25. Jahrestagung der GI Fachgruppe *Logik in der Informatik*
Workshop *Logic in Computer Science*

Venue: Friedrich Schiller University Jena, Senatssaal (inside the main building of the University – Room 127), Fürstengraben 1, Jena

Monday, 21 October

13.30 Arrival and welcome
14.00 Invited talk: **Thomas Schwentick** (TU Dortmund)
Dynamic Complexity: Recent and Complex Updates
15.00 coffee break
15:30 **Simon Knäuer** (TU Dresden)
Relation Algebras and CSPs
16.00 **Jonas Schmidt** (TU Dortmund)
Dynamic Complexity Meets Parameterised Algorithms
16.30 **Jakub Rydval** (TU Dresden)
Temporal constraint satisfaction problems in least fixed point logic
17.00 **Florian Rabe** (Universität Erlangen-Nürnberg)
The Open Archive of Formalizations
19.00 joint dinner

Tuesday, 22 October

09.30 Invited talk: **Christoph Berkholz** (Humboldt-Universität zu Berlin)
A comparison of algebraic and semi-algebraic proof systems
10.30 coffee break
11.00 **Florian Wörz** (Universität Ulm)
Reversible Pebble Games and the Relation Between Tree-Like and General Resolution Space
11.30 **Artur Riazanov** (Steklov, Saint-Petersburg)
Almost tight lower bounds on regular resolution refutations of Tseitin Formulas for all graphs.
12.00 **Joshua Blinkhorn** (Friedrich-Schiller-Universität Jena)
Size, Cost, and Capacity: A Semantic Technique for Hard Random QBFs

12.30 lunch break

14.30 **Martin Lange** (Universität Kassel)
A Learning Tool for Modelling Discrete Problems Using Propositional Logic
15.00 **Martin Lück** (Leibniz Universität Hannover)
Abstract Team Logic
15.30 **Florian Buse** (Universität Kassel)
Capturing Bisimulation-Invariant Complexity Classes using Higher-Order Modal Fixpoint Logic

Thomas Schwentick (TU Dortmund)

Dynamic Complexity: Recent and Complex Updates

In most real-life databases data changes frequently and thus makes efficient query answering challenging. Auxiliary data might help to avoid computing query answers from scratch all the time. One way to study this incremental maintenance scenario is from the perspective of dynamic algorithms with the goal to reduce (re-) computation time.

Another option is to investigate it from the perspective of low-level parallel computational complexity [1] or parallelizable database queries [2]. As the "lowest" complexity class AC^0 (with a suitable unifomity condition) and the core of the standard database query language SQL both coincide with first-order predicate logic, one naturally arrives at the question which queries can be answered/maintained dynamically with first-order predicate logic (DynFO).

The talk gives an introduction into dynamic complexity and presents and discusses old and recent methods and results [3,4,5,6].

[1] Sushant Patnaik and Neil Immerman. Dyn-FO: A parallel, dynamic complexity class. J. Comput. Syst. Sci., 55(2):199--209, 1997.

[2] Guozhu Dong and Jianwen Su. Incremental and decremental evaluation of transitive closure by first-order queries. Inf. Comput., 120(1):101--106, 1995.

[3] Samir Datta, Raghav Kulkarni, Anish Mukherjee, Thomas Schwentick, Thomas Zeume: Reachability Is in DynFO. J. ACM 65(5): 33:1-33:24 (2018)

[4] Thomas Schwentick, Nils Vortmeier, Thomas Zeume: Dynamic Complexity under Definable Changes. ACM Trans. Database Syst. 43(3): 12:1-12:38 (2018)

[5] Samir Datta, Anish Mukherjee, Thomas Schwentick, Nils Vortmeier, Thomas Zeume: A Strategy for Dynamic Programs: Start over and Muddle through. ICALP 2017.

[6] Samir Datta, Anish Mukherjee, Nils Vortmeier, Thomas Zeume: Reachability and Distances under Multiple Changes. ICALP 2018: 120:1-120:14

Simon Knäuer (TU Dresden)

Relation Algebras and CSPs

Network satisfaction problems for finite relation algebras are classical computational problems, studied intensively since the 1990s.
They are examples of infinite-domain constraint satisfaction problems.
The major open research challenge in this context is to classify these problems with respect to their computational complexity.
We explain the connection between network satisfaction problems and constraint satisfaction and translate in this way open questions from the theory of relation algebras into questions about the model theory of homogeneous labeled graphs.
We give a classification result for network satisfaction problems of finite relation algebras with a flexible atom.

Jonas Schmidt (TU Dortmund)

Dynamic Complexity Meets Parameterised Algorithms

Dynamic Complexity studies the maintainability of queries with logical formulas in a setting where the underlying structure or database changes over time. Most often, these formulas are from first- order logic, giving rise to the dynamic complexity class DynFO. This talk investigates extensions of DynFO in the spirit of parameterised algorithms. In this setting structures come with a parameter k and the extensions allow additional “space” of size f(k) (in the form of an additional structure of this size) or additional time f(k) (in the form of iterations of formulas) or both. The resulting classes are compared with their non-dynamic counterparts and other classes. Furthermore, the applicability of methods for parameterised algorithms to this setting are explored through case studies for various well-known parameterised problems. The results are joined work with Thomas Schwentick, Nils Vortmeier, Thomas Zeume and Ioannis Kokkinis and are accepted for CSL 2020.

