05301 Abstracts Collection
Exact Algorithms and Fixed-Parameter Tractability
— Dagstuhl Seminar —

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Abstract. From 24.07.05 to 29.07.05, the Dagstuhl Seminar 05301 "Exact Algorithms and Fixed-Parameter Tractability" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. This is a collection of abstracts of the presentations given during the seminar.

Keywords. Fixed-parameter tractability, parameterized complexity, exact algorithms

05301 Summary – Exact Algorithms and Fixed-Parameter Tractability

Summary of the Dagstuhl Seminar held 24. July–29. July 2005.

Keywords: Fixed-parameter tractability, parameterized complexity, exact algorithms

Joint work of: Downey, Rod; Grohe, Martin; Woeginger, Gerhard

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/439

Combinatorial Games in Proof Complexity

Albert Atserias (TU of Catalonia - Barcelona, E)

Propositional proof complexity was originally motivated by Cook's program and the NP vs co-NP question, but has smoothly evolved into the more feasible program of better understanding practical proof system that people use. This better understanding sometimes leads to new ideas for developing and analysing algorithms for NP-complete problems, such as search-based algorithms based on resolution, and also integer or linear programming algorithms based on cutting planes or the Lovasz-Schrijver proof system. In this talk we overview the recent characterizations of the complexity of sequent-based calculus in terms of a certain class of Ehrenfeucht-Fraisse games that were introduced independently in the context of finite model theory. In the particular case of resolution, the characterization provides new insights in the width vs. space problem for resolution, and also on the influence of the treewidth of an unsatisfiable 3-CNF formula.

The new result is that, in a certain technical but precise sense, the only "rich" classes of formulas for which bounded width resolution is complete are the classes of formulas of bounded treewidth.

Keywords: Propositional proof complexity, sequent calculus, Ehrefeucht-Fraisse games, resolution, 3-CNF formulas, treewidth

Algorithms in the W-Hierarchy

Jonathan Buss (University of Waterloo, CDN)

We develop the "AW-program" model of Chen/Flum/Grohe, showing that more powerful operations are permissible on the guess registers, without changing the power of the model. In particular, for W[t], $t \geq 2$, no restrictions are required on the use of guess registers after the initial nondeterministic block.

These results lead to improvements for some problems in W[P] and/or L[2]:

(1) Some nontrivial subclasses of these are in W[2].

(2) Improved bounds for various problems: Subset Sum (in W[3]), Maximal Irredundant Set, Bounded DFA intersection, and related problems.

Keywords: W-hierarchy, AW-programs, Subset Sum, Bounded DFA Intersection

Joint work of: Buss, Jonathan F.; Islam, Tarique M

Some Results in Structural Parameterized Complexity

Jianer Chen (Texas A&M University, USA)

This talk reports research results in two pieces of work I have done recently with my colleagues. The first is with Zhang, and the second is with Huang, Kanj, and Xia. Details are given as follows.

1. we present natural complete problems for the classes W[3] and W[4]. These seem the first group of natural complete problems for higher levels in the W-hierarchy beyond the generic complete problems based on weighted satisfiability on bounded depth circuits.

The problems come from the study of supply chain management, which has been growing at a rapid pace in recent years as a research area and as a practical discipline.

2. Motivated by the recent pregress in strong lower bounds for parameterized problems, we introduce the concept of linear fpt-reductions. We then formally investigate the notions of W[t]-hardness and W[t]-completeness under the linear fpt-reductions and study the structural properties of the corresponding complexity classes. Strong computational lower bounds for many important computational problems are established based on this study.

Keywords: Structural complexity, lower bound, W-hierarchy, complete problem

An Isomorphism between Exponential Time and Parameterized Complexity

Yijia Chen (HU Berlin, D)

We show an isomorphism between exponential time complexity and parameterized complexity of the problems in the class EPT and the class uniform-XP via the miniaturization mapping.

