Modeling Approximations of Computational Semantics for Cyber-Physical System Design

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With the seemingly unbounded proliferation of computing power into most any engineered artifact, ever more 'smart' systems are being created. This increase of available smarts in engineered systems has given rise to a new field of innovation where unique value is derived from having intelligent systems interact in novel and unforeseen manners. With the physical world an intrinsic part of the interaction and the smarts being implemented in a networked information modality, also called *cyber space*, these innovative systems are referred to as *Cyber-Physical Systems*. Modeling cyber aspects, physics, and their nexus then plays a crucial role in the design of Cyber-Physical Systems.

In the first part of this presentation, a pick-and-place machine is presented as a paradigmatic example of such Cyber-Physical Systems. The example serves to illustrate the intricate interplay between cyber space and physics. Moreover, it motivates the necessity to provide tools that integrate support for modeling, simulation, and analysis of combined physics, geometry, signal processing, and control aspects, which falls under the charter of *computer automated multi-paradigm modeling* [2, 3].

The second part of this presentation concentrates on solver approximations in generating behaviors for differential equations. At a macroscopic level, physics models often comprise differential and algebraic equations and these equations typically require computational approaches to derive solutions. Approximations introduced by the solvers that derive these solutions to a large extent determine the meaning of the models, in particular when continuous-time behavior interacts with discontinuities such as in so-called *hybrid dynamic systems*. In reasoning about models that are solved computationally it is therefore imperative to also model the solvers. This presentation outlines an approach to modeling numerical solver approximations to help reason about approximations [1, 5, 6]. The solver model further unlocks the opportunity to use model checking for stiff hybrid dynamic systems. In the pick-and-place machine, model checking then allows synthesizing a feedforward control profile for the pick action [4].

References

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