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On Semantically-Deterministic Automata

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Bader Abu Radi and Orna Kupferman

Abstract: Nondeterminism is a fundamental notion in Theoretical Computer Science.
A nondeterministic automaton is {\em semantically deterministic\/} (SD) if different nondeterministic choices in the automaton lead to equivalent states. Semantic determinism is interesting as it is a natural relaxation of determinism, and as some applications of automata in formal methods require deterministic automata, yet in fact can use automata with some level of nondeterminism, tightly related to semantic determinism.

In the context of finite words, semantic determinism coincides with determinism, in the sense that every pruning of an SD automaton to a deterministic one results in an equivalent automaton. We study SD automata on infinite words, focusing on B\"uchi, co-\buchi, and weak automata. We show that there, while semantic determinism does not increase the expressive power, the combinatorial and computational properties of SD automata are very different from these of deterministic automata.
In particular, SD \buchi and co-\buchi automata are exponentially more succinct than deterministic ones (in fact, also exponentially more succinct than history-deterministic automata), their complementation involves an exponential blow up, and decision procedures for them like universality and minimization are PSPACE-complete. For weak automata, we show that while an SD weak automaton need not be pruned to an equivalent deterministic one, it can be determinized to an equivalent deterministic weak automaton with the same state space, implying also efficient complementation and decision procedures for SD weak automata.

Presenter: RADI, Bader Abu

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