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Sommersemester 2013

Real-Time Systems

http://swt.informatik.uni-freiburg.de/teaching/SS2013/rtsys

Exercise Sheet 1

Early submission: Monday, 2014-05-12, 14:00   Regular submission: Tuesday, 2014-05-13, 14:00

Exercise 1 (5/20 Points)

In the introductory lecture, we tried to give examples for clearly real-time, clearly non real-time, and "somehow but not really" systems.
Please give one good own example for each of these categories and explain briefly why it is a (good) example.
Hint: refer to the lecture's definition of real-time system. For example, are there real-time aspects in the Soft-Drink Vending Machine, or with networks like TCP/IP, CAN, ...

Exercise 2 (7/20 Points)

Recall the airbag example from the introductory lecture (cf. Figure 1). One functional requirement on the controller software was that the system consisting of crash sensor, airbag, and the controller running this software should ensure:

> "When a crash is detected, fire the airbag within 300ms $+/-\varepsilon$ after the crash."

(i) Give an adequate set of observables for formalising the above given requirement. What could be a different but also adequate set of observables? Explain. (2)

(ii) Explain your understanding of the requirement in natural language as precise as you can.

Formalise your understanding of the requirement using first-order logic.

Explain why your formalisation is correct. (2)

(iii) Give three system evolutions such that

a) one non-trivially satisfies the requirement,

b) one trivially (what do you understand under trivially?) satisfies the requirement,

c) one does not satisfy the requirement.

Explain. (3)

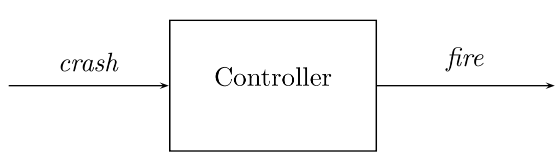

Figure 1: Illustrative picture.

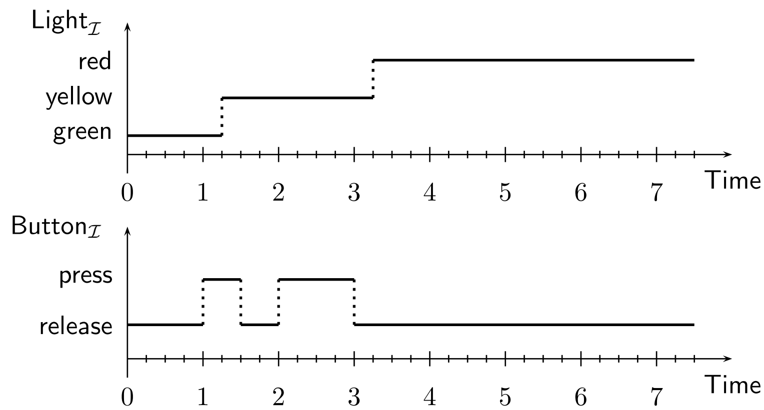

Figure 2: Interpretation of 'Light' and 'Button'.

Exercise 3 [1] **(8/20 Points)**

A traffic light for pedestrians is modelled by the observables 'Light' of data type $\{\mathsf{red}, \mathsf{yellow}, \mathsf{green}\}$ and 'Button' of data type $\{\mathsf{press}, \mathsf{release}\}$.
Consider an interpretation $\mathcal{I}$ of these observables as given by the timing diagrams in Figure 2.

(i) Calculate the truth value of the state assertion

$$(\mathsf{Light} = \mathsf{green})$$

at $t_1 = 0.5$ and $t_2 = 3.0$.

Hint: Compute $\mathcal{I}[\![\cdot]\!](t)$ and give the details on how you compute it. (2)

(ii) Draw the interpretation of the state assertion

$$\mathsf{Light} = \mathsf{green} \wedge \neg(\mathsf{Button} = \mathsf{release})$$

on the interval $[0, 7]$. (2)

(iii) Equip the term

$$x \cdot \int \mathsf{Light} = \mathsf{green} \wedge \neg\mathsf{Button} = \mathsf{release} \qquad \text{(A)}$$

with proper parentheses. (1)

(iv) Bring the term (A) into prefix normal form (e.g. $+(\theta_1, \theta_2)$ instead of $(\theta_1 + \theta_2)$ and colour it according to the following colour scheme:

- DC symbols are violet, other symbols blue, maths black,
- underbrace each state assertions in beige and each term in green. (1)

(v) Let $\mathcal{V}(x) = 5$. Calculate the real value of the term (A) in the interval $[1, 6]$. (2)

References

[1] Ernst-Rüdiger Olderog and Henning Dierks. *Real-Time Systems - Formal Specification and Automatic Verification.* Cambridge University Press, 2008.