

ESF – SCIENCE MEETING 1871 – FINAL REPORT

SCHOOL ON ALGEBRAIC THEORY OF AUTOMATA

SUMMARY

The School on Algebraic Theory of Automata was held on September 1-12, 2008, at the Complexo Interdisciplinar da Universidade de Lisboa, Av. Prof. Gama Pinto 2, in Lisbon, Portugal.

The School aimed to present to the scientific community, both to senior researchers and post-graduated students, various topics on Algebraic Theory of Automata, delivered as Courses, Advanced Seminars and Student's Seminars.

It was attended by 69 participants (including 30 post-graduated students) from 18 different countries (Australia, Canada, Czech Republic, Estonia, France, Germany, Hungary, Italy, Latvia, Netherlands, Poland, Portugal, Russia, Slovenia, Spain, Turkey, UK, USA).

The programme consisted of a series of eight 5 hour courses, ten 50 minute lectures (Advanced Seminars), five 25 minute lectures (Student's Seminars) and a Problem Discussion Forum.

The invited lecturers for the eight courses were:

- Mikolaj Bojanczyk (University of Warsaw, Poland);
- Zoltán Ésik (University of Szeged, GRLMC, Rovira i Virgili University, Hungary);
- Daniel Kirsten (University of Leipzig, Germany);
- Michal Kunc (Masaryk University, Czech Republic);
- Jean-Éric Pin (University Paris 7 and CNRS, France);
- Pedro Silva (University of Porto, CMUP, Portugal);
- Howard Straubing (Boston College, USA); and
- Pascal Tesson (University of Laval, Canada).

Notes of each course were available for the participants.

The Problem Discuss Forum was organized by Mikhail Volkov.

The Advanced Seminars were presented by:

- Jorge Almeida (University of Porto, Portugal);
- Andris Ambainis (University of Latvia, Latvia);
- Olivier Carton (University Paris 7, France);
- Volker Diekert (University of Stuttgart, Germany);
- Sylvain Lombardy (University Paris-Est Marne-la-Vallée, France);
- Maria Madonia (University of Catania, Italy);
- Geraud Senizergues (University Bordeaux I, France);
- Benjamin Steinberg (Carleton University, Canada);
- Denis Therien (McGill University, Canada); and
- Mikhail Volkov (Ural State University, Russia).

DESCRIPTION OF THE SCIENTIFIC CONTENT OF AND DISCUSSION AT THE EVENT

COURSES

Title: Tree-walking automata and tree logics (Mikolaj Bojanczyk)

Abstract: Tree-walking automata are a natural sequential model for recognizing properties of finite trees. A tree-walking automaton walks around the tree, possibly visiting some nodes several times. The head of the automaton is always placed over a single tree node, which distinguishes the model from branching (bottom-up, or top-down) tree automata. In the first part of the course, Bojanczyk talked first about the expressive power of tree-walking automata and, in the second part of the course, about extensions of tree-walking automata, such as pebble automata. Special attention was given to the connection between pebble automata and first-order logic with transitive closure.

Title: Equational Axioms for Fixed Points and Automata (Zoltán Ésik)

Abstract: Fixed points and fixed point computations occur in just about every field of Computer Science. They are often used to give semantics to recursion, in automata and language theory, programming languages and abstract data types, concurrency and logic. For one familiar example, one can canonically associate with each context free grammar a vector valued function over the domain of all subsets of the free monoid over the set of terminals, so that the language generated by the grammar becomes a component of the least fixed point of the function. The aim of this course was to provide an introduction to that part of the theory of fixed points that has applications to weighted automata.

Title: Distance Desert Automata and the Star Height Problem (Daniel Kirsten)

Abstract: In a series of five lectures, Kirsten presented a new approach to the decidability and the first upper complexity bound to Eggen's famous star height problem (from 1963): concerning rational expressions with union, concatenation, and iteration is the star height, of a given recognizable language effectively computable? For this, a new model of weighted automata was introduced, called distance desert automata, which are essentially a hierarchical joined generalization of the distance automata by Hashiguchi and the desert automata by Bala and the author.

Title: Structure of finite semigroups and language equations (Michal Kunc)

Abstract: Kunc explained the basic notions used to deal with the structure of finite semigroups such as (Green relations and factorization forests) and demonstrated how these notions can be applied in the study of regular languages. Then he showed how quasi-orders appear as a tool in language theory generalizing finite semigroups in a natural way. The rest of the course was devoted to an excursion into a currently very active research area of language equations, where the above-mentioned techniques were successfully applied.

Title: Algebraic theory of automata: an historical perspective of the algebraic approach of automata theory and new advances (Jean-Éric Pin)

Abstract: This course presented an historical perspective of the algebraic approach of automata theory with emphasis on Eilenberg's and Reiterman's theorems and their extensions, including recent connections with duality theory. This course was developed along the following topics: Varieties of languages and varieties of finite monoids, Eilenberg's theorem; Some extensions (ordered monoids, C-varieties); The profinite metric and the free profinite monoid; Lattices of languages and their equational theories; Examples and applications; Extensions and future directions.

