Title	ハイブリッドシステムの定性的解析について
Author(s)	野村, 彰典
Citation	
Issue Date	2003-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/1652
Rights	
Description	Supervisor:平石 邦彦, 情報科学研究科, 修士

On Qualitaive Analysis of Hybrid Systems

Akinori Nomura (110102)

School of Information Science,
Japan Advanced Institute of Science and Technology

February 14, 2003

Keywords: Hybrid systems, qualitative analysis, qualitative simulation, reachability, system verification.

A hybrid system is dynamical system with both discrete and continuous state change. Therefore, it is useful for the analysis and design of distributed, embedded control systems. Hybrid systems have been used as mathematical models for many important applications, such as automated highway systems, air-traffic management systems, manufacturing systems, chemical process, robotics, real-time communication networks, and real-time circuits. Their wide applicability have inspired a great deal of research from both control theory and theoretical computer science.

Many researches on hybrid systems focus on their formal analysis and design methodology. One of main research topics in the formal analysis of hybrid systems is to verify whether a system satisfies a given specification, such as avoiding an unsafe region of the state space. Formal analysis of hybrid systems is typically a very difficult process due to their complexity. Most of the researches on the verification have been done by computational or algorithmic approaches. Analysis of hybrid systems has several difficulties. The first difficulty it to deal with infinite continuous states. One of solutions to this difficulty is abstracting discrete state changes from a given hybrid system by using bisimulation, however this is applicable only for restricted classs of hybrid systems. The second difficulty is that reachability, one of the fundamental problems in the verification, is undecidable even for simple classes of hybrid systems. A solution to this difficulty is to restrict the continuous or the discrete dynamics. The third difficulty is the fact that a little change of parameters may cause drastic change in the behavior.

Reachability problem is one of central issues in the verification of hybrid systems. It is decidable only for some special cases of hybrid systems, and is undecidable in general. KRONOS, COSPAL, UPAAL, and HYTECH are verification tools for hybrid systems. Semi-decision algorithms are implemented in these tools, i.e., termination of the algorithms are not guaranteed, when it is applied to classes of hybrid systems in which reachability is undecidable.

Large-scale hybrid system such as genome network is one of novel applications of hybrid systems. Recently, the research on description and analysis of such systems have started. In such systems, exact values of parameters are unknown, but what we want to know is only qualitative information on the system.

Qualitative analysis of hybrid systems is also useful for the parameter design problem, that is, how to assign real values to parameters of a hybrid system so that the behaviour of the system may satisfy a given specification.

Qualitative simulation was proposed as a method for qualitative analysis of continuous dynamic systems. QSIM is a common tool for qualitative simulation. It is guaranteed that the behaviours predicted from QSIM include all the possible ones. However, the predicted behaviour may include spurious ones since QSIM usually ignores largeness of different variables. Therefore, QSIM is one of approximated simulation tools. For hybrid systems with incomplete information, we propose a new simulation method *symbolic simulation* taking account of largeness of different parameters. Main aim of symbolic simulation is to predict behaviour of linear hybrid systems with incomplete information. Parameters in transition guard to compare with variable are called boundary values.

Symbolic simulation allow to compare largeness of boundary values, largeness of boundary values and rate of change, and largeness of fractions of difference of boundary values and rate of change, because of taking account of largeness of parameter. Therefore, obtained behavior may be a better approximation of the real behavior than that by usual qualitative simulation like QSIM. In general, it is impossible to decide whether a given location is reachable from the initial location by symbolic simulation, so it is still an approximated simulation method like QSIM. However, we can prove that the reachability is decidable by symbolic simulation for some restricted classes of hybrid systems.