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

**Important note:**
This is a *fundamental, theory* course, not a hands-on course. So be prepared to expect definitions, theorems, proofs, etc.
2. General information on the course

- Web site: https://www.dcsc.tudelft.nl/~bdeschutter/hs or via Brightspace (course code: sc42075)
  - pdf files of slides, hand-outs, assignment, ...
  - extra information (errata, schedule, ...)

- Lecture notes:
  “Modeling and Control of Hybrid Systems - SC42075”
  by Bart De Schutter and Maurice Heemels
  December 2015
  Available on-line via https://readers.tudelft.nl
  or https://www.webedu.nl/bestellen/tudelft/
Assessment

• written exam:
  * online exam, exact format to be decided
  * counts for 60% of the final marks
  * please register via Osiris!

• assignment:
  * counts for 40% of the final marks
  * 1) modeling a simple hybrid system as a hybrid automaton
     2) designing a hybrid systems controller
        for control of microgrid
  * group work (2 students/group)
    → assessment based on written report

+ bonus (max. 1, by reporting errors in lecture notes)
Assessment

Important: partial marks for exam or assignment do not carry over from one academic year to the next.
Contact information

• Important: Please ask your questions on the lectures, slides, and assignment via the Brightspace forum.

• Email address of lecturer:
  b.deschutter@tudelft.nl

• Teaching assistant (for assignment):
  Ximan Wang (x.wang-15@tudelft.nl)

• Please enroll via Brightspace if you want to stay informed!

• Group registration will also be done via Brightspace
Schedule

- Online lectures: see ’downloads’ section on course website
- “Office hours” (for assignment): via Brightspace forum
- Exam: Monday, June 22, 2020, 13.30-16.30
- Resit: Monday, July 20, 2020, 13.30-16.30
3. Assignment

- Topic: 1) hybrid automaton modeling
  2) designing hybrid systems controller
  → control of microgrid

- Group work (2 students/group)
  with written report

- Description: see course website/Brightspace

- Registration: via Brightspace, in groups of 2

- Deadline (hard): Friday, June 19, 2020, 17.00 p.m.
  Upload **single pdf** file to Brightspace
  Max. 50 pages (including appendices)
3. Assignment (continued)

- Set-up: microgrid

- Continuous dynamics + discrete actions $\rightarrow$ hybrid model (MLD)
- Control inputs: diesel generators + batteries
- Design MPC controller using MLD model
4. Hybrid systems: Motivating examples

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

\[
\begin{align*}
\text{on mode} & : \dot{T} = f_{\text{on}}(T, w) \\
\text{off mode} & : \dot{T} = f_{\text{off}}(T, w)
\end{align*}
\]

\[T > T_{\text{upp}}\]

\[T < T_{\text{low}}\]
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

Diagram showing the process of beer brewing, including mashing, wort separation, boiling, whirlpool, holding vessel, maturation/conditioning, filtration, and packaging stages.
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 $\rightarrow$ hybrid
Challenges

- Analysis and control
- Nowadays:
  - often heuristic & ad-hoc
  - focus exclusively on either continuous or discrete dynamics
    → structured approach necessary
- Consider hybrid nature of systems
- Combination of systems & control, computer science, mathematics, and simulation
  → this course will give some handles to tackle these issues
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