Matthias Mnich

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May 31, 2010

Application for Postdoc Position

Dear Professors Gourves and Pascual:

I am writing in order to apply for the advertised position of postdoc in "Combinatorial Optimization with Competing Agents".

For the past three years I have been working on my PhD thesis in Combinatorial Optimization, on the subject of exact exponential-time algorithms for NP-hard problems. Related to that, I have worked on fixed-parameter algorithms, in the realm of parameterized complexity theory. My main focus was on fundamental problems from graph theory and constraint satisfaction, such as the MINIMUM FEEDBACK VERTEX SET and the BETWEENNESS problem. These results employ a wide range of algorithmic techniques from algebra, probability theory and discrete mathematics. The probabilistic *Strictly Above Expectation Method*, to whose development I contributed, has solved many open problems from the literature on so-called "above-guarantee parameterizations" of NP-hard problems.

Prior to my PhD studies in combinatorial optimization, I gained much experience in other areas of optimization: my Master thesis was on optimization methods in game theory, specifically for algorithms for equilibrium computation, and during my graduate studies at Jena University I specialized in non-smooth optimization of non-differentiable functions.

It is precisely this combination of experience with intractable problems in combinatorial optimization with my background in algorithmic game theory and continuous optimization that makes me believe that I am a suitable candidate for the advertised position. I am eager to establish strong theoretical results at the interface of these areas, as well as to design practically relevant algorithms.

As your research interests – combinatorial optimization and algorithmic game theory – exactly match my interests and background, I am convinced that the COCA group will stimulate my research into the COCA project, and result in insightful scientific output.

It would provide a great opportunity for me to take up the advertised post. As I will defend my PhD thesis on September 22, the first possible starting date for me would be October 1, 2010.

Please find my CV, a summary of my PhD thesis, and contact details of referees, enclosed.

Yours sincerely,

Matthias Mnich

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Education

PhD in Mathematics at Eindhoven University of Technology, Netherlands   10.2006 – 08.2010
Topic "Moderately Exponential-Time Algorithms for NP-hard problems"
Supervisor Prof. Gerhard Woeginger

Diploma in Operations Research, Dutch Network of Operations Research   10.2006 – 01.2008

MSc in Applicable Mathematics (degree "with Distinction")   10.2005 – 09.2006
London School of Economics and Political Science, UK
Master thesis "Computation of Correlated Equilibria in Succinctly Representable Games"

Research Interests

Combinatorial Optimization;	Graph Theory;	Computational Biology;
Computational Complexity;	Exact and Parameterized Algorithms;	Algorithmic Game Theory;
Enumeration;	Extremal Combinatorics.	

I am interested in the interface of combinatorics, game theory and continuous optimization. I am very open to new directions, and I am willing to take big efforts in delving into new areas of research, from both continuous and discrete optimization.

Work Experience

Lecturer in Dutch at Friedrich-Schiller-Universität Jena, Germany   04.2009 – 09.2009

Lecturer in Swahili at Friedrich-Schiller-Universität Jena, Germany   04.2004 – 09.2009

Teaching Assistant in Mathematics, Eindhoven University of Technology   03.2007 – present

Financial Modeler at Frankfurt-Trust Invest Luxemburg S.A., Luxemburg   02.2005 – 03.2005

Research Assistant at rzw cimdata AG, Weimar, Germany   04.2004 – 06.2005

Skills

Languages:	German (native)	English (proficient)	Swahili (proficient)
	Dutch (proficient)	French (basic)	

Programming: C++, MATLAB, Mathematica, Fortran

List of Publications

<u>Journal Publications</u>

1. *The Complexity Ecology of Parameters: An Illustration Using Bounded Max-Leaf Number*.
   M. Fellows, D. Lokshtanov, N. Misra, M. Mnich, F. Rosamond and S. Saurabh,
   Theory of Computing Systems, 45(4):822-848, Springer 2009.

