Course sc4160

Modeling & Control of Hybrid Systems
Overview

Overview

1. Overview of the course
2. General information on the course
3. Examination
4. Hybrid systems: Motivating examples

1. Overview of the course

Topic: hybrid systems

Main feature: combination of discrete and continuous dynamics

Contents:

1. Introduction
2. Models
3. Dynamics & well-posedness
4. Stability
5. Switched control
6. Optimization-based control
7. Model checking and timed automata

Objectives of the course

- Get familiar with hybrid systems
- Obtain overview of modeling, analysis, and control methods
- Get insight in trade-off modeling power vs decision power
- Modeling, analysis, and control of *tractable* classes of hybrid systems
- Apply hybrid systems modeling and control to simulation case study

2. General information on the course

- Web site: `http://www.dcsc.tudelft.nl/~sc4160`
  or via Blackboard (course code: sc4160)
  - extra information (errata, schedule, . . .)
  - pdf files of hand-outs, slides, practical assignment, . . .
- Lecture notes:
  “Modeling and Control of Hybrid Systems”
  by Bart De Schutter and Maurice Heemels
  January 2009
  Sold on-line via Microweb Edu (access via Blackboard)

Assessment

- Final grade:
  - * practical assignment:
    designing a hybrid systems controller
    for adaptive cruise control

    group work (3–4 students/group)
  - → assessment based on report and
    discussion (on report & course)
  - \+ bonus points (by reporting errors)

Contact information

- Email address of lecturer: `b.deschutter@tudelft.nl`
- Teaching assistants (for practical assignment):
  - Samira Farahani (`s.safaeifarahani@tudelft.nl`,
    room 8C-3-10 (before March 1)/8C-3-23 (after March 1)
    Rudy Negenborn (`r.r.negenborn@tudelft.nl`, room 8C-3-20)
- Please enroll via Blackboard if you want to stay informed!

Schedule

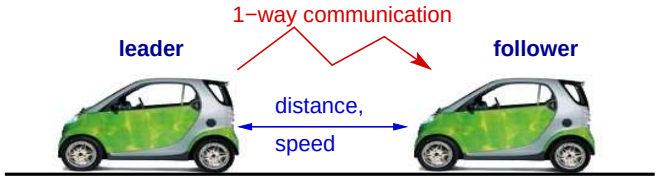
- Regular lectures:
  - Tuesdays, 8.30–10.30 (room K): Feb. 9, 16 + March 2, 9, 16, 23
  - Thursdays, 15.30–17.30 (room F): Feb. 18 + March 4
- Office hours (for assignment, by Samira Farahani and Rudy Negenborn):
  - Wednesdays, 14.00-16.00: Feb. 24 + March 10, 17, 24, 31
  - Fridays, 15.00–17.00: Feb. 26 + March 12, 19, 26
- Question hour (room K):
  Tuesday, 8.30–10.30: March 23 (last lecture)
- Examination: April 7, 2006, 14.00–17.00 ($\pm$ 30 min per group)

3. Practical assignment

- Topic: designing a hybrid systems controller
  → adaptive cruise control
- Group work (3–4 student/group)
  with report and discussion (= oral examination)
- Description: see course website
- Deadline: Wednesday, March 31, 17.00 p.m.
  Send your pdf file to `b.deschutter@tudelft.nl`

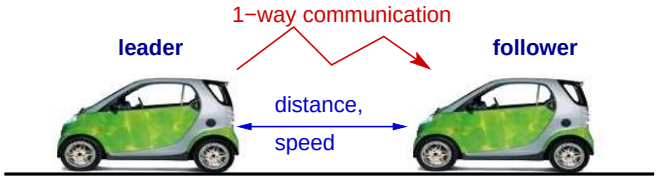
3. Practical assignment (continued)

- Set-up: adaptive cruise control



- Continuous model for Smart $\rightarrow$ hybrid model
- Design MPC controller (implicit, and maybe also explicit) for speed adaptation

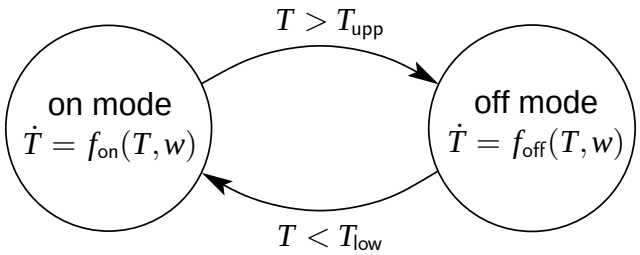
Schedule (continued)



