

# Semester Report WS04/05 of Ares Ribó Mor

Supervisor: Prof. Dr. Günter Rote  
Field of Research: Geometry and Combinatorics  
Topic: Self-Touching Configurations and Rigidity Theory  
Spanning trees of Planar Graphs  
Counting Polyominoes  
PhD Student at the program since February 1, 2002

## Field of Research and Results

This was my last semester in the Graduate Program, and I spent most of the time in writing down my thesis, which I am about to finish. My PhD thesis includes the following topics:

- Linkages in the plane.
  - Unfoldability of monotone trees.
  - Perturbations of self-touching configurations.
  - Maxwell-Cremona theorem for self-touching configurations.
  - Locked and unlocked chains of planar shapes.
- The maximum number of spanning trees of a planar graph, with applications to embedding polytopes in small integer three-dimensional grids.
- Counting polyominoes on twisted cylinders.

One of the most successful results that we got this semester is that finally we have been able to prove our main conjecture about perturbations of self-touching configurations. First we prove the theorem for one-dimensional self-touching configurations, showing that for any planar drawing with  $x$ -monotone edges, there exists a straight line embedding with given  $x$ -coordinates. Then we prove the theorem for the general planar case, by perturbing the self-touching configuration in two stages. The idea is to structure the self-touching configuration into several one-dimensional cigars, so that each cigar contains several overlapping edges. This structuring allows us to perturb the configuration in two stages. In a first stage, we perturb the boundaries of all cigars so that they become convex. In a second stage, we

perturb the interior of the cigars using the results for the one-dimensional self-touching configurations.

During my research stay in Poznan, I worked with Andrzej Ruciński and Tomasz Luczak, and I learnt from them several probabilistic bounds which could be applied to the problem of finding upperbounds for the maximum number of spanning trees of a planar graphs. We are at the moment trying to apply to the problem Suen's inequality [3], which possibly will give us nice bounds for planar triangulated graphs, planar graphs without triangles, and planar graphs without triangles and quadrilaterals. For this, we model the problem by a linear optimisation program.

At the beginning of the semester, we also tried to improve the results on locked and unlocked chains of planar convex shapes. We have generalised them to any shape, convex or concave, with slender adornments, obtaining the following result: a strictly simple polygonal chain adorned by slender adornments can always be straightened or convexified. (We call an adornment *slender* if every inward normal of the shape intersects the base, possibly at the base's endpoints). But still there are some important details of the proof which must be worked out, and I hope we will be able to solve them.

We also finished the work on counting polyominoes on the plane. The paper has been submitted for publication.

In my last semester report I would like to thank to all the members of the Graduate Program for these three years of intensive learning and enjoying, in the nicest atmosphere: thanks to all the faculty members, the two coordinators of the program Bettina Felsner and Andrea Hoffkamp, the speaker of the program Helmut Alt, and Günter Rote, my PhD advisor. Also to the students and former members of the program for their company.

## Publications

- Gill Barequet, Micha Moffie, Ares Ribó and Günter Rote, *Counting polyominoes on twisted cylinders*. Gill Barequet, Micha Moffie, Ares Ribó und Günter Rote. Manuscript, December 2004, 29 pages, submitted for publication,
- Robert Connelly, Erik D. Demaine, Martin L. Demaine, Sándor Fekete, Stefan Langerman, Joseph S. B. Mitchell, Ares Ribó and Günter Rote, *Locked and unlocked chains of planar shapes*. Manuscript, August 2004, 12 pages.

## Activities

- Attended the *Monday Lectures and Colloquia* of the Graduate Program. Presentation of the talk *Advances in Counting Polyominoes on the Twisted Cylinder*, on November 8th, 2004.
- Attended the *Mittagsseminar Theoretische Informatik* at FU Berlin. Presentation of the talks:
  - *Locked and unlocked chains of planar shapes*, August 19th, 2004.
  - *1-D Self-Touching Configurations are Perturbable*, December 14th, 2004.
- Attended the 4th CGC Workshop, October 4th-7th, 2004, Stels, Switzerland. Presentation of the talk *1-D Self-Touching Configurations are Perturbable*.
- Research stay at the Department of Discrete Mathematics of the Adam Mickiewicz University in Poznan, by Prof. Michal Karoński, during the month of October 2004.
- Talk *The Maximum Number of Spanning Trees of a Planar Graph*, at the noon seminar of the Department of Discrete Mathematics of the Adam Mickiewicz University, October 12th, 2004.
- Subreferee for SoCG 2005.

## References

- [1] G. Barequet and M. Moffie, The complexity of Jensen’s algorithm for counting polyominoes, *Proc. 1st Workshop on Analytic Algorithmics and Combinatorics*, New Orleans, LA, January 2004.
- [2] R. Connelly, E. Demaine and G. Rote, Infinitesimally locked self-touching linkages with applications to locked trees, *Physical Knots: Knotting, Linking, and Folding Geometric Objects in  $\mathbb{R}^3$* . Contemporary Mathematics 304, American Mathematical Society 2002, 287–311.
- [3] S. Janson, T. Luczak and A. Ruciński, *Random graphs*, Wiley-Interscience Series in Discrete Mathematics and Optimization, 2000.

- [4] I. Jensen, Enumerations of lattice animals and trees, *J. of Statistical Physics*, 102 (2001), 865–881.
- [5] J. Richter-Gebert, *Realization spaces of polytopes*, chapter 13. Lecture Notes in Mathematics **1643**, Springer–Verlag Berlin Heidelberg 1996.