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Co-Simulation of Physical Model and Self-Adaptive Predictive Controller Using Hybrid Automata

Background

Self-adaptive predictive (SAP) control is a promising approach to regulating cyber-physical systems (CPS) through continuous adjustment of control parameters and dynamic system modeling. For example, to provide optimized insulin administration, an artificial pancreas system models a patient's glycemic response by constantly adapting to feedback. However, with the evolving behavior of time-variant physical systems, safety verification of SAP controllers becomes a highly complex and often intractable problem. Reachability analyses, which determine the set of states that can be reached given initial states, require approximations for time-variant systems that may present reliability concerns. For this reason, a methodology able to effectively verify SAP controllers in these environments can be vital for guaranteeing the safety of intricate automated processes.

Invention Description

Researchers at Arizona State University have developed a co-simulation platform for SAP controller verification and reachability analysis. Unlike existing hybrid automata tools, this method achieves run-time self-adaption through the time synchronization of: (1) the controller's discrete decision-making module, (2) physical model update method, and (3) the physical system evolution. Updating of the predictive model is performed by comparing the expected value of the model parameters to estimated parameters computed from the physical system. Reachability is established by combining all regions of the state space visited by the system after each new initial controller configuration, allowing identification of any intersections with an unsafe set.

Potential Applications

- Medical devices
- Software development
- Cyber-physical system safety

Benefits and Advantages

- Dynamic – Predictive system model updates continuously
- Rigorous – Uses hybrid automata to achieve a higher level of safety verification than numerical simulation
- Innovative – Provides a new solution to the uncommonly addressed challenge of SAP controller verification for time-variant systems

Laboratory Homepage of Professor Sandeep Gupta