Weighted LARS and Weighted Automata

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LOGICAL METHODS IN COMPUTER SCIENCE

Regular Languages

A language $\mathcal{L}$ is regular iff it can be defined using a

- regular expression
- finite state automaton (both deterministic and non-deterministic)
- monadic second order (MSO) formula
- regular grammar
- LARS program
- ...

LARS

Logic-based framework for Analytic Reasoning over Streams (LARS) [Beck *et al.*, 2018]:

- reasoning over finite streams of timed data
- answer set/stable model semantics
- propositional connectives and $\Box, \Diamond, @_t, \boxplus^w$

Recognisable Formal Power Series

A function $\phi : A^* \rightarrow R$ for an alphabet A and a semiring over the elements of R is recognisable iff it can be defined using a

- weighted automaton
- restricted weighted MSO formula
- restricted LARS measure

Weighted LARS Syntax

We define weighted LARS formulas over a semiring $\mathcal{R} = (R, \oplus, \otimes, e_\oplus, e_\otimes)$ similarly to how weighted MSO formulas are defined in [Droste and Gastin, 2007]

$$\alpha ::= k \mid p \mid \neg p \mid \alpha \wedge \alpha \mid \alpha \vee \alpha \mid \Diamond\alpha \mid \Box\alpha \mid @_t\alpha \mid \boxplus^w\alpha,$$

where $k \in R$ and p is a propositional variable.
We want to assign a formula a numerical value over $\mathcal{R}$.

Weighted LARS Semantics

- Use $e_\otimes$ and $e_\oplus$ as truth and falsehood respectively
- Interpret disjunctive connectives ($\vee, \Diamond$) as sum ($\oplus$)
- Interpret conjunctive connectives ($\wedge, \Box$) as multiplication ($\otimes$)
- Negation is inversion of the truth value
- The semantics of a formula are a a weighted power series:

$$[\![\alpha]\!]_{\mathcal{R}} : A^* \to R$$

References I

Harald Beck, Minh Dao-Tran, and Thomas Eiter.
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Artificial Intelligence, 261:16–70, 2018.

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Weighted automata and weighted logics.
Theoretical Computer Science, 380(1):69, 2007.