Program for Highlights and Jewels of Automata Theory 2024

Sep 16 - Sep 20, Bordeaux

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LABORATOIRE BORDELAIS DE RECHERCHE EN INFORMATIQUE LaBRI
BORDEAUX INP
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Monday, Sep 16, 2024

08h30 - 09h00 **Registration and Informal Meeting**

09h00 - 09h50 invited talk by **Wolfgang Thomas**

On the Finiteness of Infinite Regular Games

Starting with McNaughton's pioneering technical report of 1965 in which he initiated the automata theoretic study of infinite games, we pursue his view that plays of an infinite game should terminate in finite time with the correct declaration of the winner. Such a reduction of regular infinite games to reachability games or safety games is well-known, for example, in the study of parity games. We focus on this reduction for Muller games (reporting on work of D. Neider, R. Rabinovich, M. Zimmermann, Aachen) which offers a so far unexploited player-dependent approach for solving Muller games, based on a new kind of memory structure and avoiding the step through parity games. We conclude with a more general discussion of determinacy proofs for infinite games, motivated by Büchi's difficult last paper that has not received attention since it appeared in 1983.

09h50 - 10h40 invited talk by **Artur Jeż**

What's new in word equations

A word equation is a formal equation using words (also called strings), variables (representing words) and concatenation as the only allowed operation, i.e. they are of the form u = v, where u, v consists of letters and variables. A solution substitutes variables with words so that this formal equality is turned into true equality of strings. Often we also allow usage of additional constraints, say we require that a substitution for a variable is from a certain regular language or that lengths of substitutions satisfy some linear inequality, etc.
In this talk I will present state of the art, some recent results and directions on word equations:

– what is known about satisfiability and major techniques that are used,

this will include some restricted classes of equations, including some recent upper bounds of NP for subclasses of quadratic equations.

– what is known about the solution sets, this includes recent result bounding the number of solutions of equations using one variable only.
– detail a new trend in application of word equations in verification, usually referred as string solving, this will also include some gentle introduction to fragments of logics over word equations
– and some smaller, particular results.

11h10 - 12h00 invited talk by **Jarkko Kari**

Low complexity colorings of the two-dimensional grid

A two-dimensional configuration is a coloring of the infinite grid Z^2 using a finite number of colors. For a finite subset D of Z^2, the D-patterns of a configuration are the patterns of shape D that appear in the configuration. The number of distinct D-patterns of a configuration is a natural measure of its complexity. We consider low-complexity configurations where the number of distinct D-patterns is at most |D|, the size of the shape. We use algebraic tools to study periodicity of such configurations [1]. We show, for an arbitrary shape D, that a low-complexity configuration must be periodic if it comes from the well-known Ledrappier subshift, or from a wide family of other similar algebraic subshifts [2]. We also discuss connections to the well-known Nivat's conjecture: In the case D is a rectangle - or in fact any convex shape - we establish that a uniformly recurrent configuration that has low-complexity with respect to shape D must be periodic [3]. This implies an algorithm to determine if a given collection of mn rectangular patterns of size mxn admit a configuration containing only these patterns. Without the complexity bound the question is the well-known undecidable domino problem.

References

[1] J. Kari, M. Szabados. An Algebraic Geometric Approach to Nivat's Conjecture. Information and Computation 271, pp. 104481 (2020).

[2] J. Kari, E. Moutot. Nivat's conjecture and pattern complexity in algebraic subshifts. Theoretical Computer Science 777, pp. 379–386 (2019).

[3] J. Kari, E. Moutot. Decidability and Periodicity of Low Complexity Tilings. Theory of Computing Systems 67, pp- 125-148 (2023).

14h00 - 14h50 invited talk by **Barbara König**

Up-To Techniques for Language Equivalence and Behavioural Metrics

Up-To Techniques are coinductive proof techniques that provide small witnesses for lower bounds for greatest fixpoints (respectively upper bounds for least fixpoints). They have been introduced for bisimilarity checks, but can also be fruitfully be used for language equivalence or behavioural metrics, typically by exploiting an algebraic structure on the state space.