Title: Automata in Group Theory (Pedro Silva)

Abstract: Silva illustrated different applications of finite automata to group theory and pointed out some generalizations to the wider context of monoids. The connections to finite groups being well known, Silva concentrated on applications to infinite groups. Most of the course was focused on free groups and closed structures, but some applications to wider classes of high geometric significance such as hyperbolic groups, automatic groups and self-similar groups were also discussed.

Title: Algebraic Approaches to the Study of Tree Automata (Howard Straubing)

Abstract: In this course, Straubing presented the study of automata and logics for finite labeled unranked trees, that is, trees in which there is no fixed upper bound on the number of children a node is permitted to have. As is the case with both words and ranked trees, the properties of unranked trees recognizable by finite automata are exactly those expressible in monadic second-order logic (MSO). He was principally concerned with the question of understanding the expressive power of various fragments of MSO - both temporal and predicate logics.

Title: Computational complexity and Algebraic automata theory (Pascal Tesson)

Abstract: The framework of algebraic automata theory has been tremendously useful in classifying regular languages and understanding finite automata. It is now well-established that these very tools can also be used to analyze more complex models of computation including branching programs, boolean circuits and communication protocols. In turn, this line of work in computational complexity has highlighted important new questions and insights in algebraic automata theory. These interactions between the two subjects were the focus of this course.

ADVANCED SEMINARS

Title (Speaker)

- Careful synchronization of partial automata (Mikhail Volkov)
- Non-Archimedean Words (Volker Diekert)
- Conjugacy and equivalence of weighted automata (Sylvain Lombardy)
- The Cerny conjecture and group representations (Benjamin Steinberg)
- An algebraic point of view on computational learning theory (Denis Therien)
- Algebraic methods for infinite objects (Olivier Carton)
- Higher-order Pushdowns and monoids (Geraud Senizergues)
- Recognizable Two-dimensional Languages (Maria Madonia)
- Quantum finite automata (Andris Ambainis)
- McCammond's normal form for omega-words revisited (Jorge Almeida)

STUDENT'S SEMINARS

Title (Speaker)

- Learning Automata with Classes (Adrian Horia-Dediu)
- Automata theory within abstract algebraic logic (Alexandre Madeira)
- On the word problem in the unary semigroup variety generated by all finite epigroups (Inna Mikhaylova)
- Algebraic extensions in free groups (Enric Ventura)
- Efficient probability amplification in two-way quantum finite automata (Abuzer Yakaryilmaz)

ASSESSMENT OF THE RESULTS AND IMPACT OF THE EVENT ON THE FUTURE DIRECTION OF THE FIELD

The aim of the school was to present, to the scientific community interested in Algebraic Theory of Automata, various promising research topics which, from the point of view of the organizers and according to the feedback received, was well accomplished.

The school brought together top researchers, both senior and young, as well as post-graduate students interested in this field of research. The participants were exposed to highly interesting research directions, through the courses and the advanced seminars presented. The courses were delivered by researchers, authors of important results and the same happened with the advanced seminars. Written notes were distributed to facilitate the understanding of the courses.

The courses, both from Algebra or from Computer Science, were well planned to suit the knowledge of the audience which, as mentioned before, went from senior researchers to less experienced post-graduate students.

This school provided the perfect environment to further develop existing research contacts among top researchers as well as to establish connections with students interest in this area. All participants, and in particular the students, will certainly benefit from the different overviews and from having been exposed to such promising research directions.

The organizers of the school are strongly convinced that SATA2008 will have a very positive impact on the development of this research area.

FINAL PROGRAMME OF THE MEETING

Monday, September 1

9:00am	Opening Session
9:30am	C1 - Tree walking automata and tree logics (Mikolaj Bojanczyk)
10:30am	Coffee break
11:00am	C2 - Equational axioms for fixed points and automata (Zoltán Ésik)
12:00pm	C3 - Algebraic theory of automata: an historical perspective of the algebraic approach of automata theory and new advances (Jean-Éric Pin)
1:00pm	Lunch
2:30pm	C4 - Automata in group theory (Pedro Silva)
3:30pm	Coffee break
4:00pm	Advanced Seminar - Careful synchronization of partial automata (Mikhail Volkov)

Tuesday, September 2

9:00am	C1 - Tree walking automata and tree logics (Mikolaj Bojanczyk)
10:00am	Coffee break
10:30am	C2 - Equational axioms for fixed points and automata (Zoltán Ésik)
11:30am	C3 - Algebraic theory of automata: an historical perspective of the algebraic approach of automata theory and new advances (Jean-Éric Pin)
12:30pm	Lunch
2:00pm	Student's Seminar - Learning Automata with Classes (Adrian Horia-Dediu)
2:30pm	C4 - Automata in group theory (Pedro Silva)
3:30pm	Coffee break
4:00pm	Advanced Seminar – Non-Archimedean Words (Volker Diekert)

