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 [AG00] is helpful.

For the discussion of preservation of regularity by match-bounded rewriting, some knowledge on “automata and reachability” [FGT04] is helpful (as provided by the ISR 2017 course by Thomas Genet).

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. I will synchronize with Carsten Fuhs since his ISR 2017 course (Progam Termination) will also include some constraint programming.

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.

References

[AG00] Thomas Arts and Jürgen Giesl. Termination of term rewriting using dependency pairs. *Theor. Comput. Sci.*, 236(1-2):133–178, 2000.

[BN98] Franz Baader and Tobias Nipkow. *Term rewriting and all that*. Cambridge University Press, 1998.

[DKE09] Manfred Droste, Werner Kuich, and Heiko Vogler (Eds.). *Handbook of Weighted Automata*. Springer, 2009.

[EWZ08] Jörg Endrullis, Johannes Waldmann, and Hans Zantema. Matrix interpretations for proving termination of term rewriting. *J. Autom. Reasoning*, 40(2-3):195–220, 2008.

[FGT04] Guillaume Feuillade, Thomas Genet, and Valérie Viet Triem Tong. Reachability analysis over term rewriting systems. *J. Autom. Reasoning*, 33(3-4):341–383, 2004.

[GHW04] Alfons Geser, Dieter Hofbauer, and Johannes Waldmann. Match-bounded string rewriting systems. *Appl. Algebra Eng. Commun. Comput.*, 15(3-4):149–171, 2004.

[HW04] Dieter Hofbauer and Johannes Waldmann. Deleting string rewriting systems preserve regularity. *Theor. Comput. Sci.*, 327(3):301–317, 2004.

[KW09] Adam Koprowski and Johannes Waldmann. Max/plus tree automata for termination of term rewriting. *Acta Cybern.*, 19(2):357–392, 2009.

[Wal10] Johannes Waldmann. Polynomially bounded matrix interpretations. In Christopher Lynch, editor, *Proc. RTA 2010*, volume 6 of *LIPIcs*, pages 357–372. Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, 2010.

[Wal16] Johannes Waldmann. Efficient completion of weighted automata. In Andrea Corradini and Hans Zantema, editors, *Proc. TERMGRAPH 2016*, volume 225 of *EPTCS*, pages 55–62, 2016.