- Description (+ road map): next lecture / website
- Registration list: next lecture / email
- Teaching assistants: Samira Farahani and Rudy Negenborn

4. Hybrid systems: Motivating examples

- Hybrid: combination of continuous and discrete dynamics
- Temperature control system:



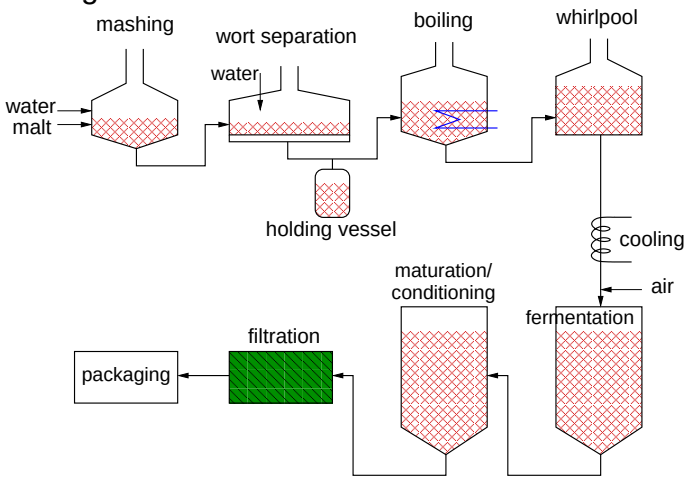
Motivating examples

- Hierarchical control in process industry
- Telecommunication systems
- Manufacturing systems
- Airplane coordination control
- Beer brewing

Human intervention in smooth systems $\rightarrow$ hybrid

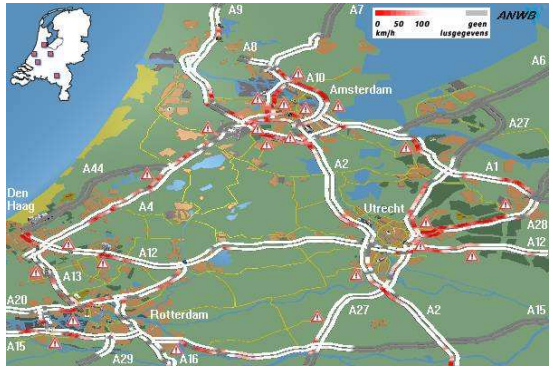
Motivating examples

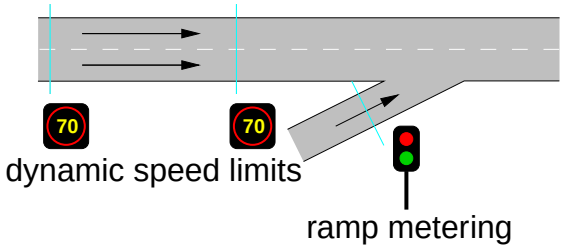
- Beer brewing



Motivating examples

- Traffic control systems



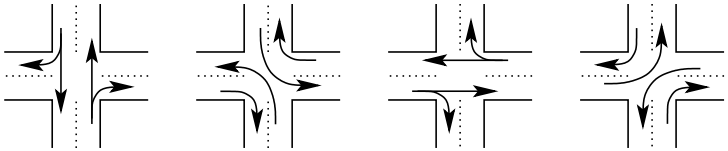


dynamic speed limits

ramp metering

Motivating examples

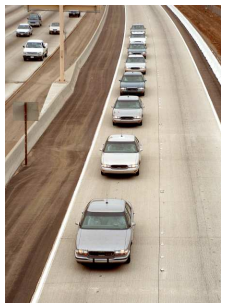
- Intersection with traffic signals



4 modes, states: queue lengths

- Automatic platooning

merging & splitting



Motivating examples

- Evolution of rigid bodies (contact/no contact)
- Electrical networks (switching, diodes)
- Fermentation process (lag, growth, stationary, inactivation)
- Saturation, hysteresis
- Actuator and sensor failures

Switching between dynamical regimes → hybrid

Challenges

- Analysis and control
- Nowadays:
  - often heuristic & ad-hoc
  - focus exclusively on either continuous or discrete dynamics

  $\rightarrow$ structured approach necessary
- Consider hybrid nature of systems
- Combination of systems & control, computer science, mathematics, and simulation

$\rightarrow$ this course will give some handles to tackle these issues

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