Master 2 internship proposal

Title: Comparison of robustness and samplability for timed automata

Location: Laboratoire d'Informatique Fondamentale de Marseille
`http://www.lif.univ-mrs.fr`

Supervisor:
Pierre-Alain Reynier
Tel: 04 91 82 93 13
Web: `http://www.lif.univ-mrs.fr/~preynier`
Email: `pierre-alain.reynier@lif.univ-mrs.fr`

This internship may lead to a PhD thesis.

Context.

Verification of software is a major challenge of computer science. Model-checking techniques, which heavily rely on automata-logic connections, have proven to be successful.

Timed automata [1] [1] are a timed extension of finite-state automata, providing an automata-theoretic framework to design, model, verify and synthesise systems with timing constraints. However, the semantics of timed automata is an idealisation of real-time systems; it assumes, for instance, perfect clocks for arbitrarily precise time measures, and instantaneous actions. Thus, properties proven on timed automata may not hold in a real implementation, and similarly, a synthesised controller may not be realisable on a real hardware.

Such robustness issues have been studied in the last decade, using different approaches (see [2] for a survey). One of them is based on a parametric enlargement of the constraints of the timed automaton, relying on the fact that whenever the (enlarged) timed automaton is correct for a positive value of the parameter, then there exists a correct implementation of the system.

A different point of view is that of discretization. Indeed, the semantics of timed automata uses dense time (delays between actions can be any non-negative real number). This is contrast with real hardware systems, which manipulate discretized clocks. It is thus natural to consider a sampling semantics of a timed automaton parameterized by some value η, that is the set of behaviours obtained when actions are performed every η time units.

Objectives

Considering a timed automaton and a Büchi condition, the *robust acceptance problem* consists in determining whether there exists a timed word accepted by the timed automaton, even under arbitrarily small perturbations on its timestamps. Recently, this problem has been shown to be decidable in PSPACE [5].

On the other hand, the *samplability problem* for timed automata consists in determining whether there exists $\eta > 0$ such that the η-sampling semantics of the

[1] For an introduction to timed automata, one can have a look at the following tutorial: `http://www.lsv.ens-cachan.fr/~bouyer/files/movep14.pdf`

timed automaton is non-empty (we consider here a Büchi acceptance condition too). It has been shown in [3] that this problem is decidable in PSPACE too.

The overall objective of the internship is to study the connections between robust acceptance and samplability.

The first objective consists in proving that whenever a timed automaton robustly accepts some infinite word, then it has a positive answer to the samplbility problem. This should follow from results presented in [5].

In a second step, one should prove that the robust acceptance problem can actually be reduced to a modification of the samplability problem, with additional constraints.

As a perspective, one could study the recent result of [4] which extends the decidability of robust acceptance to the setting of (probabilistic) timed games. It may be interesting to use this result in the setting of samplability.

References

[1] R. Alur and D. L. Dill. A theory of timed automata. *Theoretical Computer Science*, 126(2):183–235, 1994.

[2] P. Bouyer, N. Markey, and O. Sankur. Robustness in timed automata. In *Reachability Problems - 7th International Workshop, RP 2013, Uppsala, Sweden, September 24-26, 2013 Proceedings*, Lecture Notes in Computer Science 8169, pages 1–18. Springer, 2013.

[3] P. Krcál and R. Pelánek. On sampled semantics of timed systems. In *FSTTCS 2005: Foundations of Software Technology and Theoretical Computer Science, 25th International Conference*, Lecture Notes in Computer Science 3821, pages 310–321. Springer, 2005.

[4] Y. Oualhadj, P.-A. Reynier, and O. Sankur. Probabilistic robust timed games. In *Proceedings of the 25th International Conference on Concurrency Theory (CONCUR'14)*, Lecture Notes in Computer Science 8704, pages 203–217. Springer, 2014.

[5] O. Sankur, P. Bouyer, N. Markey, and P.-A. Reynier. Robust controller synthesis in timed automata. In *Proceedings of the 24th International Conference on Concurrency Theory (CONCUR'13)*, Lecture Notes in Computer Science 8052, pages 546–560. Springer, 2013.