This talk will start by introducing the lattice-theoretic foundations of up-to techniques and review results by Bonchi and Pous on checking language equivalence for NFAs. We will then generalize these results to a coalgebraic setting and to behavioural metrics, where the use of up-to techniques sometimes allows to resort to finite witnesses (rather than infinite ones).

This is joint work with Filippo Bonchi, Daniela Petrisan, Keri D'Angelo, Sebastian Gurke, Johanna Maria Kirss, Matina Najafi, Wojciech Rozowski and Paul Wild.

14h50 - 15h40 invited talk by **Jérôme Leroux**

On the Home-Space Problem for Petri Nets

A set of configurations H is a home-space for a set of configurations X of a Petri net if every configuration reachable from (any configuration in) X can reach (some configuration in) H. The semilinear home-space problem for Petri nets asks, given a Petri net and semilinear sets of configurations X, H, if H is a home-space for X. In 1989, David de Frutos Escrig and Colette Johnen proved that the problem is decidable when X is a singleton and H is a finite union of linear sets with the same periods. In this presentation, we show that the general (semilinear) problem is decidable. This result is obtained by proving a duality between the reachability problem and the non-home-space problem. In particular, we prove that for any Petri net and any semilinear set of configurations H we can effectively compute a semilinear set C of configurations, called a non-reachability core for H, such that for every set X the set H is not a home-space for X if, and only if, C is reachable from X. We show that the established relation to the reachability problem yields the Ackermann-completeness of the (semilinear) home-space problem. For this we also show that, given a Petri net with an initial marking, the set of minimal reachable markings can be constructed in Ackermannian time.

16h10 - 17h00 invited talk by **Anca Muscholl**

Diamonds are concurrency's best friends

Zielonka's construction of asynchronous automata for regular, commutation-closed languages is a prime example of distributed synthesis. In this talk we present the latest construction, as well as simpler variants for restricted cases, and we discuss potential applications of this seminal result to distributed monitoring of concurrent programs.

Tuesday, Sep 17, 2024

09h00 - 09h50 invited talk by **Karin Quaas**

Automata over Concrete Domains

We define Büchi automata over concrete domains, where transitions are labelled with constraints. We then give an overview over the decidability status of the nonemptiness problem for such automata over typical concrete domains, and we explain the symbolic approach as a tool to prove decidability of the nonemptiness problem.

09h50 - 10h40 invited talk by **Daniel Smertnig**

Weighted Automata over Fields - Determinization and related problems

A weighted finite automaton (WFA) computes a function that maps each input word to an output in an underlying semiring of weights. Two WFA are equivalent if they compute the same function. While every boolean (i.e., unweighted) finite automaton is equivalent to a deterministic one, this is no longer true for weighted automata. In general, there are strict inclusions between the classes of functions computable by deterministic (=sequential), unambiguous, finitely ambiguous, polynomial ambiguous, and exponentially ambiguous WFA, giving rise to a natural ambiguity hierarchy.
While it is classically known to be decidable whether a given automaton is deterministic, unambiguous, etc., it is much harder to decide whether a WFA is equivalent to a deterministic, unambiguous, etc. WFA. In particular, deciding determinizability for WFA is a classical problem, typically considered over tropical (min/max-plus) semirings or over fields. The tropical case is still not fully resolved.
This talk is about the field case. I will discuss joint work with Jason Bell (Waterloo), which shows that equivalence with deterministic, respectively, unambiguous WFA is decidable. The approach is based on a characterization of the semantics, i.e., the functions computed by such WFA, using arithmetic properties and a theorem from Diophantine number theory. I will also discuss current work together with Antoni Puch (Warsaw). Restricting to the case in which all transition matrices are invertible, we obtain a complete correspondence between the ambiguity hierarchy and arithmetical properties. This shows that also equivalence with finitely ambiguous and polynomial ambiguous WFA is decidable in the invertible case.