Wednesday, September 3

9:00am	C1 - Tree walking automata and tree logics (Mikolaj Bojanczyk)
10:00am	Coffee break
10:30am	C2 - Equational axioms for fixed points and automata (Zoltán Ésik)
11:30am	C3 - Algebraic theory of automata: an historical perspective of the algebraic approach of automata theory and new advances (Jean-Éric Pin)
12:30pm	Lunch
2:00pm	Student's Seminar - Automata theory within abstract algebraic logic (Alexandre Madeira)
2:30pm	C4 - Automata in group theory (Pedro Silva)
3:30pm	Coffee break
4:00pm	Advanced Seminar – Conjugacy and equivalence of weighted automata (Sylvain Lombardy)

Thursday, September 4

9:00am	C1 - Tree walking automata and tree logics (Mikolaj Bojanczyk)
10:00am	Coffee break
10:30am	C2 - Equational axioms for fixed points and automata (Zoltán Ésik)
11:30am	C3 - Algebraic theory of automata: an historical perspective of the algebraic approach of automata theory and new advances (Jean-Éric Pin)
12:30pm	Lunch
2:00pm	Student's Seminar - On the word problem in the unary semigroup variety generated by all finite epigroups (Inna Mikhaylova)
2:30pm	C4 - Automata in group theory (Pedro Silva)
3:30pm	Coffee break
4:00pm	Advanced Seminar – The Cerny conjecture and group representations (Benjamin Steinberg)

Friday, September 5

9:00am	C1 - Tree walking automata and tree logics (Mikolaj Bojanczyk)
10:00am	Coffee break
10:30am	C2 - Equational axioms for fixed points and automata (Zoltán Ésik)
11:30am	C3 - Algebraic theory of automata: an historical perspective of the algebraic approach of automata theory and new advances (Jean-Éric Pin)
12:30pm	Lunch
2:00pm	Student's Seminar - Algebraic extensions in free groups (Enric Ventura)
2:30pm	C4 - Automata in group theory (Pedro Silva)
3:30pm	Coffee break
4:00pm	Advanced Seminar – An algebraic point of view on computational learning theory (Denis Thérien)

Saturday, September 6

8:30am Excursion

Monday, September 8

9:00am	C5 - Structure of finite semigroups and language equations (Michal Kunc)
10:00am	Coffee break
10:30am	C6 - Distance desert automata and the star height problem (Daniel Kirsten)
11:30am	C7 - Computational complexity and algebraic automata theory (Pascal Tesson)
12:30pm	Lunch
2:00pm	C8 - Algebraic approaches to the study of tree automata (Howard Straubing)
3:00pm	Coffee break
3:30pm	Advanced Seminar - Algebraic methods for infinite objects (Olivier Carton)

Tuesday, September 9

9:00am	C5 - Structure of finite semigroups and language equations (Michal Kunc)
10:00am	Coffee break
10:30am	C6 - Distance desert automata and the star height problem (Daniel Kirsten)
11:30am	C7 - Computational complexity and algebraic automata theory (Pascal Tesson)
12:30pm	Lunch
2:00pm	Student's Seminar - Efficient probability amplification in two-way quantum finite automata (Abuzer Yakaryilmaz)
2:30pm	C8 - Algebraic approaches to the study of tree automata (Howard Straubing)
3:30pm	Coffee break
4:00pm	Advanced Seminar - Higher-order Pushdowns and monoids (Geraud Senizergues)

Wednesday, September 10

9:00am	C5 - Structure of finite semigroups and language equations (Michal Kunc)
10:00am	Coffee break
10:30am	C6 - Distance desert automata and the star height problem (Daniel Kirsten)
11:30am	C7 - Computational complexity and algebraic automata theory (Pascal Tesson)
12:30pm	Lunch
2:00pm	C8 - Algebraic approaches to the study of tree automata (Howard Straubing)
3:00pm	Advanced Seminar - Recognizable Two-dimensional Languages (Maria Madonia)
4:00pm	Coffee break
4:30pm	Discussion of Problems

Thursday, September 11

9:00am	C5 - Structure of finite semigroups and language equations (Michal Kunc)
10:00am	Coffee break
10:30am	C6 - Distance desert automata and the star height problem (Daniel Kirsten)
11:30am	C7 - Computational complexity and algebraic automata theory (Pascal Tesson)
12:30pm	Lunch
2:00pm	C8 - Algebraic approaches to the study of tree automata (Howard Straubing)
3:00pm	Coffee break
3:30pm	Advanced Seminar - Quantum finite automata (Andris Ambainis)

Friday, September 12

9:00am C5 - Structure of finite semigroups and language equations (Michal Kunc)
10:00am Coffee break
10:30am C6 - Distance desert automata and the star height problem (Daniel Kirsten)
11:30am C7 - Computational complexity and algebraic automata theory (Pascal Tesson)
12:30pm Lunch
2:00pm C8 - Algebraic approaches to the study of tree automata (Howard Straubing)
3:00pm Coffee break
3:30pm Advanced Seminar - McCammond's normal form for omega-words revisited
(Jorge Almeida)

The Organizing Committee

Mário J.J. Branco
Manuel Delgado
Vítor H. Fernandes
Gracinda M.S. Gomes
António Malheiro

Lisbon, November 11, 2008