Jakub Rydval (TU Dresden)

Temporal constraint satisfaction problems in least fixed point logic

Finite-domain constraint satisfaction problems are either solvable by Datalog, or not even expressible in least fixed point logic with counting.
The border between the two regimes coincides with an important dichotomy in universal algebra.
For infinite-domain CSPs the situation is more complicated even if the template structure of the CSP is model-theoretically tame.
We present a complete classification of (infinite-domain) temporal CSPs that can be solved in fixed point logic (with or without counting).
Our results also show that many naive generalisations of the equivalent conditions in the finite fail to capture expressibility in least fixed point logic already for temporal CSPs.

Christoph Berkholz (Humoldt-Universität zu Berlin)

A comparison of algebraic and semi-algebraic proof systems

Algebraic and semi-algebraic proof systems are propositional proof systems that are inspired from (semi-)algebraic methods such as the Gröbner basis algorithm and linear or semi-definite programming hierarchies. Contrary to classical propositional proof systems (such as the resolution calculus or textbook Frege systems), the derived objects in these (semi-)algebraic proof systems are not propositional formulas, but polynomial equations or inequalities. When encoding propositional formulas by polynomials, such systems can be used to prove the unsatisfiability of a propositional formula similar as in the resolution calculus. The advantage of these systems is that on the one hand they allow to generate more succinct refutations of propositional statements and that on the other hand the underlying algorithms can be used as efficient proof search methods. In this talk, I will give an overview of different proof systems and discuss their relative strength.

Florian Wörz (Universität Ulm)

Reversible Pebble Games and the Relation Between Tree-Like and General Resolution Space

We show a new connection between the space measure in tree-like resolution and the reversible pebble game in graphs. Using this connection we provide several formula classes for which there is a logarithmic factor separation between the space complexity measure in tree-like and general resolution. We show that these separations are almost optimal by proving upper bounds for tree-like resolution space in terms of general resolution clause and variable space. In particular we show that for any formula F, its tree-like resolution is upper bounded by space(\pi) log time(\pi) where \pi is any general resolution refutation of F. This holds considering as space(\pi) the clause space of the refutation as well as considering its variable space. For the concrete case of Tseitin formulas we are able to improve this bound to the optimal bound space(\pi) log(n), where n is the number of vertices of the corresponding graph.

Artur Riazanov (Saint-Petersburg)

Almost tight lower bounds on regular resolution refutations of Tseitin Formulas for all graphs.

We show that size of any regular resolution refutation of Tseitin formula T(G,c) based on a graph G is at least $2^{\Omega(tw(G))/\log n}$, where n is the number of vertices in G and tw(G) is the treewidth of G. For constant degree graphs there is known upper bound $2^{O(tw(G))}$ [Alekhnovich, Razborov, FOCS-2002], so our lower bound is tight up to a logarithmic factor in the exponent.
In order to prove this result we show that any regular resolution proof of Tseitin formula T(G,c) of size S can be converted to a read-once branching program computing satisfiable Tseitin formula T(G,c') of size $S^{\log n}$. Then we show that any read-once branching program computing satisfiable Tseitin formula T(G,c') has size at least $2^{\Omega(tw(G))}$; the latter improves the result of [Glinskih, Itsykson, CSR-2019].
Talk is based on joint work with Dmitry Itsykson, Danil Sagunov and Petr Smirnov.

Martin Lange (Universität Kassel)

A Learning Tool for Modelling Discrete Problems Using Propositional Logic

Logic is (also) a modelling language, and modelling any kind of decision problem in logical languages is an essential skill that computer scientists should possess. However, building this skill also constitutes one of the hardest learning tasks for computer science students. We introduce the DiMo tool, a language, interpreter and tester that support the formal modelling of parameterised problems in propositional logic. They aim at transferring the "code-compile-run" loop of learning how to program to the world of propositional logic.

Martin Lück (Leibniz Universität Hannover)

Abstract Team Logic

Team semantics is a novel framework for expressing notions of dependence and independence, and has been introduced to systems such as propositional, modal, temporal and first-order logic. We study its core ideas on an abstract level and generalize it for arbitrary compositional logics. We also prove abstract expressivity results.

Florian Buse (Universität Kassel)

Capturing Bisimulation-Invariant Complexity Classes using Higher-Order Modal Fixpoint Logic

Otto's Theorem characterizes bisimulation-invariant PTIME as the class of queries defined by formulas of the polyadic modal mu-calculus.
Polyadic Higher-Order Fixpoint Logic (PHFL) is an extension of the polyadic mu-calculus by a simply-typed lambda-calculus. PHFL is naturally stratified by the type-theoretic order of its formulas.
Moreover, PHFL contains a subset of formulas called the tail-recursive fragment in which the interplay between recursion and the lambda-calculus is restricted. We provide characterizations in the style of Otto's Theorem for k-EXPTIME and k-EXPSPACE, for all k, as the sets of queries defined by PHFL-formulas of order k, respectively tail-recursive PHFL-formulas of order k+1. The proofs follow the general template provided by Otto's Theorem by using (extensions of) the Immerman-Vardi Theorem, respectively the Abiteboul-Vianu Theorem. The main challenge lies in encoding higher-order quantification into PHFL fixpoints