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

Overview

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...

Embedded and Cyber-Physical Systems

original computer: standalone device

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

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

more examples?

Embedded and Cyber-Physical Systems

cyber-physical system[1]: collection of communicating computers, interacting with the physical world via feedback

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

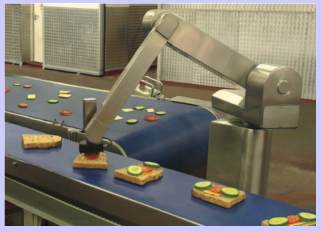
example: team of autonomous robots retrieving target inside house

more examples?

[1] term coined by Helen Gill at the US National Science Foundation (NSF) in 2006

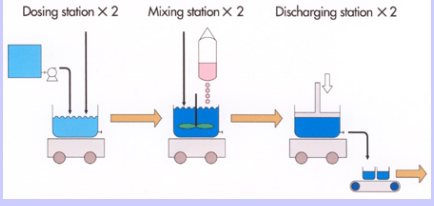
CPS Research in Grenoble

assisted and automated driving

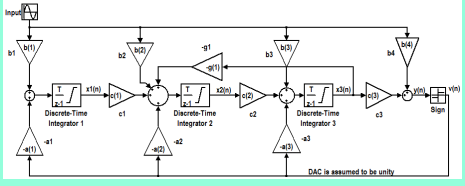


human-robot interaction

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

Fundamentals of Dynamical Systems

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?

Fundamentals of Dynamical Systems

goal: More to come next week