2. *Uniqueness, Intractability and Exact Algorithms: Reflections on Level-k Phylogenetic Networks*.
   S. Kelk, L. van Iersel and M. Mnich,
   Journal of Bioinformatics and Computational Biology, 7(4):597-623, Imperial College Press 2009.

3. *Betweenness Parameterized Above Tight Lower Bound.*
   G. Gutin, E.J. Kim, M. Mnich and A. Yeo,
   Journal of Computer and System Sciences, http://dx.doi.org/10.1016/j.jcss.2010.05.001

<u>Conference Proceedings</u>

4. *Linear Kernel for Planar Connected Dominating Set*.
   D. Lokshtanov, M. Mnich and S. Saurabh,
   Proc. of 6th TAMC, Lecture Notes in Computer Science 5532:281-290, Springer 2009.

5. *Kernel and Fast Algorithm for Dense Triplet Inconsistency*.
   S. Guillemot and M. Mnich,
   accepted for publication at TAMC 2010.

<u>Submitted</u>

6. *Feedback Vertex Sets in Tournaments*.
   S. Gaspers and M. Mnich
   Preprint available at http://arxiv.org/abs/0905.0567
7. *Quadratic Kernels for Ternary Constraint Satisfaction Problems Parameterized Above Average.*
   G. Gutin, L. van Iersel, M. Mnich and A. Yeo,
   Preprint available at http://arxiv.org/abs/1004.1956
8. *Induced Matchings in Subcubic Planar Graphs.*
   R. Kang, M. Mnich and T. Müller

Awards and Scholarships

1. Winner of the Philips Award by the Royal Society for Mathematics in the Netherlands (2010)

2. Winner at competition "Mathematics & The Arts" for "Year of Mathematics", by German Federal Ministry for Education and Research (2008)

3. UK Engineering and Physical Sciences Research Council (EPSRC) Travel Grant (2006)

4. Rotary Ambassadorial Scholarship (2005/2006)

5. Rotary Individual Grant (2005) for successful promotion of literacy in East Africa

6. e-fellows Research Scholarship (2004 – 2010)

7. Achievers International Award by the British Ambassador to Germany (1999 and 2000)

Teaching Experience

Local Search (Lecturer [replacement]), Fall 2009, PhD Level, Dutch Network of OR

Linear Algebra (Instructor), Fall 2009, Undergraduate Level, Eindhoven University

Optimization in Networks (Lecturer [replacement] + Instructor), Spring 2009, Graduate Level, Eindhoven University

Linear Algebra (Instructor), Fall 2008, Undergraduate Level, Eindhoven University

Linear Programming (Instructor), Fall 2007, Undergraduate Level, Eindhoven University

Vector Calculus (Instructor), Spring 2007, Undergraduate Level, Eindhoven University

Community Service

Reviewing for journals:
- *ACM Transactions on Algorithms*
- *Discrete Applied Mathematics*
- *Journal of Algorithms in Cognition, Informatics and Logic*

Reviewing for conferences:
- *ESA 2009: European Symposium on Algorithms 2009*
- *WG 2009: Workshop on Graph-Theoretic Concepts in Computer Science 2009*
- *IWPEC 2009: International Workshop on Parameterized and Exact Computation 2009*
- *WG 2010: Workshop on Graph-Theoretic Concepts in Computer Science 2010*
- *ESA 2010: European Symposium on Algorithms 2010*

Main Organizer of *TACO 2009: Treewidth and Combinatorial Optimization,* December 2009

Talks

Parameterizations Above Guarantee, 12.03.2010, RAND Seminar, University of Bonn

Feedback Vertex Sets in Tournaments, 05.02.2010, ALGORITMe Colloquium, Utrecht, Netherlands

Parameterized Complexity for Algorithms and Analysis of NP-hard problems, 13.12.2009, Informatikseminar, Würzburg, Germany

