Behavioural Hybrid Process Calculus

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Hybrid Systems

Continuous dynamics
- mechanical movement
- chemical reactions
- electrical circuits

Discrete dynamics
- collisions
- valves, pumps, switches
- digital control

Examples of Hybrid Systems

Embedded
- Phone
- TV
- Vehicle

Traffic Control Systems
- Highway Supervision
- Air Traffic Management
- Sea Traffic Management

Production Processes Control and Robotics
- Chemical industry
- Energy (power generation)
- Food industry

Language

$$P := a.P \mid [\varphi].P \mid \bigoplus_{i \in I} P_i \mid P \parallel_A^H P \mid P[\sigma] \mid B$$

$$\frac{\{B(v) \xrightarrow{\varphi} B'(v) \mid v \in I\},\ \{B(w) \xrightarrow{\varphi} \not\to, w \in J\},\ I \neq \varnothing}{\bigoplus_{v \in I \cup J} B(v) \xrightarrow{\varphi} \bigoplus_{v \in I} B'(v)}$$

Hybrid bisimulation is a congruence

Bisimilar processes can be substituted

Process Calculus Ingredients

Trajectories & their continuations

Synchronization only on specified actions & signals

Behavioural approach

- Trajectory-prefix
- Superposition
- Parallel Composition
- Separation of Concerns
- Continuous Behaviour

Choice is made when it is really time to do it

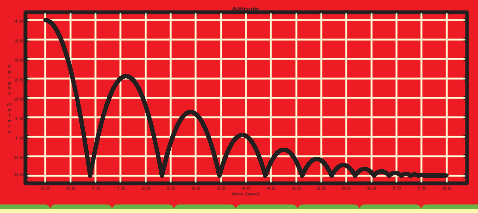
Discrete and continuous behaviours can be separated syntactically

Hybrid Transition System

$$HTS = \langle S, A, \rightarrow, W, \Phi, \rightarrow_c \rangle$$

- S is a *state space*,
- A is a set of *(discrete) action names*,
- $\rightarrow \subseteq S \times E \times S$ is a *(discrete) transition relation* $(s \xrightarrow{a} s')$,
- W is a signal space,
- Φ is a *set of (initial) trajectories* $\varphi : (0, t] \rightarrow W$ for $t \in R^+$
- $\rightarrow_c \subseteq S \times \Phi \times S$ is a *(continuous) transition relation* $(s \xrightarrow{\varphi} {}_c\, s')$

Bouncing ball



$$BB(h_0, v_0) =_{df} [h, v : \Phi(h_0, v_0) \mid h = 0].\ BB(0, -cv)$$

$$\Phi(h_0, v_0) = \begin{bmatrix} h, v : h(0) = h_0, v(0) = v_0 \\ \dot{h} = v, \dot{v} = -g \end{bmatrix}$$

Plans

Development of analytical techniques for hybrid systems in the BHPC framework

Simulation of BHPC

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