Modeling: Hybrid systems

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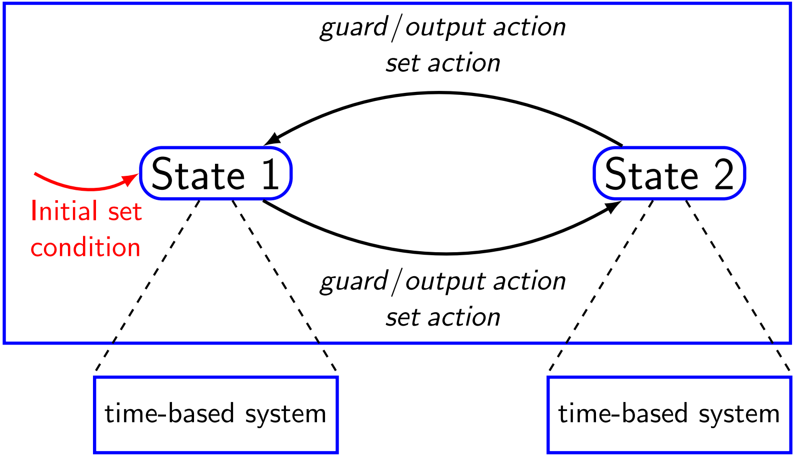
Introduction

- Most of the systems have both continuous and discrete behavior
- Continuous behavior can be modeled by ODE and discrete behavior by FSM
- Need to have separate modeling scheme to describe both the behavior
- Usually, states in discrete modelling are enhanced with time based behavior

Hybrid systems: example

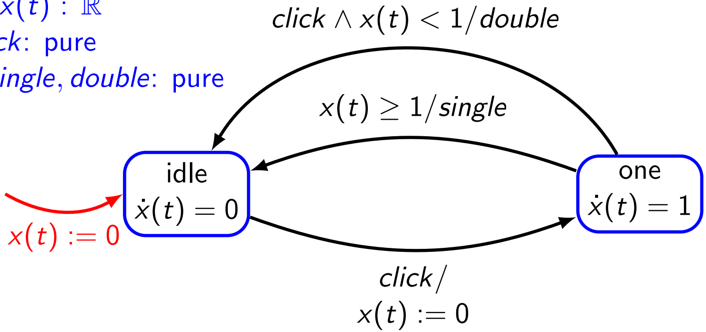
- Digital controller
  - Thermostat
  - Automatic cruise control
  - Aircraft autopilot
- Phased operation
  - Bouncing ball
  - Biological cell growth
- Multiagent systems
  - Interaction of robots
  - Ground and air transportation systems

Timed automata

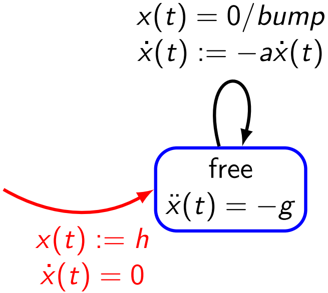


Double click detector

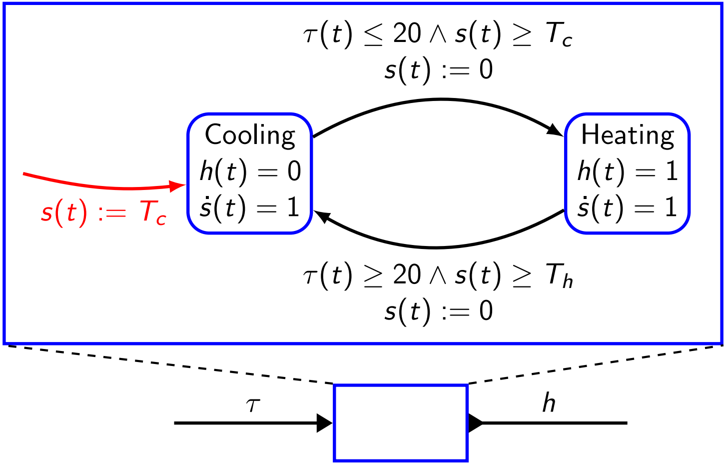
variable: $x(t) : \mathbb{R}$
input: *click*: pure
output: *single*, *double*: pure