Chromatic Coding and Subexponential Parameterized Complexity, 27.11.2009, DIAMANT/EIDMA Symposium, Lunteren, The Netherlands

Ordinal Embedding Relaxations Parameterized Above Tight Lower Bound, 13.11.2009, Oberseminar Theoretische Informatik, Humboldt-Universität Berlin, Germany

Ordinal Embedding Relaxations Parameterized Above Tight Lower Bound, 28.10.2009, EIDMA Seminar, Eindhoven, Netherlands

On Minimal Feedback Vertex Sets in Tournaments, 01.10.2009, AlGCo Seminar, Montpellier, France

Ordinal Embedding Relaxations Parameterized Above Tight Lower Bound, 04.08.2009, Oberseminar Theoretische Informatik, Jena, Germany

Shifted Subset Convolution, 17.04.2009, ALGORITMe Colloquium, Utrecht, Netherlands

Rooted and Unrooted Maximum Consistent Supertrees, 25.03.2009, DIMAP Workshop on Algorithmic Graph Theory, Warwick, UK

Möbius Inversion and Subset Convolution: Maximum Consensus Trees in O*(2^n) Time, 20.03.2009, CDAM Lunchtime Seminar, London School of Economics and Political Science, UK

The Complexity Ecology of Parameters, 18.03.2009, Royal Holloway University of London, UK

The Complexity Ecology of Parameters, 07.01.2009, EURANDOM Workshop Quantitative Models and Communication Networks, Eindhoven, Netherlands

Computing a Maximum Agreement Supertree, 31.10.2008, Algorithms Seminar, Bergen, Norway

Domination Problems in Map Graphs, 22.10.2008, Dagstuhl Seminar on Moderately Exponential-Time Algorithms, Schloss Dagstuhl, Germany

Domination Problems in Map Graphs, 15.10.2008, Algorithms Seminar, Eindhoven, Netherlands

Fast Exact Algorithms via Subset Convolution, 09.10.2008, Graphs and Matroids Seminar, Eindhoven

Exact construction of galled phylogenetic networks from triplets, 16.01.2008, 33rd Conference on the Mathematics of Operations Research, Lunteren, The Netherlands

Minimal Feedback Vertex Sets in Tournaments, 29.07.2007, DIAMANT/EIDMA Symposium, Soesterberg,

Directed Feedback Vertex Set Problems, 04.07.2007, EIDMA Seminar, Eindhoven University

Directed Feedback Vertex Set Problems, 08.06.2007, Postgraduate Combinatorial Conference 2007, St Andrews, UK

Computation of Correlated Equilibria in Succinctly-Representable Games, 06.04.2006, British Colloquium on Theoretical Computer Science 2006, Swansea, UK

PhD-Level Courses Attended

Algorithmic Game Theory, Eindhoven University, 03.2007

Learning, Prediction and Games, Max-Planck-Institute for Computer Science, 09.2007

Stability of Clustering, Max-Planck-Institute for Computer Science, 09.2007

Topological Data Analysis, Max-Planck-Inst. for Computer Science, 09.2007

Forbidden Induced Subgraphs, ADONET-CIRM, 10.2007

Graph Structures: Structure and Algorithms, ADONET-CIRM, 10.2007

Uncrossing Sets in Combinatorial Optimization, ADONET-CIRM, 10.2007

Flows in Graphs and Matroids, ADONET-CIRM, 10.2007

Submodular Functions, ADONET-CIRM, 10.2007

Rigidity of Graphs, ADONET-CIRM, 10.2007

Sum of Squares Optimization, Eindhoven University, 05.2010

References

1. Prof. Dr. Gerhard Woeginger, Technische Universiteit Eindhoven, gwoegi@win.tue.nl
2. Prof. Dr. Bernhard von Stengel, London School of Economics, stengel@maths.lse.ac.uk
3. Prof. Dr. Rolf Niedermeier, Friedrich-Schiller-Universität Jena, rolf.niedermeier@uni-jena.de
4. Prof. Dr. Hans Bodlaender, Universiteit Utrecht, hansb@cs.uu.nl
5. Dr. Saket Saurabh, Institute of Mathematical Sciences, saket@imsc.res.in

Summary of PhD thesis

My PhD thesis with title "Algorithms in Moderately Exponential Time" presents results on exact exponential-time algorithms, and parameterized algorithms, for NP-hard problems in graph theory, constraint satisfaction, and computational biology, from three different perspectives.