Joint work of: Chen, Yijia; Grohe, Martin

A spectral heuristic for bisecting random graphs

Amin Coja-Oghlan (HU Berlin, D)

In the minimum bisection problem the objective is to partition the vertices of a given graph into two classes of equal size so as to minimize the number of crossing edges. Popular heuristics for solving this problem are based on spectral techniques. Here we analyze a spectral heuristic rigorously on a suitable model of random instances; the result is that spectral techniques in combination with elementary combinatorial methods yield an optimal bisection of the random input almost surely.

Keywords: Minimum bisection problem, spectral techniques, random graphs

Full Paper: http://www.informatik.hu-berlin.de/ coja/bisect.ps

M[1] and Its Uses

Mike Fellows (University of Newcastle, AU)

The last couple of years have seen the discovery and development of new techniques in the parameterized complexity toolkit connected with the new and rather natural parameterized intractability class M[1] that sits in the tower: FPT contained in M[1] contained in W[1].

The appearance of any such class between FPT and W[1] is quite surprising to oldtimers. M[1] seems to be both interesting and important to the concrete concerns of the working parameterologist. It is also strongly related to the concerns of exact exponential classical complexity by the connection that FPT=M[1] iff n-variable 3SAT can be solved in time 2 to the exponent little o(n).

The intuitive grounding of the hypothesis that FPT is not equal to W[1] is essentially the same as for P not equal to NP and is quite firm. The hypothesis that FPT is not equal to M[1] is much less so. In view of the "ordinary working usefulness" of the M[1] reference point, the question of whether M[1] = W[1] therefore appears central to both fields, and it also perhaps is approachable. Very little is known.

Based on the supposed parameterized intractability of M[1] are three new tools for addressing the complexity of a wide variety of concrete problems:

(1) M[1] seems possibly to be a quite convenient starting point for proofs of parameterized intractability, (2) M[1] supports a way of analyzing "optimality" of FPT results — e.g., no FPT algorithm for PLANAR VERTEX COVER can be O-star 2 to the exponent little o(sqrt(k)) unless FPT = M[1], and (3) "XP optimality" can also be analyzed, e.g., there can be no n to the exponent little o(k) algorithm for k-INDEPENDENT SET unless FPT = M[1].

The talk will survey the definition and uses of M[1], and especially try to convey a "how to" sense of the new tools for parameterized complexity analysis based on M[1], and highlight some of the fundamental open problems.

Keywords: Parameterized complexity, miniature classes, exponential time

Parameterized Algorithmics for Linear Arrangement Problems

Henning Fernau (Univ. of Hertfordshire - Hatfield, GB)

We discuss different variants of linear arrangement problems from a parameterized perspective. More specifically, we concentrate on developing simple search tree algorithms for these problems.

However, the analysis of these algorithms is sometimes not so easy.

We were tempted to call our paper (less technically): “Simplified means parameterized tractable,” inspired by the title “Some simplified NP-complete graph problems," of a now classical paper written by Garey, Johnson, and Stockmeyer back in 1976.

Namely, there they list a number of problems, amongst them problems on planar graphs and on graphs with degree bounds, as well as more logical problems like; all of the corresponding optimization problems, when parameterized in a standard way, have been shown to be parameterized tractable, well, all of them but one case, which is the family of linear arrangement problems, the problem we treated here.

This justifies the alternative title we were inclined to use.

Keywords: Parameterized algorithms, linear arrangement problems

Bounded Fixed-Parameter Tractability

Jörg Flum (Universität Freiburg, D)

In the definition of fixed-parameter tractability arbitrary computable functions are allowed to bound the dependence on the parameter of the running time.

This liberal definition is mainly justified by the hope that "natural" problems in FPT will have "low" parameter dependence.

While this is true for many problems, there are important exceptions.

There are viable alternatives to the notion of fixed-parameter tractability obtained by simply putting upper bounds on the growth of the parameter dependence.

In the talk we introduce a general framework of "bounded fixed-parameter tractability", address the question of how to define the notion of many-one reductions, and study the analogue of the class W[P]. Furthermore, we present some concrete results for one specific bounded theory, namely for the case where we restrict the parameter dependence by a function in $2^{O(k)}$.

