# Abstracts of the Tutorials and Keynotes

## Tutorial I: Christof Löding

*From finite to infinite words: congruences and learning for finite automata*

Abstract: In this tutorial, we begin with basic algorithms for learning deterministic finite automata (DFA). These algorithms operate in two main settings: passive learning, where a model is inferred from a fixed set of example words, and active learning, where an oracle answers queries about a target language. While there are many variants of these algorithms, nearly all rely on the characterization of minimal DFAs via the Myhill-Nerode right-congruence, whose equivalence classes correspond to the DFA states. To some extent, these DFA learning algorithms can be extended to classes of deterministic $\omega$-automata, where the Myhill-Nerode framework is generalized to languages of infinite words. We will discuss such adaptations, as well as challenges in this setting. Moreover, for most standard classes of deterministic $\omega$-automata, such as Büchi, co-Büchi, and parity automata, there are no known congruence-based characterizations. Therefore, we will also examine recent developments in alternative representations of $\omega$-languages, with a particular focus on families of right-congruences and history-deterministic automata.

## Tutorial II: Szymon Torunczyk

*Monadically dependent classes and the model checking problem*

Abstract: A central problem in theoretical computer science concerns the complexity of the model-checking problem: to decide if a given formula holds in a given structure. Here, I will focus on formulas of first-order logic, and assume that the structure comes from a fixed class of structures, typically graphs. For some 'tame' graph classes – such as the class of planar graphs, or every class of graphs with bounded maximum degree – the model-checking problem is tractable (in the sense of parameterized complexity), while for some others, it is hard. It is conjectured that for hereditary classes, tractability corresponds precisely to the notion of monadic dependence (or monadic NIP), originating in Shelah's classification programme in model theory. This conjecture is by now confirmed in several special cases, most notably: 1) for monotone graph classes, for which monadic dependence coincides with the notion of nowhere denseness, introduced by Nesetril and Ossona de Mendez; 2) for hereditary classes of ordered graphs, for which monadic dependence coincides with the notion of bounded twin-width, introduced by Bonnet, Kim, Thomasse, and Watrigant. I will survey the recent progress in this area, connecting methods from structural graph theory, model theory, as well as statistical learning theory and computational geometry – such as VC-dimension and $\varepsilon$-nets.

## Keynote I: Mahsa Shirmahammadi

*Differential Tree Automata*

Power series arise everywhere in computer science and mathematics—from combinatorics, counting problems, and the analysis of algorithms to solutions of differential equations.

I introduce the notion of differential tree automata: a natural generalization of weighted tree automata, where transition weights are rational functions in the tree size. The main result I will discuss is that the ordinary generating functions of the series recognized by these automata are precisely the differentially algebraic power series. Along the way, I will describe a general recurrence satisfied by the coefficients of these series—extending Reutenauer's matrix representation for polynomially recursive sequences. A useful byproduct of our construction is a decision procedure for testing equivalence between two differential tree automata.

In the second part of the talk, I will focus on a specific subclass of differentially algebraic series called rationally dynamically algebraic (RDA) power series. These arise as components of solutions to systems of differential equations of the form y'=F(y), where F is a vector of rational functions defined at the initial condition. RDA power series form a rich and expressive class: they generalize algebraic power series, yet lie strictly within the broader class of differentially algebraic ones. I will present a new combinatorial characterisation of RDA power series, based on exponential generating functions of regular languages over labelled trees.

## Keynote II: Yu-Fang Chen

*An automata-based framework for quantum program verification*

I will present an approach that enables fully automatic verification of quantum programs. The talk will begin with a brief introduction to quantum fundamentals—from a high-level overview of the goals of quantum computing to our focus today: verifying program correctness. We will introduce the semantics of quantum programs using a novel perspective: modeling quantum states as decision trees, and consequently, sets of quantum states as tree automata.

## Keynote III: Liat Peterfreund

*From Standardization to Theory and Back: A Formal Look at the GQL Standard*

Property-graph databases are increasingly used in practice, which initiated the creation of the GQL standard in 2019, an ISO graph query language. GQL aims to play the same foundational role for graph databases that SQL has long played for relational ones.

In this talk, I will present a theoretical exploration of GQL. By drawing on techniques from logic and automata theory, we examine GQL's core features, such as pattern matching, and recursion, with the aim of understanding the language's expressive power and limitations. Our results include complexity bounds, expressiveness characterizations, and fragments with desirable properties. By linking these findings to the evolving standard, we demonstrate how formal methods can actively inform the design and analysis of practical graph query languages. The talk is based on joint research published in PODS, ICDT, and VLDB.

## Keynote IV: Shaull Almagor

*Determinisation of Tropical Weighted Automata*

Tropical Weighted Automata are a simple and well-studied quantitative automata model. Nonetheless, they are notoriously difficult to reason about. In particular, the determinisation problem for weighted automata over the tropical semiring is a long-standing open problem. In this talk, I will sketch our recent result showing its decidability. In doing so, I will present some novel techniques for reasoning about nondeterministic quantitative models. The talk will feature friendly ghosts and a cactus. No prior knowledge is needed.