Manuel Bodirsky

Name:	Manuel Bodirsky
Supervisor:	Prof. Dr. Hans Jürgen Prömel
Field of Research:	Algorithmic Graph Theory
Topics:	Graph Theory for Constraint Satisfaction
	Algorithms for Period Problems and Applications for the Analysis of Markov Chains;
	(Random) Outerplanar Graphs;
PhD Student	At the program since April 2001

Fields of Research and Results

I continued the joint work with Martin Kutz (CGC at the Free University) about the tree description language of *pure dominance constraints*, which is important for the active line of research in computational linguistics for finding appropriate description languages for underspecified natural language processing. In [3] we presented an efficient algorithm that solves pure dominance constraints, which is particularly interesting since we are not using saturation algorithms checking satisfiability, which are prominent in the area of constraint satisfaction, but we use graph theoretic notions to directly construct a model of the constraint.

One paradigmatic question in the area of constraint satisfaction is a conjecture of Feder and Vardi [5]: Is every constraint satisfaction problem either in P, or NP-complete? A constraint satisfaction problem (CSP) in their setting is the problem to check for some fixed finite structure, called the *template*, whether some given input structure of the same signature can be homomorphically mapped to the template. A corresponding result for the subclass of *graph-homomorphisms* was established by Nesetril in [6]: A graph-homomorphism problem is NP-complete if and only if the template is bipartite. A generalization of this theorem to digraphs would solve the conjecture [5]. Feder and Vardi attacked the problem by concentrating on instances of CSP that can not be solved using a DATALOG saturation algorithm, and conjectured that these instances have "the ability to count", which makes it possible to use group theory to establish a dichotomy for this case.

Pure dominance constraints, as well as many other "constraint satisfaction" problems of artificial intelligence do not fit into the above framework of

CSP, since there is no *finite* template to specify the problem as a homomorphism problem. But if we modify the language of pure dominance constraints and require that a constraint is only satisfiable, if it can be mapped to a tree of height of e.g. three, the problem can be stated in CSP. Can we exploit the fact that pure dominance constraints can not be solved with a DATALOG saturation algorithm, to produce interesting instances for the attempt of Feder and Vardi to classify CSP? What is the combinatorial generalization of CSP to cover also more powerful constraint satisfaction problems, for example pure dominance constraints? Questions of this type are related to recent work of J. Nesetril in Prague, whom I met when attending some of his lectures about the combinatorics of mappings in Zürich, and he invited me to spend one of my semesters in Prague.

Secondly, I started joint work with Mihyun Kang, postdoc in the CGC at the Humboldt University, about the question how to generate random outerplanar graphs. Denise, Vasconcellos and Welsh [4] specified a simple Markov chain on the space of all planar graphs, whose limit distribution is the uniform distribution over all planar graphs. But it seems to be a very difficult problem to compute the mixing time of this Markov chain. The question is whether outerplanar graphs have enough structure that helps finding a rapidly mixing generating Markov chain, or other Monte Carlo algorithms.

Finally, together with Tobias Gärtner, Timo von Oertzen and Jan Schwinghammer, we found two efficient algorithms for the period problems that I have been working on already in the last semester. These period problems come up when studying the convergence of the probability to be in a given set of states in a Markov chain. We found some elegant theorems about the combinatorics of periods over abelian groups, that led to an efficient algorithm [1]. If we are considering periods over the rational or real numbers, we found a different and faster algorithm using power series representations of the periods [2].

Activities

- Blockcourse *Randomized Algorithms* by Emo Welzl in Zürich.
- Blockcourse *Topological Methods in Combinatorics and Geometry* by J. Matousek in Zürich.

- The Fall School Discrete Geometry: Triangulations from various points of view, October 4–6, Berlin.
- Colloquia of the Graduate Program.
- Colloquia of the Department Algorithms and Complexity at Humboldt University.
- European Summer School for Logic, Language and Information, August 10–24, Helsinki.

Preview

- The 28th Berliner Algorithmentag, 15. February 2002.
- The 19th Annual Symposium on Theoretical Aspects of Computer Science (STACS'02) 14-16 March, in Antibes - Juan le Pins.
- A short visit of Prof. Nesetril and Prague in spring 2002.

Literatur

[1] M. Bodirsky, T. Gärtner, T. von Oertzen, and J. Schwinghammer. Efficiently dealing with periods, available under `http://www.informatik.hu-berlin.de/~bodirsky/publications/periods.html`. Submitted, 2002.

[2] M. Bodirsky, T. Gärtner, T. von Oertzen, and J. Schwinghammer. Long-run properties of periodic probabilistic systems, available under `http://www.informatik.hu-berlin.de/~bodirsky/publications/periods.html`. Submitted, 2002.

[3] M. Bodirsky and M. Kutz. Pure dominance constraints. In *Proceedings of the 19th Annual Symposium on Theoretical Aspects of Computer Science (STACS'02)*, Antibes - Juan le Pins, Mar. 2002.

[4] A. Denise, M. Vasconcellos, and D. Welsh. The random planar graph. *Congressus Numerantium*, (113):61–79, 1996.

[5] T. Feder and M. Y. Vardi. The computational structure of monotone monadic SNP and constraint satisfaction: A study through datalog and group theory. *Proceedings of the 25th ACM STOC*, pages 612–622, 1993.

[6] P. Hell and J. Nesetril. On the complexity of h-coloring. *Journal of Combinatorial Theory, Series B*, 48:92–110, 1990.