

# Weighted Automata and Rewriting

Proposal for Course in Advanced Track of ISR

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## 1 Motivation

A classical automaton accepts or rejects its input (a word, or a tree). A weighted automaton evaluates its input in some semiring, for instance, the standard semiring  $(\mathbb{N}, 0, +, 1, \cdot)$ , or the arctic semiring  $(\{-\infty\} \cup \mathbb{N}, -\infty, \max, 0, +)$ .

If the valuation defined by a weighted automaton is compatible with a rewrite relation, then it proves termination, and bounds derivational complexity.

Over the last 10 years, weighted automata methods (a.k.a. matrix interpretations) have become an essential part of automated analysis of termination and complexity of rewriting.

## 2 Topics

- semirings, matrices, weighted automata and their algebra [DKE09]
- local compatibility of a weighted automaton with a rewrite system, termination [EWZ08]
- inferring bounds on derivational complexity [Wal10]
- weakly monotonic interpretations and top rewriting [KW09]
- deleting [HW04] and matchbounded rewriting [GHW04], preservation of regularity
- (time permitting) finding compatible automata via constraint programming
- finding matchbound certificates by completion [Wal16].

## 3 Prerequisites and Teaching

I will assume knowledge of basic concepts of rewriting (as in Baader/Nipkow [BN98], chapters 1–5) and automata theory (finite automata on finite words).

To appreciate the usefulness of weakly monotonic interpretations, a knowledge of the Dependency Pairs method is helpful.

For the discussion of preservation of regularity by match-bounded rewriting, some knowledge on “automata and reachability” is helpful (as would be provided by the proposed ISR 2017 course by Genet).

I will present definitions and theorems on slides, and develop examples and proofs on the blackboard. (So, the lecture room should allow to use blackboard and projection at the same time.)

I will provide exercise questions. I plan to provide online exercises as well. Students enter answer using a standard browser, and get immediate feedback on correctness. (For instance, the

student is given a rewrite system, and asked to find a suitable matrix interpretation in a specific semiring, and the system checks monotonicity and compatibility.)

I could include some constraint programming exercises - then students would need to install a Haskell compiler (`ghc`), some libraries (e.g., `ersatz`), and some solvers (e.g., `minisat` and `z3`) but I am not sure how much time I want to set aside for this.

There is some overlap with the course on *Termination and Complexity* that I taught at ISR 2014, but this time I will focus on weighted automata right from the start, and overlap in students should be small anyway (because of the distance, both in space and in time).

I would *very much* prefer  $3 \times 60$  min teaching over  $2 \times 90$  min.

## 4 About the Speaker

Johannes Waldmann's research in rewriting started with his PhD thesis, where he used tree automata methods to answer a question in Combinatory Logic. He co-invented the method of match-bounds for proving termination and preservation of regularity of rewriting; as well as the method of matrix interpretations for proving termination and bounding derivational complexity. Since 2003, he is a professor of computer science at Hochschule für Technik, Wirtschaft und Kultur, Leipzig, Germany (<http://www.imn.htwk-leipzig.de/~waldmann/>). His teaching includes Concepts of Programming Languages, Declarative Programming, Constraint Programming, and Symbolic Computation.

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