Manuel Bodirsky

Name:	Manuel Bodirsky
Supervisor:	Prof. Dr. Hans Jürgen Prömel
Field of Research:	Algorithmic Graph Theory
Topics:	Graph Algorithms for Constraint Satisfaction;
	Generation of Random Outerplanar and Planar Graphs;
PhD Student	At the program since April 2001

Fields of Research and Results

My first topic is graph algorithms for combinatorial constraint satisfaction. In particular, I an interested in *tree description languages*. In the last months we found several new results. One is that the algorithmic idea that we already presented in [4] extends to the full constraint logic of *pure dominance constraints* introduced by Cornell in computational linguistics.

Pure dominance constraints talk about nodes in a tree in the same way as Allen's algebra talks about intervals on the real line. But whereas Allen's algebra is NP-hard in the general case, we presented an quadratic time algorithm for satisfiability of pure dominance constraints. In some cases we further improved the running time using results from the area of *decremental graph connectivity algorithms*. Currently we are preparing a long version of [4], where we will also present simplified proofs, the algorithm for the whole constraint logic of Cornell, and a decremental connectivity algorithm for the logic without equality.

Moreover, the approach in [4] turned out to be useful also for *normal dominance constraints* previously introduced by Mehlhorn et al. [1]. We found a new algorithm that checks satisfiability of a more general tree description language than normal dominance constraints [2] that has additional applications in computational linguistics. At the same time, we improved the running time of the best algorithm in the literature for constructing a solution of normal dominance constraints from $O(n^5\alpha(n^2))$ to $O(n^2)$, where n is the size of the input.

There are still many open problems. Is there an algorithm for a constraint language that combines the expressive power of pure dominance constraints and normal dominance constraints? The satisfiability test for a particular language of this type that we are currently looking at is polynomial time equivalent to the following surjective homomorphism problem: Given a n-

ary relation over a finite set, is there a surjective homomorphism to the ternary relation $R = \{(1,\ldots,1),(2,\ldots,2),\ldots,(n,\ldots,n),(1,2,\ldots,n)\}$ over the elements $1,2,\ldots,n$ (the so called *template*). More general, it would be interesting to classify the complexity of such surjective homomorphism problems according to their template, in a similar way like as it was undertaken for arbitrary homomorphisms [5]. This is a topic I started joint work with Petr Kolman from Charles University in Prague.

Generation of Random Structures. The second topic of the last semester was efficient generation of combinatorial structures uniformly at random. Together with Mihyun Kang (CGC at Humboldt-University) I developed an efficient generator for labeled and unlabeled outerplanar graphs [3]. Our approach uses formulas that count the number of rooted outerplanar graphs along their block structure. Two-connected outerplanar graphs finally correspond to dissections of convex polygons and are counted by the Schröder numbers [7]. Currently we try to apply a similar technique to generate random labeled planar graphs, using the structure of the triconnected components [6] and Tutte's census of planar maps [8].

Activities

Lectures, schools, workshops, conferences:

- Lectures and Colloquia of the Graduate Program.
- Forschungscolloquia of the Department Algorithms and Complexity I at Humboldt University.
- Lecture *Chech*, FU Berlin.
- The 29th Berliner Algorithmentag, ZIB Berlin, July 19, 2002.
- The 19th Annual Symposium on Theoretical Aspects of Computer Science (STACS'02) in Antibes - Juan le Pins, 14-16 March, 2002.
- *On the effectiveness logic in computer science (ELICS'02).* A symposium in honour of Moshe Vardi, Saarbrücken, March 4-7, 2002.
- Visiting Charles University in Prague in spring 2002. Attending the Spring school in Combinatorics, April 15-20, 2002.

- CGC Spring School *Approximation Algorithms for Hard Problems* in Chorin, May 20-23.

Talks:

- *Canonical Programs in Constraint Satisfaction*, Spring School in Combinatoris, Vysoka Lipa, April 17, 2002.
- Günther Hotz Medal. Saarbrücken, April 12, 2002.
- *Interesting Examples for the Approach of Feder and Vardi to classify CSP*, ELICS'02, Saarbrücken, March 5, 2002.
- *Parity Games*, Tag der Informatik, HU Berlin, May 16, 2002.
- *A New Algorithm for the Configuration Problem of Dominance Graphs*, HU Forschungsseminar, June 14, 2002.
- *Graph Algorithms for Dominance Constraints* at the CGC review meeting at FU Berlin, June 24, 2002.
- *Efficiently Generating Outerplanar Graphs Uniformly at Random*, Poznan Workshop, June 28, 2002.
- *Generating Random Outerplanar Graphs*, Mittagsseminar FU Berlin, July 25, 2002.

Preview

- A second visit of Charles University in Prague in the first week of September.
- ADFOCS: 3rd Max-Planck Advanced Course on the Foundations of Computer Science, Saarbrücken, September 9 - 13, 2002.
- CGC Fall School *Algorithms for Hard Problems*, Bildungszentrumm Matt, Schwarzenberg, Switzerland, September 23-27, 2002.
- GI Jahrestagung, September 30 - October 3, 2002.
- Diskrete Mathematik 2002, Dresden, October 3-4, 2002.

- Combinatorics in honour of Walter Deuber's 60th Birthday, Humboldt-Universität zu Berlin, October 7-8, 2002.
- CGC workshop Hiddensee, October 9-12, 2002.
- End of October: Moving to Prague.

Literatur

[1] E. Althaus, D. Duchier, A. Koller, K. Mehlhorn, J. Niehren, and S. Thiel. An efficient algorithm for the configuration problem of dominance graphs. In *Proceedings of the 12th ACM-SIAM Symposium on Discrete Algorithms*, pages 815–824, Washington, DC, Jan. 2001.

[2] M. Bodirsky, D. Duchier, J. Niehren, and S. Miele. An efficient algorithm for weakly normal dominance constraints. 2002.

[3] M. Bodirsky and M. Kang. Generating random outerplanar graphs. Manuscript, 2002.

[4] M. Bodirsky and M. Kutz. Pure dominance constraints. In *Proceedings of the 19th Annual Symposium on Theoretical Aspects of Computer Science (STACS'02)*, pages 287–298, Antibes - Juan le Pins, 2002.

[5] T. Feder and M. Vardi. The computational structure of monotone monadic SNP and constraint satisfaction: a study through datalog and group theory. *SIAM J. Comput.*, (28):57–104, 1999.

[6] J. Hopcroft and R. E. Tarjan. Dividing a graph into triconnected components. *SIAM J. Comput.*, 2:135–158, 1973.

[7] E. Schröder. Vier combinatorische Probleme. *Z. Math. Physik*, 15:361–376, 1870.

[8] W. Tutte. A census of planar maps. *Canad. J. Math.*, 15:249–271, 1963.