11h10 - 12h00 invited talk by **Nathanaël Fijalkow**

Parity games: The calm after the storm?

The complexity of solving parity games has been a long standing open problem for decades. Progress has been very slow until a breakthrough came in 2017, improving the state of the art from mildly subexponential to quasipolynomial. Since then, many more quasipolynomial time algorithms have been constructed, with distinct flavours and algorithmic paradigms, with many exciting insights into the structure of parity games. The flow of new algorithms is slowing down, and one can now ask: how close are we to the ultimate breakthrough - a polynomial time algorithm -, or possibly to impossibility / complexity hardness results? What are the lessons learned since 2017 on quasipolynomial time algorithms?

14h00 - 14h50 invited talk by **Marc Zeitoun**

Decision problems for regular languages

Given a class of regular languages, the C-membership problem asks whether a given regular language belongs to C. While most questions about automata are well understood today, the C-membership problem remains open for several significant classes, in particular for most levels of the quantifier alternation hierarchy in first-order logic. This talk will present approaches to solving this problem, aimed at simultaneously capturing several variants of a specific level.

14h50 - 15h40 invited talk by **Tatiana Starikovskaya**

Efficient membership testing for regular languages

Regular language membership is a key primitive in myriads of applications, from web scraping to bioinformatics. The quick growth of data volume and the presence of noise in the applications demand efficient and robust methods for membership testing, and this talk will provide a survey of such methods and open questions.

16h10 - 17h00 invited talk by **Georg Zetzsche**

Inclusion problems for formal languages

It is a classic phenomenon in formal language theory that inclusion between languages is hard to decide: For context-free languages, it is undecidable, and already for NFAs, the problem is PSPACE-complete. However, recent work by various authors has shown that under some restrictions on the input languages, deciding inclusion is surprisingly tractable and admits interesting new techniques. The talk will survey such results (and open problems), with a focus on non-regular languages.

Wednesday, Sep 18, 2024

09h00 - 10h00 invited talk by **Mikołaj Bojańczyk**

Polyregular Functions

The polyregular functions are string-to-string functions that have polynomial size outputs, and which can be computed by finite-state devices. This class of functions can be described using many different models that pop up in different areas, and its seems to be a plausible (unique?) candidate for the notion of regularity for functions that have polynomial outputs size. I will report on some recent progress on this topic, regarding questions about the expressive power, as well as some algorithmic problems.

10h06 - 11h09 **Session 1: Formal Languages**

10h06 - 10h15 Jérôme Guyot

On state complexity for subword-closed languages

10h15 - 10h24 Loïc Germerie Guizouarn

Reversible Transducers over Infinite Words

10h24 - 10h33 Ismaël Jecker

Finite-valued Streaming String Transducers

10h33 - 10h42 Saina Sunny

Deciding Conjugacy of a Rational Relation

10h42 - 10h51 Georg Zetzsche

Slice closures of indexed languages and word equations with counting constraints

10h51 - 11h00 Ryoma Sin'ya

Measure Theoretic Approach to Formal Languages

11h00 - 11h09 Lia Schütze

Verifying Unboundedness via Amalgamation

11h15 - 12h00 **Session 2: MSO Logic**

11h15 - 11h24 Thomas Colcombet
Tree algebras and bisimulation-invariant MSO on finite graphs

11h24 - 11h33 Aliaume Lopez
Labelled Well Quasi Ordered Classes of Bounded Linear Clique Width

11h33 - 11h42 Joris Nieuwveld
On the decidability of monadic second-order logic with arithmetic predicates

11h42 - 11h51 Paweł Parys
A Dichotomy Theorem for Ordinal Ranks in MSO

11h51 - 12h00 Alexander Rabinovich
Rabin Uniformization Problem with Restricted Domain Variables

14h00 - 15h00 invited talk by **Albert Atserias**
The "Raison d'Être" of Descriptive Complexity Theory

