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LOGICAL ANALYSIS OF HYBRID SYSTEMS: A COMPLETE ANSWER TO A COMPLEXITY CHALLENGE[1]

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ABSTRACT

Hybrid systems are systems with interacting discrete and continuous dynamics. They are models for understanding, e.g., computer systems interfacing with the physical environment. Hybrid systems have a complete axiomatization in differential dynamic logic relative to continuous systems. They also have a complete axiomatization relative to discrete systems. Moreover, there is a constructive reduction of properties of hybrid systems to corresponding properties of continuous systems or to corresponding properties of discrete systems. We briefly summarize and discuss some of the implications of these results.

Keywords: survey, differential dynamic logic, hybrid systems, completeness, complexity

1. Overview

Hybrid (dynamical) systems [2, 7, 12] are dynamical systems that combine discrete and continuous dynamics. They are important for modeling embedded systems and cyber-physical systems. Hybrid systems are natural models for many application scenarios, especially because each part of the system can be modeled in the most natural way. Discrete aspects of the system, e.g., discrete switching, computing, and control decisions can be modeled by discrete dynamics. Continuous aspects of the system, e.g., motion or continuous physical processes can be modeled by continuous dynamics. Hybrid systems combine both kinds of dynamics, not just side by side but with interactions.

This flexibility makes hybrid systems very natural for system modeling. Even very complicated systems can be modeled as hybrid systems by recognizing that some parts of the system are simply discrete, others are simply continuous, and the systems themselves are only complicated because both simple pieces interact in complicated ways. Discrete and continuous aspects can be added to the system model on an as needed basis without having to commit to a prior bias on all modeling elements having

[1]This brief survey is based on an abstract for an invited talk at DCFS [31].