Width parameters and exact algorithms

Fedor V. Fomin (University of Bergen, N)

Dynamic programming is one of the common tool used in the design of exact algorithms.

Here we discuss how structural properties of graphs and combinatorial bounds can be used to obtain fast exponential algorithms on planar and sparse graphs.

We also show how this technique can be used for parameterized algorithms.

Keywords: Treewidth, branchwidth, planar graph, sparse graph

Improved Algorithms and Complexity Results for Power Domination in Graphs

Jiong Guo (Universität Jena, D)

The Power Dominating Set problem is a variant of the classical domination problem in graphs:

Given an undirected graph $G = (V, E)$, find a minimum $P \subseteq V$ such that all vertices in V are "observed" by vertices in P.

Herein, a vertex observes itself and all its neighbors, and if an observed vertex has all but one of its neighbors observed, then the remaining neighbor becomes observed as well.

We show that Power Dominating Set can be solved by "bounded-treewidth dynamic programs." Moreover, we simplify and extend several NP-completeness results, particularly showing that Power Dominating Set remains NP-complete for planar graphs, for circle graphs, and for split graphs.

Specifically, our improved reductions imply that Power Dominating Set parameterized by |P| is W[2]-hard and cannot be better approximated than Dominating Set.

Joint work of: Guo, Jiong; Niedermeier, Rolf; Raible, Daniel

Width parameters of graphs and matroids

Petr Hlineny (Techn. University - Ostrava, CZ)

We will review some known "width" parameters of graphs, and relate them to matroids.

In particular, we use matroids to introduce a vertex-free definition of graph tree-width, and we show how matroid branch-width is related with decidability of MSO theories of both matroids and graphs (cf. rank-width).

Keywords: Tree-width, branch-width, clique-width, rank-width, matroid

Joint work of: Hlineny, Petr; Seese, Detlef; Whittle, Geoff

Algorithm Engineering for Optimal Graph Bipartization

Falk Hüffner (Universität Jena, D)

We examine exact algorithms for the NP-complete problems Edge Bipartization and Vertex Bipartization that ask for a minimum set of vertices (resp. edges) to delete from a graph to make it bipartite.

Based on the "iterative compression" method recently introduced by Reed, Smith, and Vetta, we present a new algorithm for Edge Bipartization running in $O(2^k m^2)$ time, where m is the number of edges in the input and k is the number of edges to delete. We extend this algorithm to give an alternative presentation of the $O(3^k kmn)$ time algorithm by Reed et al., thereby hopefully making this interesting result more accessible. We then present a way to save a factor of k in the run time, and give a heuristic method to speed up the algorithm in particular for dense graphs. Our best algorithm can solve all problems from a testbed from computational biology within minutes, whereas established methods are only able to solve about half of the problems within reasonable time.

A New Parameter for Clique Problems

Kazuo Iwama (Kyoto University, J)

For a given graph G of n vertices and m edges, a clique S of size k is said to be c-isolated if there are at most ck outgoing edges from S. It is shown that this parameter c is an interesting measure which governs the complexity of finding cliques. Our main result says that for a given graph G and an integer $c \geq 1$, all c-isolated maximum cliques can be enumerated in time $O(c^5 \times 2^{2(c-1)} \times m)$. In particular, if c is a constant, then we can enumerate all c-isolated maximal cliques in linear time and in polynomial time if $c = O(\log n)$. Note that there is a graph which has a superlinear number of c-isolated cliques if c is not a constant and a superpolynomial number of those if $c = \omega(\log n)$. In this sense our algorithm is optimal for the linear-time and polynomial-time enumeration of c-isolated cliques. Some applications to an analysis of Web graphs are also mentioned.

