Hybrid and Multi-Formalism Modelling

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Overview

- Hybrid Modeling System
- Purpose of the Project
- Tool: HyVisual in Ptolemy II
- Project: A Train System
- Demo
- Conclusion
Hybrid Modelling System [1]

- Heterogeneous systems including continuous-time subsystems interaction with discrete events
- Effective to model physical systems interacting with software or undergoing discrete mode changes

Hybrid Modelling System

- Continuous Subsystem
  - Using differential equations

- Discrete Event
  - Using finite state machines
  - Transitions between states represent either discrete mode changes or actions taken by software subsystems
Purpose of this project

• Explore how to use hybrid modelling formalism to stimulate real-world system:
  • Tools: HyVisual in Ptolemy II
  • Simulated system: A Train System
• Show the advantages of hybrid modelling formalism
Tool: HyVisual in Ptolemy II

• Ptolemy Project [2]
  • UC Berkeley EECS Department
  • Study modeling, simulation, and design of concurrent, real-time, embedded systems
  • http://ptolemy.eecs.berkeley.edu/index.htm

• Ptolemy II
  • A open-source software framework supporting simulation experimentation with actor-oriented design

Tool: HyVisual in Ptolemy II

• HyVisual [3]
  • Hybrid System Visual Modeler
  • Block-diagram editor and simulator for continuous-time dynamical systems and hybrid systems
  • Supporting construction of hierarchical hybrid systems
    • Using block-diagram representation ordinary differential equations (ODEs) to define continuous dynamics
    • Using finite state machine to define discrete events
    • Allowing mix of continuous-time signals with events that are discrete in time

Tool: HyVisual in Ptolemy II

- HyVisual:
HyVisual: Directors

- Continuous Directors (Simulator)
  - Manage the continuous simulation
  - Contains a sophisticated ODE solver
HyVisual: Actors

- Actors: software components that can execute concurrently and communicate through messages sent via interconnected ports
HyVisual: Actors

- Actors used in this project:
  - Modal Model Actor
  - Source Actor:
    - const actor
  - Mathematical Actors:
    - Add/Abstract actor
    - Scale actor
  - Continuous Actors:
    - Integrator actor
    - Resettable timer actor
  - Random Actors:
    - uniform random Actor
HyVisual: State Machine

- An example: bouncing ball

The "free" state contains a refinement that describes the physics of a mass in free-fall. The self-loop transition on this state models a bounce by reversing the direction of motion.

```
init
guard: true
set: free.initialPosition = initialPosition; free.initialVelocity = 0.0
```

```
guard: bump_isPresent
set: free.initialVelocity = -elasticity * velocity; free.initialPosition = position
```
HyVisual: Hierarchical Models

- Continuous Actors
  - Continuous Model (a Modal Model Actor)
  - Input/output ports: State
  - Transactions: State
  - Continuous Model: State

Diagram:

- Continuous Actors
  - Continuous Model (a Modal Model Actor)
    - State
    - Input/output ports
    - Transactions: State
    - Continuous Model: State
Project: Simulation of A Train System

- Discrete Event:
  - loading and unloading passengers
  - Change between modes
- Continuous dynamics:
  - Train accelerating and decelerating
Project: Simulation of A Train System

• Empty train (discrete):
  • Load passengers, until the train is full
• Full train (continuous & discrete):
  • Leave the station, start accelerating
  • Velocity control: bang-bang control
  • Get close to the destination, start baking until stop at the destination's station
• Arrive at the destination (discrete):
  • Unload passengers
More Details & Demo
Conclusion

- Build a hybrid system: the Train System using HyVisual
  - Based on block-diagram – straightforward, easily handle complicated hierarchical structures
- Hybrid Modelling:
  - Embrace discontinuities and discrete events along with the usual piecewise continuous signals
  - Provide modelling semantics and results that are not only predictable, but easily understandable
Hybrid and Multi-Formalism Modelling

Question?