Descriptive complexity grew up as a theory drawing ideas and problems from several different sources. We list four of these sources: (1) finite model theory, (2) automata theory, (3) relational database theory, and (4) computational complexity theory. The leading thread of this overview talk is to present five open problems in descriptive complexity theory coming from these areas. These are problems that I consider particularly important or beautiful and none appears to be impossible to solve. At least two of these problems ask to give a new proof of a known fact just using different methods. However, I hope that their solution may be useful to eventually achieve the promise that descriptive complexity has aspired to from its early days: to make new progress on the fundamental questions of computational complexity theory by using the methods of mathematical logic.

15h09 - 16h03 **Session 3: Reachability, Invariants, Infinite-State Systems**

15h09 - 15h18 Nicolas Waldburger
Reachability in one-counter automata with tests

15h18 - 15h27 Łukasz Kamiński
Bi-reachability in Petri nets with data

15h27 - 15h36 Edon Kelmendi
Multiple Reachability for Linear Dynamical Systems

15h36 - 15h45 Arka Ghosh
Equivariant ideals of polynomials

15h45 - 15h54 Valentin Krasotin
Computing Inductive Invariants of Regular Abstraction Frameworks

15h54 - 16h03 Gabriel Bathie
The complexity of testing regular languages

16h09 - 17h03 **Session 4: Tree Automata**

16h09 - 16h18 Karoliina Lehtinen
A characterisation of trees on which Büchi and parity automata are equivalent

16h18 - 16h27 Antoine Amarilli
Dynamic membership for regular tree languages

16h27 - 16h36 Luisa Herrmann
Tree Automata with Global and Non-Global Counting

16h36 - 16h45 Olivier Idir
An alternative characterization of the Mostowksi index for omega-regular tree languages

16h45 - 16h54 Quentin Aristote
Multicategorical framework for minimization and learning of bottom-up tree automata with effects

16h54 - 17h03 Corto Mascle
Verification of distributed systems with locks and variables using tree automata

17h09 - 17h54 **Session 5: Protocols & Agents**

17h09 - 17h18 Michael Raskin
Modular Population Protocols

17h18 - 17h27 Chana Weil-Kennedy
Verification of Population Protocols with Unordered Data

17h27 - 17h36 Noa Izsak
Learning Broadcast Protocols

17h36 - 17h45 Mathieu Sassolas
Pessimism of the Will, Optimism of the Intellect: Fair Protocols with Malicious but Rational Agents

17h45 - 17h54 Dietmar Berwanger
Full-Information Protocols

19h00 - 23h59 **Picnic**
Parc des Sports Saint-Michel in Bordeaux

Thursday, Sep 19, 2024

09h00 - 10h00 invited talk by **Pablo Barceló**

The Role of Logic in Advancing Machine Learning: Three Case Studies

I present three case studies from my collaborative research that highlight the essential role of logic in enhancing our understanding of modern machine learning architectures. The first two examples focus on the expressive capabilities of two prominent architectures: Transformers, which have revolutionized NLP applications, and Graph Neural Networks, a leading approach for classifying graph-structured data. We employ temporal logic techniques to analyze the properties that Transformers can recognize, and modal logics to examine the properties discernible by Graph Neural Networks. The third example addresses the pursuit of explainable AI, demonstrating how first-order logic can be used to design languages that declare, evaluate, and compute explanations for decisions made by machine learning models.

