Invited Talk: Enclosing Hybrid Behavior

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Abstract

Rigorous simulation of hybrid systems relies critically on having a semantics that constructs enclosures. Edalat and Pattinson's work on the domain-theoretic semantics of hybrid systems almost provides what is needed, with two exceptions.

First, domain-theoretic methods leave many operational concerns implicit. As a result, the feasibility of practical implementations is not obvious. For example, their semantics appears to rely on repeated interval splitting for state space variables. This can lead to exponential blow up in the cost of the computation.

Second, common and even simple hybrid systems exhibit Zeno behaviors. Such behaviors are a practical impediment because they make simulators loop indefinitely. This is in part due to the fact that existing semantics for hybrid systems generally assume that the system is non-Zeno.

The feasibility of reasonable implementations is addressed by specifying the semantics algorithmically. We observe that the amount of interval splitting can be influenced by the representation of function enclosures. Parameterizing the semantics with respect to enclosure representation provides a precise specification of the functionality needed from them, and facilitates studying their performance characteristics. For example, we find that non-constant enclosure representations can alleviate the need for interval splitting on dependent variables.

We address the feasibility of dealing with Zeno systems by taking a fresh look at event detection and localization. The key insight is that computing enclosures for hybrid behaviors over intervals containing multiple events does not necessarily require separating these events in time, even when the number of events is unbounded. In contrast to current methods for dealing with Zeno behaviors, this semantics does not require reformulating the hybrid system model specifically to enable a transition to a post-Zeno state. The new semantics does not sacrifice the key qualities of the original work, namely, convergence on separable systems.

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Biography

Walid Taha is a Professor of Computer Science at Halmstad University. He is interested in the design, semantics, and implementation of programming and hardware description languages. His current research focus is on modeling, simulation, and verification of cyberphysical systems, and in particular the Acumen modeling language.

Taha is credited with developing the idea of multi-stage programming (or "staging" for short), and is the designer of several systems based on it, including MetaOCaml, ConCoqtion, Java Mint, and the Verilog Preprocessor. He contributed to several other programming languages innovations, including statically typed macros, tag elimination, tagless staged interpreters, event-driven functional reactive programming (E-FRP), the notion of exact software design, and gradual typing. Broadly construed, his research interests include cyberphysical systems, software engineering, programming languages, and domain-specific languages.

Taha was the principal investigator on a number of research awards and contracts from the National Science Foundation (NSF), Semi-conductor Research Consortium (SRC), and Texas Advanced Technology Program (ATP). He received an NSF CAREER award to develop Java Mint. He founded the ACM Conference on Generative Programming and Component Engineering (GPCE), the IFIP Working Group on Program Generation (WG 2.11), and the Middle Earth Programming Languages Seminar (MEPLS). Taha chaired the 2009 IFIP Working Conference on Domain Specific Languages.

According to Google Scholar, Taha's publications had over 2,400 citations and an h-index of 26.

Prof. Taha holds an Adjunct Professor position at Rice University.