Bouncing ball



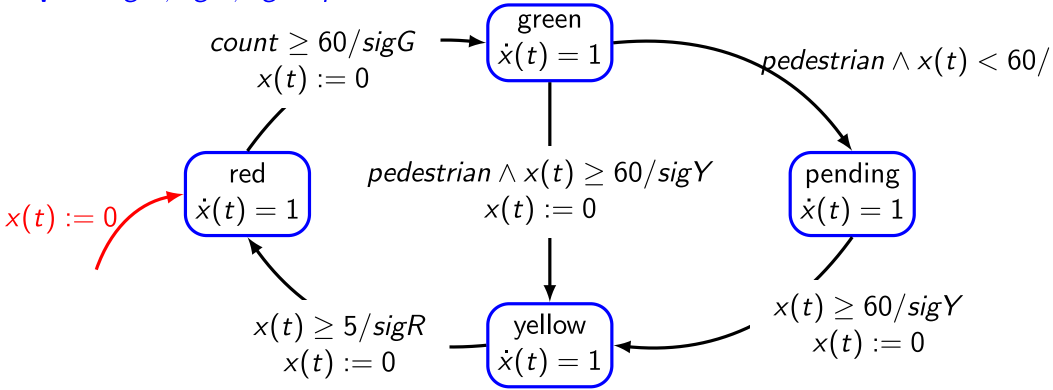
Thermostat



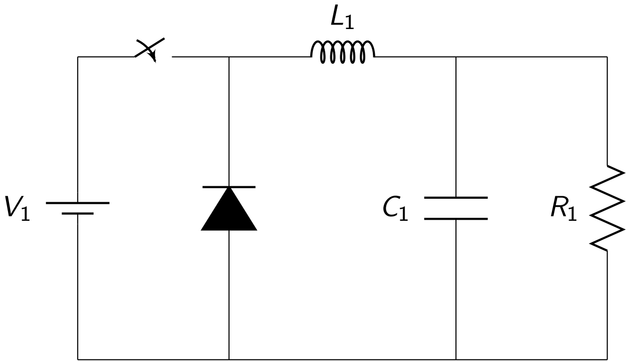
τ(t) ≤ 20 ∧ s(t) ≥ T_c
s(t) := 0
Cooling
h(t) = 0
ṡ(t) = 1
Heating
h(t) = 1
ṡ(t) = 1
s(t) := T_c
τ(t) ≥ 20 ∧ s(t) ≥ T_h
s(t) := 0
τ
h

Example: pedestrian crosswalk

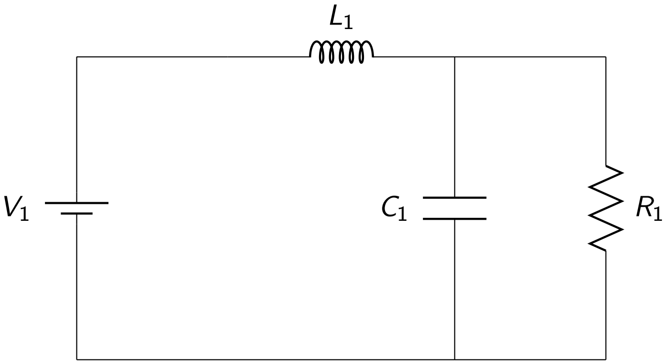
variable: $count : \{0, 1, \ldots, 60\}$
input: $pedestrian : pure$
output: $sigY, sigG, sigR : pure$



