Hybrid Systems Model Transformations with HYST

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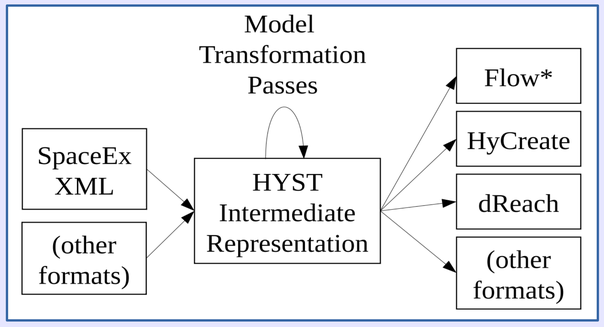
Overview

HYST: a source-to-source translation tool for hybrid automaton models. Two main functions:

- Model translation
- Model transformation



HYST Conversion Architecture

Model transformations ease modeling and improve reachability analysis:

- Model Optimization
- Hierarchy Flattening
- Look-up Table Conversion
- Model-Order Reduction
- Automated Pseudo-Invariants
- Continuization of Real-Time Controllers
- Simulation-Guided Hybridization

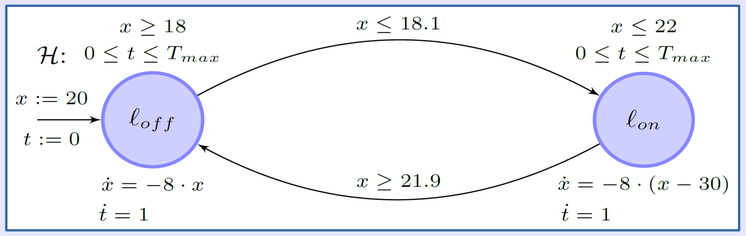
Recent Publications

- "HYST: A Source Transformation and Translation Tool for Hybrid Automaton Models", S. Bak, S. Bogomolov, T. Johnson, Tools Paper, ACM/IEEE 18th International Conference on Hybrid Systems: Computation and Control (HSCC 2015)
- "Periodically-Scheduled Controller Analysis using Hybrid Systems Reachability and Continuization", S. Bak, T. Johnson, 36th IEEE Real-Time Systems Symposium (RTSS 2015)
- "Scalable Static Hybridization Methods for Analysis of Nonlinear Systems", S. Bak, S. Bogomolov, T. Henzinger, T. Johnson, P. Prakash, 19th International Conference on Hybrid Systems: Computation and Control (HSCC 2016)
- Hoang-Dung Tran, Luan Viet Nguyen, Taylor T. Johnson, "Benchmark: A Nonlinear Reachability Analysis Test Set from Numerical Analysis", In Applied Verification for Continuous and Hybrid Systems Workshop (ARCH 2015)

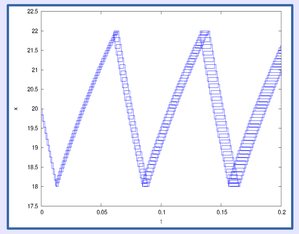
Experimental Results

HYST and examples are available online at: http://verivital.uta.edu/hyst/

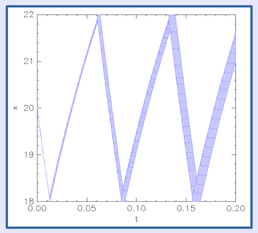
Reach set visualizations for on/off heater system in different target tools



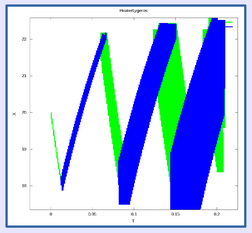
Hybrid Automaton



Flow*



SpaceEx STC

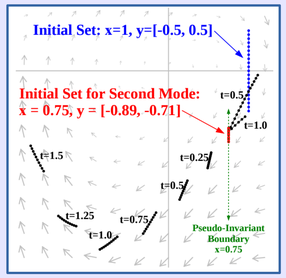


HyCreate2

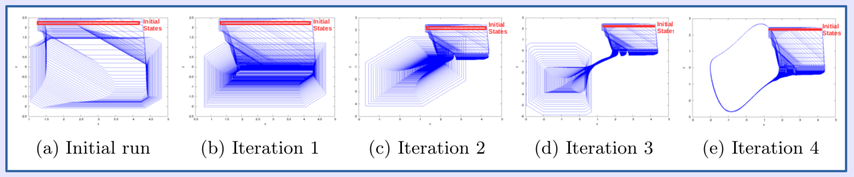
Transformation: Automated Pseduo-Invariants

$$\begin{aligned} x' &= y \\ y' &= (1 - x^2) * y - x \end{aligned}$$

Vanderpol Dynamics



Auxiliary Hyperplane

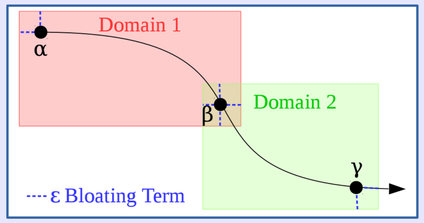


(a) Initial run (b) Iteration 1 (c) Iteration 2 (d) Iteration 3 (e) Iteration 4

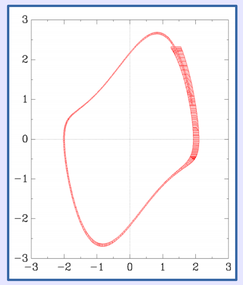
Multiple Iterations may be Necessary

➔ **Simulations are used to determine the placement of auxilary hyperplanes, improving accuracy.**

Transformation: Static Simulation-Guided Hybridization



Simulation-Guided Domains

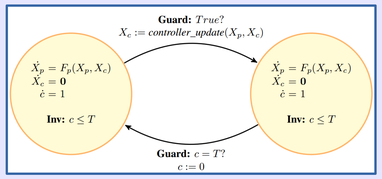


SpaceEx Result

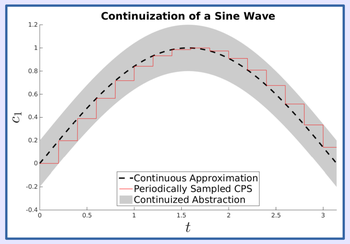
➔ **Time-triggered transitions and limited linearization domains enable scalable abstractions for nonlinear systems.**

Transformation: Continuization of Real-Time Controllers

➔ **Real-time scheduling guarantees periodic actuation for low-level controllers. Continuization enables analysis of such systems using continuous dynamics approximations with additional bounded noise.**



Model of a Real-Time Low-Level Controller



Enclosing Abstraction