. This deserves a second thought. The following might be a possible place to start. *Definition.* A parameterized problem Π is in *quantum FPT* (QFPT) if and only if a decision about (x, k) can be reached in polynomial time on a k' qubit quantum computer, where k' is some function of k.

In other words, QFPT could be reasonably defined as that part of FPT that can be pushed down into P with the power of k' qubits.

Grant Success

Congratulations to Janier Chen who has recently received two NSF grants supporting his research in parameterized computation:

- Computational Upper and Lower Bounds via Parameterized Complexity, National Science Foundation, PI: Jianer Chen, September 1, 2004 to August 31, 2007.
- Exact Computational Biology Algorithms with Small Parameters, National Science Foundation, co-PIs: Sing-Hoi Sze and Jianer Chen, September 1, 2003 to August 31, 2006.

Resources

Marco Cesati's excellent compendium is `http://bravo.ce.uniroma2.it/home/cesati/research/compendium/`. The core set of problems can also be found in lists of Michael Hallett and H. Tod Wareham.

Rolf Neidermeier's group puts their publications and many other helpful items on their excellent web page `http://www.minet.uni-jena.de/www/fakultaet/theinf1/publications`.

New Results and Publications

New Results

Janier Chen reports that his group has found some natural complete problems for W[3] and W[4]. These are from the applications in supply chain management. A paper on this will appear in AAIM'05.

Publications and Manuscripts

There are at least three FPT papers at WADS 2006:

1. *Improved Fixed-Parameter Algorithms for Two Feedback Set Problems.* J. Guo, J. Gramm, F. Hffner, R. Niedermeier, and S. Wernicke.
2. *Parameterized Counting Algorithms for General Graph Covering Problems.* N. Nishimura, D. Thilikos, and P. Ragde.
3. *Parameterized Complexity of Generalized Vertex Cover problems.* J. Guo, R. Niedermeier, and S. Wernicke.

Interesting unpublished papers:

D. Marx. *Complexity of Clique Coloring and Related Problems*, (`http://www.cs.bme.hu/~dmarx/publications.html`).

R. Christian, M. Fellows, F. Rosamond, A. Slinko. *On Complexity of Lobbying in Multiple Referenda*, to be published in Review of Economic Design, December 2005. (`a.slinko@auckland.ac.nz`).

Conferences

Dagstuhl

24.07.-29.07.05, Seminar N 05301 *Exact Algorithms and Fixed-Parameter Tractability*, organized by R. Downey (Univ. of Wellington, NZ), M. Grohe (HU Berlin, DE),

M. Hallett (McGill Univ., CA), G. Woeginger (Univ. of Twente, NL). Rod Downey has been approached by Alan Selman regarding editing a volume of the journal, *Theory of Computing Systems* (formerly *Math Systems Theory*) devoted to related to refereed papers from the Dagstuhl meeting.

IWPEC

The 2006 IWPEC Conference will co-locate with ESA and ALGO.

Out and About

Position Changes

Rudolf Fleischer is Full Professor at Fudan University, Shanghai, PRC. Stefan Szeider is Lecturer and member of a newly established research group on Algorithms and Complexity at Durham University (`http://www.dur.ac.uk/computer.science/research/`).

Henning Fernau has taken a position at University of Hertfordshire, UK.

Prof. Karsten Weihe is at TU Darmstadt, Fachbereich Informatik, Darmstadt Univ. Technology, Dept. Computer Science.

Frank Dehne will return to Carlton University in January 2006, leaving Griffith University, Australia.

Who's Visiting Who

Patricia Evans is spending part of her sabbatical with Ulrike Stege at the University of Victoria, and will most likely attend ISMB (Intelligent Systems for Molecular Biology).

Venkatesh Raman is busy consulting for an analytics startup company in Chennai. His students Saket and Somnath are working hard on exact and parameterized complexity of several problems.

Detlef Seese and Petr Hlineny continue their work on matroids, including an old conjecture of Detlef's: Let K be a class of countable structures. If K has a decidable MSO-theory then there is a class T of trees in such a way that the MSO-theory of K is interpretable into the MSO-theory of T. The last is for graphs equivalent to having bounded clique-width.

Mike Langston is spending his sabbatical at the Oakridge National Laboratories (home of the Mouse House). He is using fpt clique algorithms to extract groups of highly interconnected transcripts (cliques) from genetic correlation matrices containing millions of expresion level correlations. Mike visited Faisal Abu-Khzam in Beirut in March doing sight-seeing and research, including a new Face Cover paper with Henning Fernau.

Occasions

Birthdays and Babies

A very happy birthday to Stefan Arnborg, who celebrated his 60th birthday this year. Andrzej Proskurowski and Detlef Seese attended the honorary coloquium in Stockholm. Detlef says, "It was great."

Two-year old Sophia, daughter of Mike Hallett and Bettina is expecting a little brother or sister in July. She must wait until Mike returns from giving a 3 week course in Bogota, Columbia in June.

Marco Cesati and Tole are the proud parents of their first daughter, Elena.

Benjamin Juedes, six month old son of David and Lucy is in the 90%-ile for height. David promises, "I'll teach him some parameterized complexity as soon as he can talk. Right now, he is working on the parameterized complexity of smashed peas and carrots."

