Teoria sistemelor
Curs 1

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Outline

- **References**
- Real-world examples to understand control
- What is automatic control?
- Application examples
- A typical control system
- How to design a control system
- What will you learn in this course

References / 1

- K. J. Åström, R. M. Murray, Feedback Systems: An Introduction for Scientists and Engineers, Princeton University Press, Princeton, NJ, 2008
- R. C. Dorf, R. H. Bishop, Modern Control Systems, 11th edition, Prentice-Hall, Upper Saddle River, NJ, 2008
- S. H. Żak, Systems and Control, Oxford University Press, New York, NY, 2003

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- A. Bemporad, Automatic Control 1, Lecture Notes, University of Trento, Italy, 2011, http://cse.lab.imtlucca.it/~bemporad/automatic_control_course.html
- S. Preitl, R.-E. Precup, Z. Preitl, Process Control Structures and Algorithms, vols. 1 and 2 (in Romanian: Structuri si algoritmi pentru conducerea automata a proceselor), Editura Orizonturi Universitare Publishers, Timisoara, 2009

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- S. Preitl, R.-E. Precup, Eds., Design Techniques for Automatic Control Structures. Applications (in Romanian: Tehnici de proiectare a structurilor de reglare automata. Aplicatii), Editura Orizonturi Universitare Publishers, Timisoara, 2008
- S. Preitl, R.-E. Precup, Eds., Controllers for Servo Systems: Design Methods (in Romanian: Regulatoare pentru servosisteme: metode de proiectare), Editura Orizonturi Universitare Publishers, Timisoara, 2007

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- S. Preitl, R.-E. Precup, Introduction to Control Engineering (in Romanian: Introducere in ingineria reglarii automate), Editura Politehnica Publishers, Timisoara, 2001

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- R.-E. Precup, S. Preitl, Fuzzy Controllers (in English), Editura Orizonturi Universitare Publishers, Timisoara, 1999
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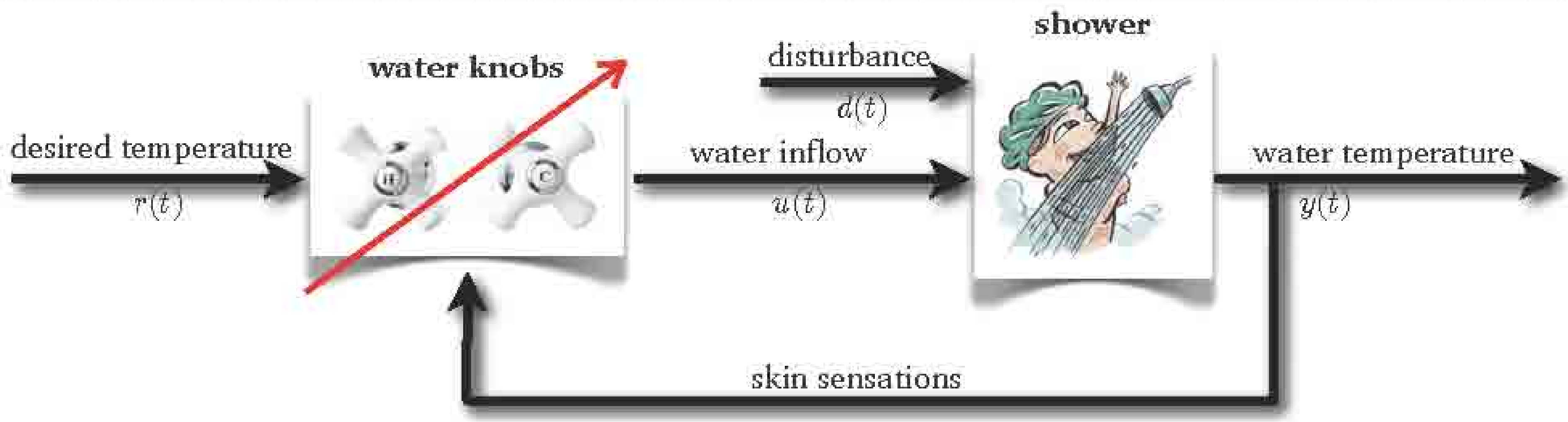
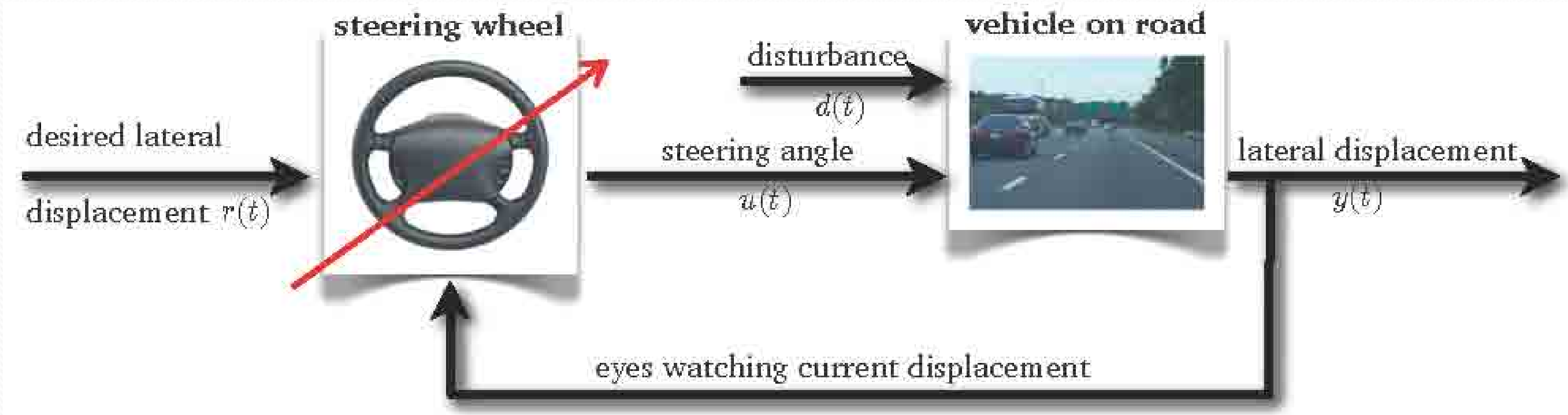
A real-world example of control (Bemporad, 2011)



