

Exam — Modeling and Control of Hybrid Systems (SC42075)

June 27, 2023

This exam has **four** questions; the maximal score for each question is marked in red next to the given question.

Questions:

- 10
1. Give a **new** example (i.e., one that has **not** been discussed in the lecture notes, the slides, the lectures, or the assignment of this and previous years) that illustrates the following concept, and next use the example to **explain** the given concept in your own words:
 - (a) guard
 - (b) bisimulation
 - (c) Zeno behavior
 - (d) global uniform asymptotic stability
 - (e) Filippov solution
- 4.5
2. For each of the following systems with a specific property, give — *if possible at all* — a **new** example (i.e., one that has **not** been discussed in the lecture notes, the slides, the lectures, or the assignment of this and previous years) of a system that satisfies the given property. **Motivate** your answer.
 - (a) a timed automaton with 3 modes and with live-lock behavior
 - (b) a non-deterministic piecewise affine system with 2 regions
 - (c) a fully deterministic hybrid automaton with at least 2 modes and with nonlinear dynamics in each mode
- 8
3. This question is about max-min-plus-scaling (MMPS) and linear complementarity (LC) systems.
 - (a) Is a constrained MMPS model always deterministic? If not, when is it deterministic and when is it non-deterministic? Explain and motivate your answer. What if we consider an *unconstrained* MMPS model?
 - (b) Is an LC model always deterministic? If not, when is it deterministic and when is it non-deterministic? Explain and motivate your answer.
 - (c) Under which conditions can an MMPS model be transformed into an LC model? Explain how the transformation can be done (the exact formulas for the equivalences used should not be given, but the nature of the formulas/equivalences should be indicated).
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4.
 - (a) Why is the concept of generalized gradient useful in the context of hybrid systems; how is it defined, and what can it be used for?
 - (b) What are the main advantages and disadvantages of a timed automaton model?

End of the exam