Joint work of: Hiro Ito, Iwama, Kazuo; Osumi, Tsuyoshi

Improved Upper Bound for Vertex Cover

Iyad Kanj (DePaul Univ. - Chicago, USA)

We present an $O(1.2738^k + kn)$-time polynomial-space algorithm for VERTEX COVER improving the previous $O(1.286^k + kn)$-time polynomial-space upper bound by Chen, Kanj, and Jia. Most of the previous algorithms rely on exhaustive case-by-case analysis, and an underlying conservative worst-case-scenario assumption. The contribution of the paper lies in the *extreme* simplicity, uniformity, and obliviousness of the algorithm presented. Several new techniques, as well as generalizations of previous techniques, are introduced including: *general folding*, *struction*, *tuples*, and *local amortized analysis*. The algorithm also improves the $O(1.2745^k k^4 + kn)$-time exponential-space upper bound for the problem by Chandran and Grandoni.

Keywords: Vertex cover, parameterized algorithms, upper bounds

Joint work of: Jianer Chen; Kanj, Iyad; Ge Xia

On the Parameterized Complexity of Exact Satisfiability Problems

Joachim Kneis (RWTH Aachen, D)

For many problems, the investigation of their parameterized complexity provides an interesting and useful point of view.

The most obvious natural parameterization for the maximum satisfiability problem—the number of satisfiable clauses—makes little sense, because at least half of the clauses can be satisfied in any formula. We look at two optimization variants of the exact satisfiability problem, where a clause is only said to be fulfilled iff exactly one of its literals is set to *true*. Interestingly, these variants behave quite differently. In the case of ResMaxExactSAT, where over-satisfied clauses are entirely forbidden, we show fixed parameter tractability. On the other hand, if we choose to ignore over-satisfied clauses, the MaxExactSAT problem is obtained. Surprisingly, it is W[1]-complete. Still, restricted variants of the problem turn out to be tractable.

Joint work of: Kneis, Joachim; Mölle, Daniel; Richter, Stefan; Rossmanith, Peter

Measure and Conquer: Domination - A Case Study

Dieter Kratsch (Université de Metz, F)

Davis-Putnam-style exponential-time backtracking algorithms are among the most common algorithms used for finding exact solutions of NP-hard problems. The analysis of such recursive algorithms is based on the bounded search tree technique: a measure of the size of the subproblems is defined; this measure is used to lower bound the progress made by the algorithm at each branching step.

For the last 30 years the research on exact algorithms has been mainly focused on the design of more and more sophisticated algorithms.

However, measures used in the analysis of backtracking algorithms are usually very simple. In this talk we stress that a more careful choice of the measure can lead to a significantly better worst case time analysis.

As an example, we consider the minimum dominating set problem. The currently fastest algorithm for this problem has been shown to have running time $O(1.81^n)$ (up to polynomial factor) on n-vertex graphs. By measuring the progress of the (same) algorithm in a different way, we refine the time bound to (1.52^n) (up to polynomial factor).

Keywords: Exponential-time algorithms, NP-hard problems, minimum dominating set problem

Joint work of: Fomin, Fedor; Grandoni, Fabrizio; Kratsch, Dieter

Tricks in Splitting Algorithms Analysis and Design: A New Upper Bound for MAX-2-SAT

Alexander S. Kulikov (Steklov Inst. - St. Petersburg, RUS)

Currently best known upper bounds for many NP-hard problems are proven by using splitting method.

Usually the analysis of a splitting algorithm contains a big number of cases. This implies that many modern papers describing splitting algorithms are quite difficult to read and verify. For this reason, recently several programs for automated case analysis appeared. In the talk I will give two simple examples of improvement of splitting algorithms and their analysis.

Namely, a procedure for simplifying CNF formulas that generalizes many known simplification rules will be presented. It is also possible to improve an upper bound on the running time of a splitting algorithm by estimating its running time w.r.t. combined complexity measure. As a result we obtain a computer assisted proof of new upper bounds for particular cases of the MAX-SAT problems (including MAX-2-SAT).

Recent Progress on Large-Scale FPT Applications

Michael A. Langston (University of Tennessee, USA)

Computational biology continues to deliver timely problems and huge volumes of data to drive FPT-based methods. A variety of applications are discussed. New tools for systems biology are described in the context of radiation response analysis.

