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Hybrid Automata Mining from Input/Output Traces of Cyber-Physical Systems

Background Hybrid systems are versatile in modeling the interaction between the cyber and physical components of cyber-physical control systems (CPS) such as artificial pancreases. They are typically used for analysis of safety of the human-centric control systems which have serious consequences of failure. As such, hybrid systems are parameterized and the variables often depend on the subject on which the control system is deployed. Traditionally, control systems are initially developed using average statistical estimates of the subject-specific parameters. However, such excursions may lead to suboptimal designs. Invention Description Researchers at Arizona State University have developed a hybrid system parameter estimation tool where the subject-specific parameters in a hybrid system are automatically learned from experimental traces from the operation of a human-centric CPS control system. As inputs, the algorithm takes in: (1) the time series traces of the controller outputs, and (2) the observed variables that are collected using sensors by the controller and used to compute the next controller output. This innovation employs a hybrid system mode segmentation method to derive the discrete modes of the hybrid system. Using analysis based on Fisher information and the Cramer-Rao bound, transitions between two modes are defined by guards; such guards are assumed to be urgent and accommodate not only rectangular forms but also those that are linear functions of the continuous system variables. This innovation is covered by U.S. Pat. No. 11,054,807. Overall approach scheme. Potential Applications • Cyber-physical control systems • Hybrid automata • Personalized medical devices including artificial pancreases and blood glucose control Benefits and Advantages • Able to extract control modes where the controller output is a linear combination of the continuous state variables • State variables follow a set of linear differential equations • Guard conditions can be rectangular and non-rectangular expressed as a linear combination of the continuous state variables Related Publication: HyMn: Mining linear hybrid automata from input output traces of cyber-physical systemsResearch Homepage of Professors Sandeep Gupta and Ayan Banerjee