Feedback Control and Real-Time Systems

Course HECS3: Performance and quantitative properties

High-confidence Embedded and Cyber-Physical Systems
Master of Science in Informatics at Grenoble
Univ. Grenoble Alpes
What to Expect in this Lecture

**concepts** from Embedded and Cyber-Physical Systems

- standard terminology (and some buzzwords)
- informal presentation (formalization in future lectures)
- a rough map of the territory
- what it is all for...
original computer: standalone device

**embedded system**: integrated with non-computational hardware for a specific purpose

- watches, cameras, refrigerators (integrated microcontroller), …

more examples?
cyber-physical system: collection of communicating computers, interacting with the physical world via feedback

• using control, computing, communication
• smart buildings, medical devices, cars, …

example: team of autonomous robots retrieving target inside house

more examples?

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1 term coined by Helen Gill at the US National Science Foundation (NSF) in 2006
CPS Research in Grenoble

Variety of Application Domains
1. Automated vehicle of Tecnalia
2. Sandwich assembly robot of R.U.Robotics Ltd.
4. MILOX™: Pipeless Production System
5. Dang, Donzé, Maler. Verification of analog and mixed-signal circuits using hybrid systems techniques. FMCAD’04
6. Bitcraze Crazyflie

- assisted and automated driving
- human-robot interaction
- smart buildings
- chemical batch plants
- analog mixed-signal circuits
- autonomous drones

FP7 + H2020 projects  NANO 2017 project  Collaborations
Overview
Key Features of CPS [Alur’15]

reactiveness

• traditionally: input → computing → output → stop
• mathematically: function: inputs → outputs
• reactive: ongoing computation
• mathematically: function from sequence of inputs to sequence of outputs

examples?
Key Features of CPS

concurrency

- traditionally: sequential computation (Turing machine)
- concurrent: multiple threads of computation, exchanging information
- synchronous computation: all components execute in lock-step
- asynchronous computation: components act independently, communicating via messages
- both can be useful levels of abstraction

examples?
Key Features of CPS

feedback control

• control system interacts with physical world with sensors and actuators
• design requires modeling the dynamics of physical quantities
• traditionally: continuous dynamics
  – a small enough change in the input generates a small change in the output

examples?
Key Features of CPS

real-time

• traditionally: no explicit notion of real time
• CPS: computation needs to finish within a given time frame
• timing delays, timing-dependent coordination protocols, resources allocation → study of real-time systems

examples?
Overview
goal: a unified view of seemingly disparate systems

• using the same concepts
• adapting techniques where necessary
• combining different techniques when systems have heterogeneous components

... which they do in cyber-physical systems!

examples?
**goal**: More to come next week