The Closest Substring problem with small distances

Daniel Marx (HU Berlin, D)

The Closest Substring problem is a string matching problem motivated by applications in computational biology: given k strings and integers d and L, the task is to find a string s of length L such that each of the k strings has a substring of length L whose Hamming distance is at most d from the string s. We present two exact algorithms for the problem with running times $f(d)n^{O(\log d)}$ and $f(d,k)n^{O(\log\log k)}$, respectively. We also investigate the parameterized complexity of the problem, and show that it is W[1]-hard even if d and k are both parameters. The hardness result shows that the two algorithms are optimal in the sense that the exponent of n cannot be $o(\log d)$ or $o(\log\log k)$, unless FPT=M[1].

Parameterized Complexity of Generalized Vertex Cover Problems

Rolf Niedermeier (Universität Jena, D)

Important generalizations of the Vertex Cover problem have been intensively studied in terms of approximability.

However, their parameterized complexity has so far been completely open. We close this gap here by showing that, with the size of the desired vertex cover as parameter, Connnected Vertex Cover and Capacitated Vertex Cover are both fixed-parameter tractable while Maximum Partial Vertex Cover is W[1]-hard. This answers two open questions from the literature. The results extend to several closely related problems. Interestingly, although the considered generalized Vertex Cover problems behave very similar in terms of constant-factor approximability, they display a wide range of different characteristics when investigating their parameterized complexities.

Joint work of: Guo, Jiong; Niedermeier, Rolf; Wernicke, Sebastian

Graphs of Bounded Rank-width

Sang-il Oum (Princeton University, USA)

We review results on clique-width and rank-width discussed in my thesis paper.

We define rank-width of graphs to investigate clique-width.

Rank-width is a complexity measure of decomposing a graph in a kind of tree-structure, called a rank-decomposition.

We show that graphs have bounded rank-width if and only if they have bounded clique-width.

It is unknown how to recognize graphs of clique-width at most k for fixed $k > 3$ in polynomial time.

However, we find an algorithm recognizing graphs of rank-width at most k, by combining following three ingredients.

First, we construct a polynomial-time algorithm, for fixed k, that confirms rank-width is larger than k or outputs a rank-decomposition of width at most $f(k)$ for some function f.

It was known that many hard graph problems have polynomial-time algorithms for graphs of bounded clique-width, however, requiring a given decomposition corresponding to clique-width (k-expression); we remove this requirement.

Second, we define graph vertex-minors which generalizes matroid minors, and prove that if $\{G_1, G_2, \ldots\}$ is an infinite sequence of graphs of bounded rank-width, then there exist $i < j$ such that G_i is isomorphic to a vertex-minor of G_j.

Consequently there is a finite list $\mathcal{C}_k$ of graphs such that a graph has rank-width at most k if and only if none of its vertex-minors are isomorphic to a graph in $\mathcal{C}_k$.

Finally we construct, for fixed graph H, a modulo-2 counting monadic second-order logic formula expressing a graph contains a vertex-minor isomorphic to H.

It is known that such logic formulas are solvable in linear time on graphs of bounded clique-width if the k-expression is given as an input.

Another open problem in the area of clique-width is Seese's conjecture; if a set of graphs have an algorithm to answer whether a given monadic second-order logic formula is true for all graphs in the set, then it has bounded rank-width.

We prove a weaker statement; if the algorithm answers for all modulo-2 counting monadic second-order logic formulas, then the set has bounded rank-width.

Keywords: Clique-width, rank-width, local complementation, Seese's conjecture, branch-width, well-quasi-ordering, monadic second-order logic

Problems with Closure Properties: Exact Algorithms and Parameterization

Stefan Porschen (Universität Köln, D)

IIn this talk we introduce a specific class of problems called CLOS. Members of CLOS are characterized by a specific equivalence relation (e.r.) underlying their search space such that partial feasible solutions are class invariants. Such an e.r. is closely related to a closure operator providing a distinct system of class representatives. Relying on that closure property we propose a parameterization approach for problems in CLOS.

By assuming some additional computational conditions one obtains fixed-parameter tractability results in the CLOS class.

We discuss some examples of problems with closure property and show how it may help to reduce time complexity or to obtain FPT time bounds.