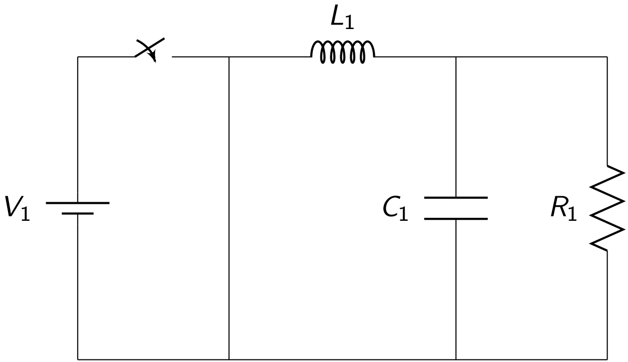
Buck converter



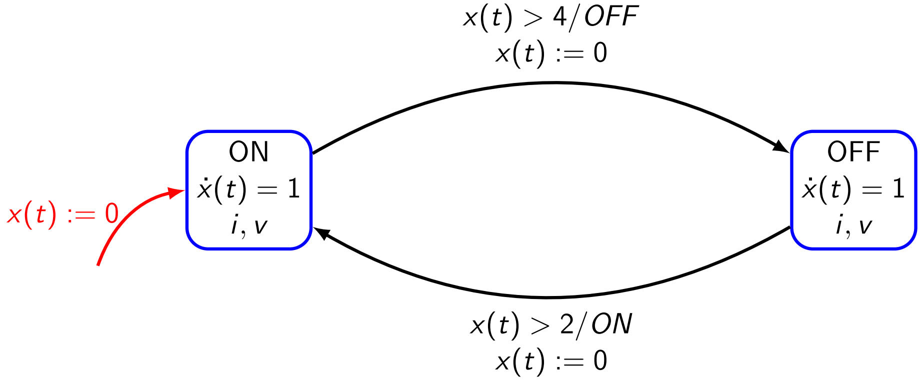
Buck converter: Mode 1



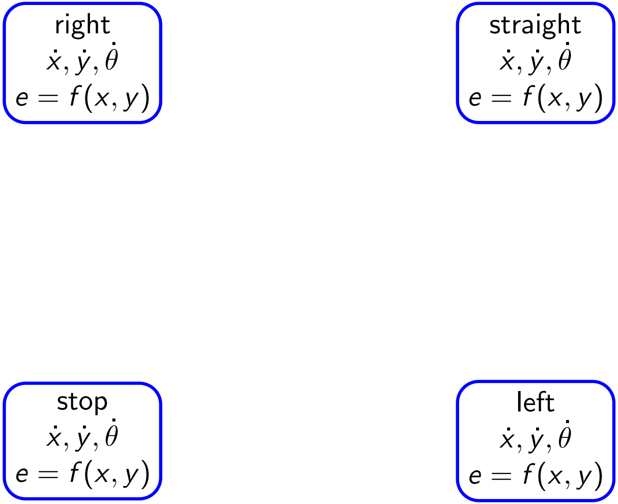
Buck converter: Mode 2



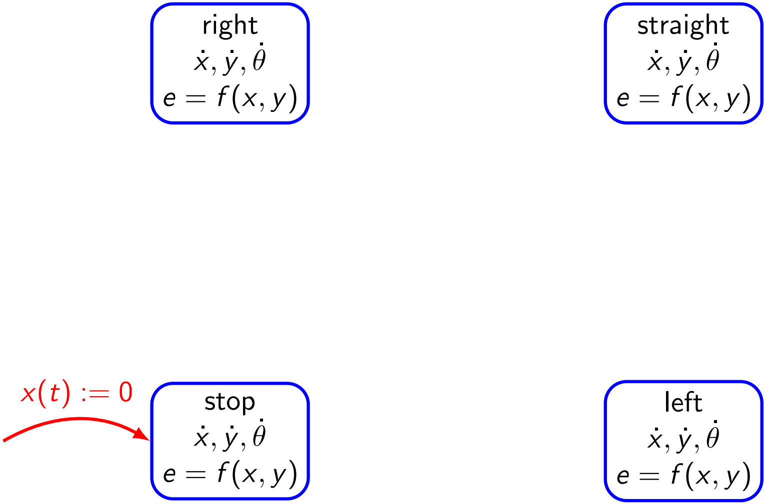
Buck converter: hybrid automata



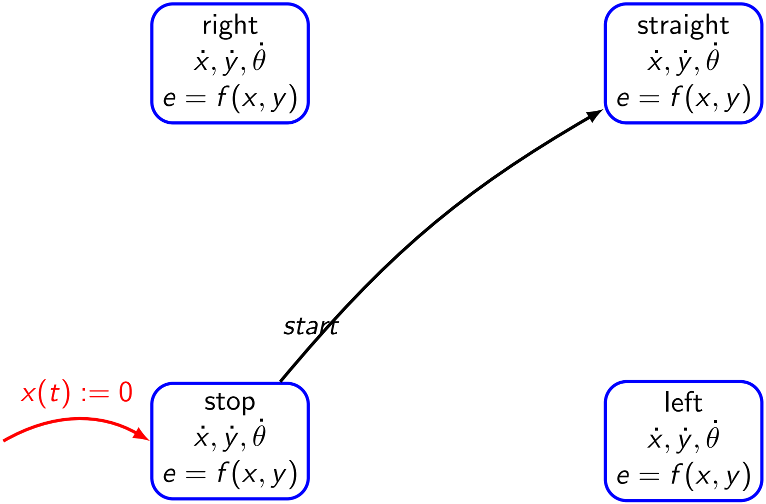
Automatic cruise control



