Tutorial 9: Hybrid systems part 2

December 5, 2025

Exercise 1a: modelling a parachute jump

We want to model a parachute jump with a hybrid system. The person jumps from the aircraft at a height between 4000 and 4200 metres. Their initial velocity is 0 and they are submitted to a vertical acceleration of $g/4$ m/s^2. The person does not open the parachute immediately after leaving the aircraft but waits for some time t (in seconds) such that $40 < t < 80$. We model the parachute in a very simple way: once it is opened, it instantaneously reduces the vertical acceleration to $g/10$ m/s^2.

Exercise 1b: analysis of the model

We would like to know whether or not the person will always survive to such a jump. We consider that a terminal speed strictly greater than 20 m/s is lethal.

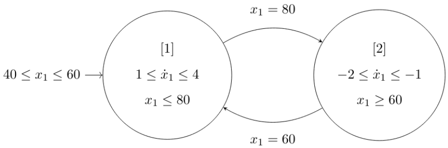
1. Extend the hybrid system with an observer process that witnesses the state of life or death of the person (you may also modify the rest of the system, e.g. by adding synchronisation labels).
2. Is there a reachable state where the person dies?

Zeno systems

The arrow never reaching its target.
Wikipedia page

Your turn, will be discussed next week (source January 2024)

A thermostat is modeled by the following hybrid system, in which the control locations [1] and [2] of its single process represent (respectively) the heating and non-heating modes of operation.



(a) Does this hybrid automaton have the Zeno property? (Justify your answer.)

(b) Compute all the reachable states of this hybrid system.

(c) Create an additional process for this hybrid system, that moves to a dedicated control location whenever the first process stays continuously in the heating mode of operation for at least 10 time units, and remains in other control locations otherwise. *Note:* You cannot modify the first process, except for adding (if you wish) synchronization labels of your choice to its transitions.