Adapting some old/new ideas to 3SAT

Mike Robson (LaBRI - Bordeaux, F)

We present an algorithm for deciding 3SAT which incorporates some new ideas and has a run time bounded by $O(1.516185^n)$.

While this is not yet competitive with the best known algorithms ($O(1.481^n)$), it represents only a first step in exploiting these new methods and further reductions are certainly possible.

Keywords: 3SAT, exact algorithms

An $O*((2+epsilon)^k)$-Algorithm for the Steiner Tree Problem

Peter Rossmanith (RWTH Aachen, D)

For decades, the best algorithm for the Steiner tree problem has been the one by Dreyfus and Wagner. In this paper, a new algorithm is developed, which improves the running time from $O(3^k \cdot n^3)$ to $(2+\delta)^k \cdot \text{poly}(n)$ for arbitrary $\delta > 0$. Like its predecessor, it follows the dynamic programming paradigm. Whereas in effect the Dreyfus–Wagner recursion splits the optimal Steiner tree in two parts, our approach looks for multiple articulation nodes that separate the tree into parts containing only few terminals. It is then possible to solve an instance of the Steiner tree problem more efficiently by combining partial solutions.

Keywords: Parameterized complexity, Steiner Tree, Exact Algorithms

Joint work of: Moelle, Daniel; Richter, Stefan; Rossmanith, Peter

Exact algorithms for 3-Colourability

Ingo Schiermeyer (TU Bergakademie Freiberg, D)

We will show that for a graph G of order n and maximum degree $\Delta(G)$ $geqcn$ for some $c > 0$, 3-Colourability can be solved in $O*(1,4422^{(1-c)n})$.

For special classes of graphs 3-Colourability can be solved in polynomial time. Recently it has been shown that 3-Colourability can be solved in polynomial time for the class of P_6-free graphs (graphs containing no induced path on six vertices). We will also present some other classes of graphs with this property.

Algorithmics of Excponential Time

Uwe Schöning (Universität Ulm, D)

We present examples of varios techniques being able to improve the naive 2^n bound for brute-force search in case of NP-complete problems.

The techniques are Clever Enumeration and Backtracking, Random Reduction to some easy problem, Randomization of the evaluation order, Local Search (deterministically or via random walks), biased coins for producing an initial solution.

The problems we consider are 3-SAT, 3-Colorability, Subset Sum, And-Or Tree evaluation.

Keywords: Exponential algorithms

From graphs to matroids and back: some remarks on MSO, decidability and structure

Detlef G. Seese (Universität Karlsruhe, D)

The talk discusses structural reasons implying undecidability of monadic theories of graphs and matroids and implications on the structure of models of decidable theories.

Keywords: MSO logic, decidability, undecidability, structure, tree width, graphs, matroids

Joint work of: Seese, Detlef G.; Hlineny, Petr

Haplotyping with Missing Data via Perfect Path Phylogenies

Till Tantau (TU Berlin, D)

Computational methods for inferring haplotype information from genotype data are used in studying the association between genomic variation and medical condition. Recently, Gusfield proposed a haplotype inference method that is based on perfect phylogeny principles.

A fundamental problem arises when one tries to apply this approach in the presence of missing genotype data, which is common in practice. We show that the resulting theoretical problem is NP-hard even in very restricted cases.

To cope with missing data, we introduce a variant of haplotyping via perfect phylogeny in which a *path* phylogeny is sought.

Searching for perfect path phylogenies is strongly motivated by the characteristics of human genotype data: 70% of real instances that admit a perfect phylogeny also admit a perfect path phylogeny. Our main result is a fixed-parameter algorithm for haplotyping with missing data via perfect path phylogenies. We also present a linear-time algorithm for the problem on complete data.