Dr. Abu-Khzam is the proud father of a new baby, Dalia joining a sister Nadine.

Congratulations, Doctor!

Faisal N. Abu-Khzam. *Topics in Graph Algorithms: Structural Results and Algorithmic Techniques, with Applications.* University of Tennessee, 2003. Advisor: Michael Langston. Dr. Abu-Khzam is Assistant Professor in the Division of Computer Science and Mathematics at Lebanese American University in Beirut. (www.cs.utk.edu/ abukhzam) Faisal receives support from Oak Ridge National Lab through a subcontract with LAU, which provides a one course teaching relief. Faisal reports:

I have five graduate students; two are working on projects common with my PhD advisor, Mike Langston. A student is working on the phylogenetic footprinting problem. She will implement the latest FVS algorithms. Another student is working on maximal clique enumeration. We don't have a PhD program yet. My students are MS students, and most of their projects are implementations of sequential and parallel algorithms.

Jochen Alber. *Exact Algorithms for NP-hard Problems on Networks: Design, Analysis, and Implementation.* Wilhelm-Schickard Institut fr Informatik, Universitt Tbingen, 2002. Advisor: Rolf Niedermeier. Jochen Alber is working in industry (non-FPT) on algorithms and optimizaion. His employer's webpage: http://www.\digsilent.de/ (Optimizing electrical networks.) (http://www-fs.informatik.uni-tuebingen.de/~alber/publications.html)

Jens Gramm. *Fixed-Parameter Algorithms for the Consensus Analysis of Genomic Data.* Wilhelm-Schickard Institut fr Informatik, Universitt Tbingen, 2003. Advisor: Rolf Niedermeier. (http://www-fs.informatik.uni-tuebingen.de/~gramm/publications/index.html)

Xiuzhen Huang. *Parameterized complexity and polynomial-time approximation schemes.* Department of Computer Science, Texas A&M University, 2004. Advisor: Jianer Chen. Dr. Huang has joined the Department of Computer Science, Arkansas State University, as a tenure track assistant professor. (www.csm.astate.edu/~xzhuang/)

Daniel Marx. *Graph coloring with local and global constraints.* Department of Computer Science, Budapest University of Technology and Economics, 2004. Dr. Marx will be joining Martin Grohe in Berlin in May as a postdoctoral fellow. Daniel's excellent website includes his publications and also the slides of his CCC/Freiburg talk. (http://www.cs.bme.hu/~dmarx/publications.html)

Catherine McCartin. *Contributions to Parameterized Complexity.* Victoria University of Wellington, 2003. Advisor: Rod Downey. Dr. McCartin is on the faculty of computer science at Massey University. (http://www-ist.massey.ac.nz/mccartin/~Mypubs/mccartinthesis.pdf)

Andrew D. Smith. *Common Approximate Substrings.* University of New Brunswick, 2004. Advisor: Patricia Evans. Dr. Smith is doing a postdoc with Michael Zhang at Cold Spring Harbor Labs.

Sagi Snir. *Computational Issues in Phylogenetic Reconstruction: Analytical Maximum Likelihood Solutions, and Convex Recoloring.* Technion, Israel, 2004. Advisor: Benny Chor. Dr. Snir is doing a postdoc with Lior Pachter in mathematics at UCBerkeley. (www.cs.technion.ac.il/~ssagi/)

Iris van Rooij. *Tractable Cognition: Complexity Theory in Cognitive Psychology.* University of Victoria, Canada, 2003. Advisor: Ulrike Stege and Helen Kadlec. Dr. van Rooij is a post-doctoral researcher in the JDM group at Technische Universiteit Eindhoven. (http://www.ipo.tue.nl/homepages/ivrooij/)

Vida Dujmovic. *Track Layouts of Graphs.* McGill University, 2004. Advisor: Sue Whitesides. Dr. Dujovic has accepted an NSERC Postdoctoral Fellow at Carlton University School of Computer Science and was awarded the D. W. Ambridge prize as McGill's Outstanding Ph.D. graduate in Science and Engineering. (http://cg.scs.carleton.ca/ vida/pubs/pubs.html)

Soon to become Doctors

The following have very nearly finished. Keep them in mind for post-doc positions.

Elena Rodriguez-Prieto. *Systematic Kernelization in FPT Algorithm Design.* The University of Newcastle, Australia. Advisors(now on leave): Mike Fellows, Fran Rosamond. Current Advisor: Pablo Moscato.

Matt Suderman. *Layered Graph Drawing.* The dissertation presents both theoretical results and experimental work with FPT algorithms for layered graph drawing. Advisor: Sue Whitesides, McGill University. Contratulations to Matt for being awarded a 2-year NSERC post-doctoral fellowship. He will be working with Mike Hallett at MCB after his defense.

Aleksandr Slivkins. Ph.D. in Computer Science, expected June 2006. Cornell University, Ithaca NY. Committee: Jon Kleinberg, Eva Tardos and Emin G. Sirer.

Christian Sloper. Tentative version is *Algorithmic techniques for FPT.* Christian is in Prague on a COMBSTRU grant. He recommends the Bohemian Woods National Park. Master's Thesis: *Parameterized complexity and the method of testsets.* University Bergen. Advisor: Jan Arne Telle. (http://www.ii.uib.no/~sloper/)