Faster Running Times. Faster running times of moderately exponential-time algorithms usually far outweigh reduction of computation times by applying more advanced computer technology. Doubling computing power, measured as the number of simple operations performable per second, often only allows to solve additively larger instances of intractable problems within the same amount of time. Whereas improving an algorithm with running time $\Omega(c^n)$ to one running in time $O(d^n)$ for a constant d only slightly smaller than c means that multiplicatively larger instances can be solved within the same amount of time. For some intractable problems, even exponential speed-ups compared to exhaustive search are conceivable, by reducing running times of $\Omega(c^n)$ to $c^{o(n)}$. In this thesis we describe algorithms whose running times outperform previously best time complexities by multiplicative and sometimes exponential factors.

- We give the fastest known algorithms for finding a minimum feedback vertex in tournaments and bipartite tournaments, in time $O(1.6740^n)$ and $O(1.6181^n)$, respectively. In fact, the algorithms list the minimal feedback vertex sets in time $O(1.6740^n)$ and $O(1.6181^n)$, respectively.
- We give an algorithm for finding a minimum feedback vertex sets in bipartite directed graphs in time $O(1.8621^n)$, much better than the $O(1.9977^n)$-time algorithm for general directed graphs.
- We give an algorithm that finds an efficient edge dominating set in a graph or determines that no such set exists, in time $O(1.2892^n)$.
- We give a subexponential fixed-parameter algorithm for triplet inconsistency parameterized by solution size k, running in time $2^{O(k \log k)} n^{O(1)}$.

Smaller Space Demands. Reduced time complexities are sometimes not sufficient to make a theoretically fast algorithm practically applicable, if the algorithm in question uses an exorbitant (read exponential) amount of space. Physical limits on memory size possibly mean that algorithms with exponential space demands are "useless for real life applications" [Woeginger 2004]. It is then sensible to trade time for space, and design algorithms whose space demand is very moderately exponential, or polynomial, in the input size. Our contributions are algorithms for intractable problems whose time complexity is asymptotically no worse than that of previously fastest algorithms, but with space demand exponentially smaller.

- We present polynomial-space fixed-parameter algorithms with subexponential parameter dependence for almost all bidimensional problems on graphs excluding a fixed minor. Most notably, we give such an algorithm for the fundamental problem of finding a path of length k.
- We present a polynomial-space polynomial-delay algorithm for enumerating the minimal feedback vertex sets in tournaments.

Deeper Structure Analysis. In this thesis, we contribute new fixed-parameter algorithms as well as parameterized intractability results, for various problems from graph theory, constraint satisfaction and phylogenetics, and multiple parameter choices.

- We establish linear vertex-kernels for maximum leaf spanning tree in general graphs, and its parameterized dual, connected dominating set, in planar graphs and $K_{3,h}$-minor free graphs.
- We establish fixed-parameter tractability of bandwidth, and topological bandwidth, parameterized by the maximum number of leaves over all spanning trees of the input graph.
- We establish fixed-parameter tractability of all ternary permutation constraint satisfaction problems parameterized above tight lower bound on their solution value.
- We establish fixed-parameter tractability of independent set in planar graphs with maximum degree three parameterized above tight lower bound on the solution value.

The results are obtained by applying and extending techniques from graph theory, parameterized complexity, probability theory and extremal combinatorics. Most of them are accompanied by lower bounds on running times or kernel sizes, modulo standard complexity-theoretic assumptions.