Joint work of: Gramm, Jens; Nierhoff, Till; Sharan, Roded; Tantau, Till

Parameterized Counting Algorithms for General Graph Covering Problems

Dimitrios Thilikos (TU of Catalonia - Barcelona, E)

We examine the general problem of covering graphs by graphs: given a graph G, a collection $\mathcal{P}$ of graphs each on at most p vertices, and an integer r, is there a collection $\mathcal{C}$ of subgraphs of G, each belonging to $\mathcal{P}$, such that the removal of the graphs in $\mathcal{C}$ from G creates a graph none of whose components have more than r vertices? We can also require that the graphs in $\mathcal{C}$ be disjoint (forming a "matching"). This framework generalizes vertex cover, edge dominating set, and minimal maximum matching. In this paper, we examine the parameterized complexity of the counting version of the above general problem. In particular, we show how to count the solutions of size at most k of the covering and matching problems in time $O(n \cdot r(pk + r) + 2^{f(k,p,r)})$, where n is the number of vertices in G and f is a simple polynomial. In order to achieve the additive relation between the polynomial and the non-polynomial parts of the time complexity of our algorithms, we use the compactor technique, the counting analogue of kernelization for parameterized decision problems.

Keywords: Parameterized complexity, Counting problems, kernels, compactors, minimum maximal matching, edge dominatiom

Joint work of: Nishimura, Naomi; Ragde, Pranhakar; Thilikos, Dimitrios M.

Exact (exponential) algorithms for treewidth and minimum fill-in

Ioan Todinca (Université d'Orleans, F)

We show that for a graph G on n vertices its treewidth and minimum fill-in can be computed in $O(1.89^n)$ time (up to a polynomial factor).

Our result is based on a combinatorial proof that the number of minimal separators in a graph is $O(n1.71^n)$ and that the potential maximal cliques can be listed in $O(1.89^n)$ time (up to a polynomial factor). A potential maximal clique is a set of vertices inducing a maximal clique in some minimal triangulation of G.

Keywords: Exponential algorithms; tree-width; potential maximal cliques

Joint work of: Fomin, Fedor; Kratsch, Dieter; Todinca, Ioan; Villanger, Yngve

Hybrid Algorithms

Ryan Williams (CMU - Pittsburgh, USA)

A hybrid algorithm is a collection of *heuristics*, paired with a polynomial time *selector* S that runs on the input to decide which heuristic should be executed. Hybrid algorithms are interesting in scenarios where the selector must decide between heuristics that are "good" with respect to different complexity measures.

We focus on hybrid algorithms with a "hardness-defying" property: for a problem Π, there is a set of complexity measures $\{m_i\}$ whereby Π is known or conjectured to be unsolvable within each m_i, but for each heuristic h_i of the hybrid algorithm, one can give a complexity guarantee for h_i *on the instances of* Π *that* S *selects for* h_i that is *strictly better* than m_i. More concretely, we show that for NP-hard problems, a given instance can either be solved exactly with substantially improved runtime (*e.g.* $2^{o(n)}$), or be approximated in polynomial time with an approximation ratio exceeding that of the known or conjectured inapproximability of the problem, assuming $\mathsf{P} \neq \mathsf{NP}$.

Keywords: Approximation algorithms, exact algorithms

Joint work of: Vassilevska, Virginia; Williams, Ryan; Woo, Shan-Leung Maverick

Parameterized complexity as the psychologist's guide to computational realism: A call for collaboration

Iris van Rooij (TU of Eindhoven, NL)

Unbeknownst to many computer scientists, the concept of computation is foundational to contemporary cognitive psychology. Unbeknownst to many cognitive psychologists, theoretical computer science has developed rigorous analytical tools for analyzing the resource demands of different classes of computations. A collaboration between the disciplines seems only natural and is likely to be beneficial to both sides. On the one hand, complexity analyses of cognitive models can provide psychologists with a deepened understanding of the computational basis of human cognition.

On the other hand, work on the computational problems arising in psychological theorizing can lead theoretical computer science research in new and exciting directions. In this talk I discuss a set of open problems in psychology—each problem representing a cognitive input/output model. I explain how complexity analysis can directly inform psychologists about the computational realism of such models. For purposes of psychological modeling, fixed-parameter (in)tractability is of particular interest because human minds/brains always operate within an ecology of problem parameters.