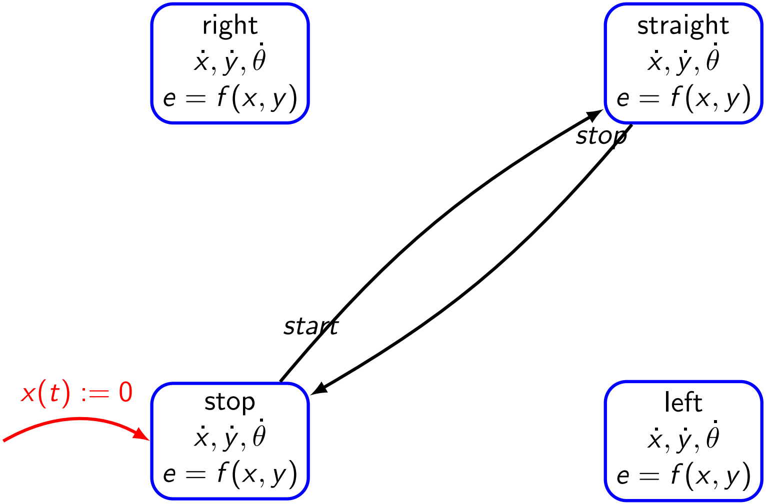
Automatic cruise control



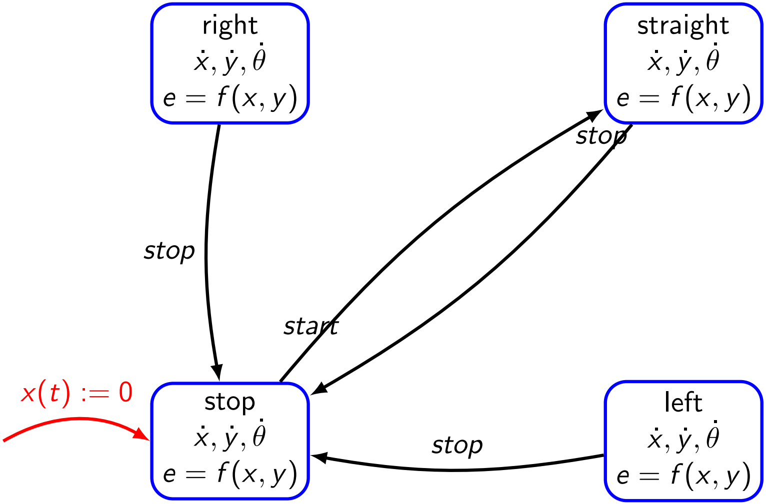
Automatic cruise control



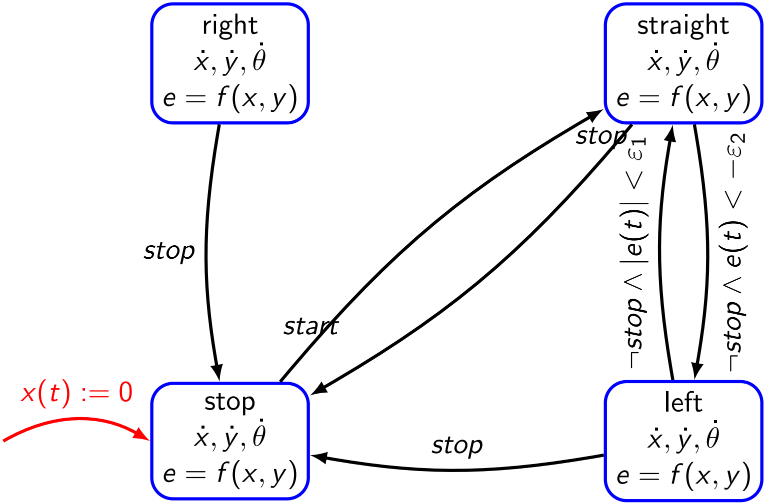
Automatic cruise control



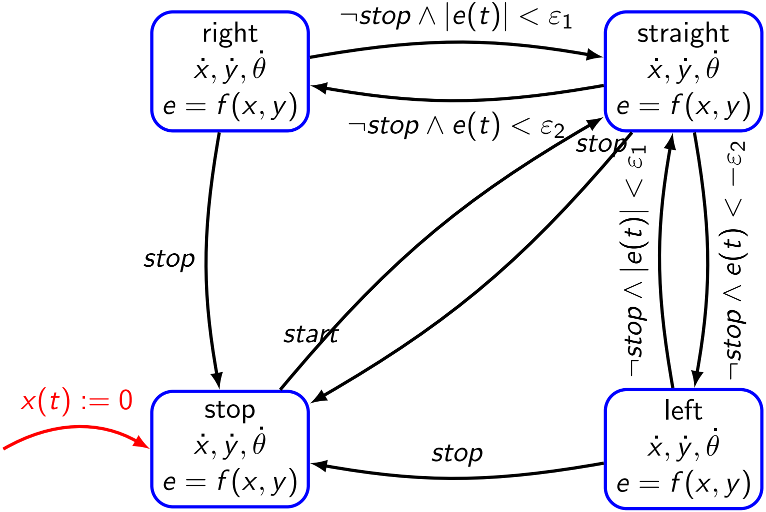
Automatic cruise control



Automatic cruise control



Automatic cruise control



Automatic cruise control