Introduction to Computer Control Systems

Responsible teacher: Kristiaan Pelckmans (kp@it.uu.se)
Credits: 5 hp
Course code: 1RT485
Period 2 (Week 43-50)
Course plan

- Teachers and activity
  - Kristiaan Pelckmans - Lectures
  - Problem solving sessions
  - Liang Dai - Labs

- Structure
  - 10 lectures (20h)
  - 10 problem solving sessions (20h)
  - 2 computer labs (4h)
  - 3 process labs (12h)

- 5hp → 400/3 h ≈ 133h. ((400/3h-56h) ≈ 77h of self-study, readings and homework assignments)
General information

- Homepage. Please, visit it frequently!
  [http://www.it.uu.se/edu/course/homepage/regsysintro/ht12](http://www.it.uu.se/edu/course/homepage/regsysintro/ht12)

- Textbook

- Examination
  - Written examination on Wednesday, December 17\textsuperscript{th} 2012.
  - Passed laboratory course is also required.
Introduction to Computer Control Systems

- What does this course offer to you?
  - The course covers theoretical and practical topics of control systems

- What are the skills that you can develop?
  - The course prepares you for analysis, design and implementation of control systems

- How will we do that?
  - Participatory lectures, problem solving sessions, process and computer labs (LEGO NXT, Matlab)

- Written exam + compulsory labs
Lecture 1: Introduction and basic notions. The control problem

- The feedback concept
What:
1. Reference $r$
2. Input System $u$
3. Controlled var. $z$
4. Meas. error $n$
5. Measured Output $y$
6. Disturbance $w$
7. Feedback
A system is defined by its inputs and outputs

- System input – a signal fed into the system
- System output – a measurable signal that is produced by the system

A system is single input - single output (SISO system) if it has one input and one output, otherwise is a multivariable system (MIMO system)
The system (II)

- A system is **causal** if \( y(t) \) only depends on current and previous values of \( u(t) \), otherwise is a non-causal system.
- A system is static if \( y(t) \) at \( t=t_1 \) depends only in \( u(t) \) at \( t=t_1 \) (no memory), otherwise is a **dynamic** system (system with memory).
The system (III)

- A system is in **discrete-time** if the inputs and outputs are defined only for a number of time points \( t = t_0 + \Delta t_0, t_0 + 2\Delta t_0, t_0 + 3\Delta t_0, \ldots \) , otherwise is a **continuous-time** system.
- A system is **time invariant** if it does not depend on absolute time, otherwise is a time varying system.
- A system is **linear** if it satisfies the principle of superposition and homogeneity, otherwise it is a **nonlinear** system.
System modelling

- A model is a mathematical representation of a system
- Models are always approximations
- Not all natural phenomena have a mathematical description
- A model can be created before the actual system is constructed
- Only certain (relevant) system properties are described

"essentially, all models are wrong, but some are useful”
George E.P. Box
Mathematical modeling

- Model derivation

  - Basic laws of nature → Mathematical rules → Model

- System identification (model fitting through optimization)

  - Experimental data → Optimization → Model
  - Basis functions
The use of mathematical modeling

Mathematical modeling is a fundamental scientific approach and utilized for **analysis** and **synthesis** of systems in nature, technology and society.

**Analysis**
- Prediction and forecast (economy, environment)
- Diagnosis

**Synthesis**
- Design and engineering of processes and systems
- Optimization of systems and processes
- Control
- Process monitoring
- Estimation of inaccessible for measurement quantities ("soft sensors", "sensor fusion")
Control systems

Examples:
1. fly-ball governor
2. Speed regulator car
3. Crane.
4. Pendulum.
Our system: LEGO car

- Input signals: motor voltage
- Output signal: car position
- Disturbance: track conditions
To do

- For next lecture
  - Read Chapter 2 of the guide book

- For lecture 4
  - Search the web and pick an article about a control system. Try to identify the control system, particularly:
    - The controlled variable
    - The control input
    - The reference signal