10h10 - 11h04 **Session 6: Automata**

10h10 - 10h19 Umang Mathur

A faster FPRAS for #NFA

10h19 - 10h28 Prince Mathew

Learning one-counter automata using SAT solver

10h28 - 10h37 Mrudula Balachander

Passive Learning of Regular Data Languages in Polynomial Time and Data

10h37 - 10h46 Matthew Hague

Parikh's Theorem Made Symbolic

10h46 - 10h55 Savinien Kreczman

Magic Numbers in Periodic Automatic Sequences

10h55 - 11h04 Uli Fahrenberg

Developments in Higher-Dimensional Automata Theory

11h15 - 12h00 Session 7: Modal & Temporal Logic

11h15 - 11h24 Yanni Dong
Algorithms for Model Checking of Random Transition Systems

11h24 - 11h33 Jędrzej Kołodziejski
Modal Logic over Ordinals is Compact

11h33 - 11h42 Benjamin Bordais
Comparing the Complexity of Learning LTL, CTL and ATL Formulas

11h42 - 11h51 Baptiste Mouillon
Boolean set cover for LTL learning

11h51 - 12h00 Elli Anastasiadi
Satisfiability-checking of modal logic with recursion via translations and tableaux

14h00 - 15h03 Session 8: Probabilistic Systems

14h00 - 14h09 Nathanaël Fijalkow
Revealing partially observable Markov decision processes

14h09 - 14h18 Raimundo Saona
Ergodic Unobservable MDPs: Decidability of Approximation

14h18 - 14h27 Chloé Capon
Taming Large MDPs Through Stochastic Games

14h27 - 14h36 James C. A. Main
A Single Dice Roll to Satisfy All Goals: Randomisation Requirements for Strategies in Multi-Objective Markov Decision Processes

14h36 - 14h45 Hugo Gimbert
Controlling a Random Population: complexity

14h45 - 14h54 Debraj Chakraborty
Learning Explainable and Better Performing Representations of POMDP Strategies

14h54 - 15h03 Tobias Winkler
Certifying Positive Almost Sure Termination of Probabilistic Pushdown Automata

15h09 - 16h12 Session 9: Vector Addition Systems

15h09 - 15h18 Henry Sinclair-Banks
The Tractability Border of Reachability in Simple Vector Addition Systems with States

15h18 - 15h27 Shrisha Rao
Continuous Pushdown VASS in One Dimension are Easy

15h27 - 15h36 A. R. Balasubramanian
Decidability and Complexity of Decision Problems for Affine Continuous VASS

15h36 - 15h45 Łukasz Orlikowski
Languages of unambiguous vector addition systems with states

15h45 - 15h54 Roland Guttenberg
Reachability in Priority Vector Addition Systems

15h54 - 16h03 Clotilde Bizière
Reachability in Two-Dimensional Branching VASS is decidable

16h03 - 16h12 Wojciech Czerwiński
Reachability in binary 3-VASS is in ExpSpace

16h18 - 17h03 Session 10: Games

16h18 - 16h27 Christophe Grandmont
As Soon as Possible but Rationally: Rational Synthesis for Reachability on Weighted Graphs

16h27 - 16h36 Aline Goeminne
Permissive Equilibria in Multiplayer Reachability Games

16h36 - 16h45 Suman Sadhukhan
Auction-Based Scheduling

16h45 - 16h54 Irmak Sağlam
Fair omega-regular games

16h54 - 17h03 Dani Dorfman
Improved bounds for strategy improvement algorithms for energy games

17h18 - 18h03 **Session 11: Verification, Monitoring, Synthesis**

17h18 - 17h27 Léo Exibard
Runtime monitoring for Hennessy-Milner logic with recursion over systems with data

17h27 - 17h36 Dhruv Nevatia
Policy Change for Treelike Monitors

17h36 - 17h45 Ramanathan S. Thinniyam
Event Driven Programs under Sequential Consistency

17h45 - 17h54 Akshatha Shenoy
Automated Property Directed Self Composition

17h54 - 18h03 Anton Varonka
Linear Loop Synthesis for Polynomial Invariants

Friday, Sep 20, 2024

09h00 - 10h00 invited talk by **Laure Daviaud**

Open problems for weighted automata, and why they are so difficult...

In this talk, I will review some open problems for weighted automata over general semirings and discuss the reasons why the usual techniques that have been used to solve similar questions, have not been successfully used for those (yet(?)). The talk is aimed to a broad audience - especially to those who know nothing/not much about weighted automata!

10h06 - 11h09 **Session 12: Timed Systems**

10h06 - 10h15 Gaëtan Staquet

Active Learning of Mealy Machines with Timers

10h15 - 10h24 Anirban Majumdar

Greybox Learning of Languages Recognizable by Event-Recording Automata

10h24 - 10h33 Sayan Mukherjee

Learning Event-recording Automata Passively

10h33 - 10h42 Damien Busatto-Gaston

Controller Synthesis in Timed Büchi Automata: Robustness and Punctual Guards

10h42 - 10h51 Laetitia Laversa

Execution-time opacity control for timed automata

10h51 - 11h00 R Govind

Model Checking for Real-time Systems using Generalized Timed Automata

11h00 - 11h09 Sarah Dépernet

Opacity problems in subclasses of timed automata

11h15 - 12h00 Session 13: Logic & Arithmetic

11h15 - 11h24 Engel Lefaucheux
When are two Parametric Semi-linear Sets Equal?

11h24 - 11h33 Khushraj Madnani
An Efficient Quantifier Elimination Procedure for Presburger Arithmetic

11h33 - 11h42 Michal Hečko
Algebraic Reasoning Meets Automata in Solving Linear Integer Arithmetic

11h42 - 11h51 Daniel Mock
First-Order Logic with Counting: EF-games and Model-Checking on Monadically Stable Classes

11h51 - 12h00 Steffen van Bergerem
Learning Aggregate Queries Defined by First-Order Logic with Counting

14h00 - 15h03 Session 14: Quantitative Systems

14h00 - 14h09 Radosław Piórkowski
Cost register automata over min–plus semiring and their boundedness problem

14h09 - 14h18 David Purser
Determinisation and Unambiguisation of Polynomially-Ambiguous Rational Weighted Automata

14h18 - 14h27 Nicolas Mazzocchi
Safety and Liveness but Quantitative

14h27 - 14h36 Sven Dziadek
Acceptance Conditions for Weighted ω-Automata

14h36 - 14h45 Lorenzo Clemente
Zeroness of weighted basic parallel processes

14h45 - 14h54 Théo Matricon
Constant Delay Enumeration of Weighted Context Free Grammar

14h54 - 15h03 Alexander Shen
Finite-state Algorithmic Information Theory and Borel Normality Revisited

15h09 - 15h54 **Session 15: Automata on Infinite Structures**

15h09 - 15h18 Denis Kuperberg
Explorable Automata

15h18 - 15h27 Jan Strejček
Tighter Construction of Tight Büchi Automata

15h27 - 15h36 Antonio Casares
State-based vs transition-based acceptance for ω-automata

15h36 - 15h45 Igor Walukiewicz
Passive learning for history-deterministic co-Buchi automata

15h45 - 15h54 Aditya Prakash
2-Token Game characterises History-Determinism on [0,2] Automata

16h00 - 16h36 **Session 16: Logic & Data**

16h00 - 16h09 Rémi Morvan
Minimizing Conjunctive Regular Path Queries

16h09 - 16h18 Sarah Kleest-Meißner
Puzzling over Subsequence-Query Extensions: Disjunction and Generalised Gaps

16h18 - 16h27 Pascal Bergsträßer
Ramsey Quantifiers in Linear Arithmetics

16h27 - 16h36 Oliver Markgraf
Effective String Solving via Regular Constraint Propagation

16h42 - 17h18 **Session 17: Neural Networks**

16h42 - 16h51 Sabine Rieder
Monitizer: Automating Design and Evaluation of Neural Network Monitors

16h51 - 17h00 Christoph Standke
Query languages for neural networks

17h00 - 17h09 Tomáš Novotný
Incompleteness of k-dimensional geometric Weisfeiler-Leman in $\mathbb{R}^{O(k)}$

17h09 - 17h18 Chris Köcher
The Power of Hard Attention Transformers on Data Sequences: A Formal Language Theoretic Perspective