- Water inflow *u*(*t*) must be **controlled** to reach and maintain the desired temperature *r*(*t*)
- Sensors on skin **measure** the water temperature *y*(*t*)
- Water inflow *u*(*t*) manipulated so that *y*(*t*)≈*r*(*t*)
- And keep it in spite of flow and temperature fluctuations *d*(*t*)

Another real-world example of control (Bemporad, 2011)



- Steering wheel must be **controlled** to reach and maintain the desired lateral displacement *r*(*t*) within the lane (e.g., staying in the middle of the lane)
- Eyes **measure** current lateral displacement *y*(*t*)
- Steering angle *u*(*t*) manipulated so that $y(t) \approx r(t)$
- And keep it in spite of road curvature *d*(*t*)

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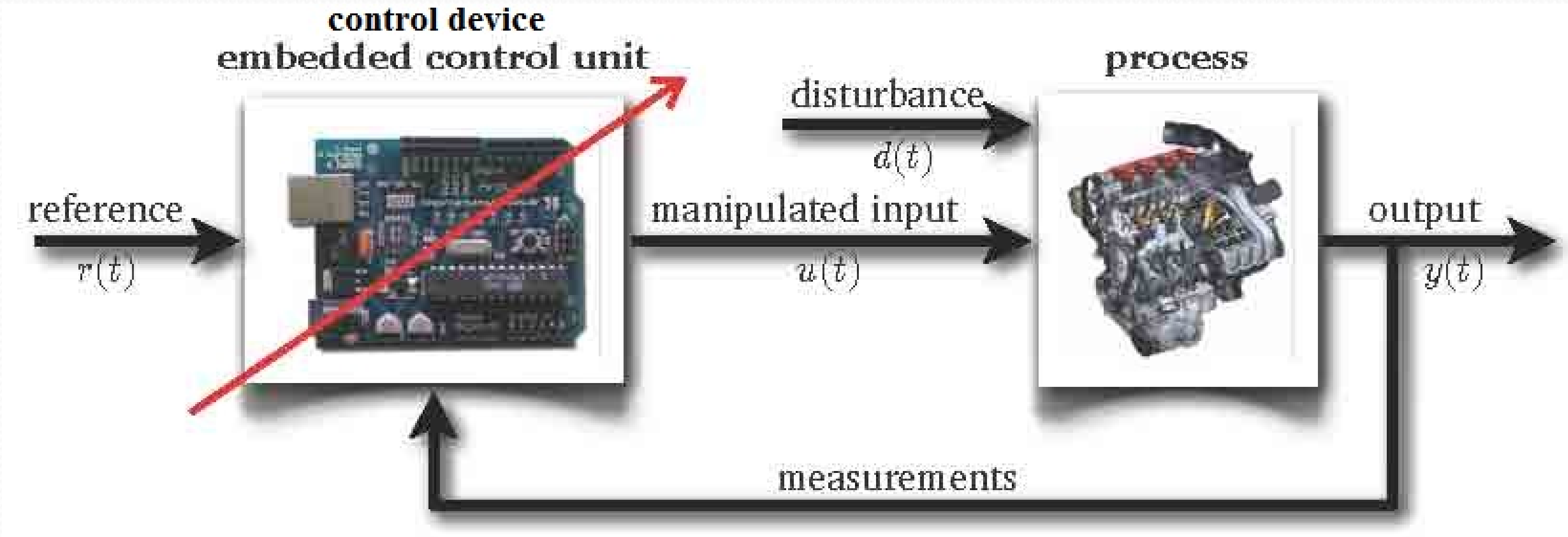
What is automatic control?



- *Performance* (tracking): how to **control** the inputs $u(t)$ to the process **automatically** to make the output $y(t)$ track the given reference input $r(t)$?
- *Robustness* (*regulation*): how to exploit the **measurements** of $y(t)$ to track the reference input $r(t)$ in spite of **disturbance**s $d(t)$ acting on the process ?

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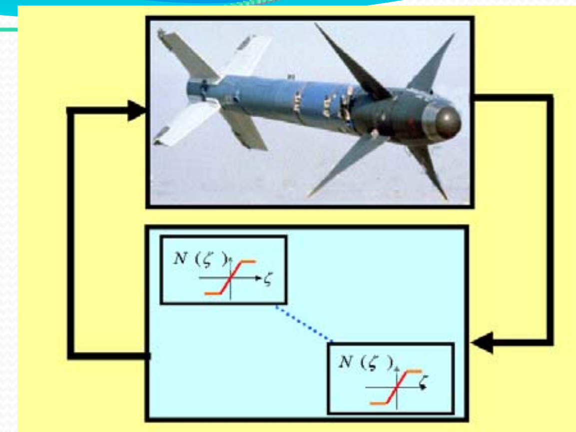
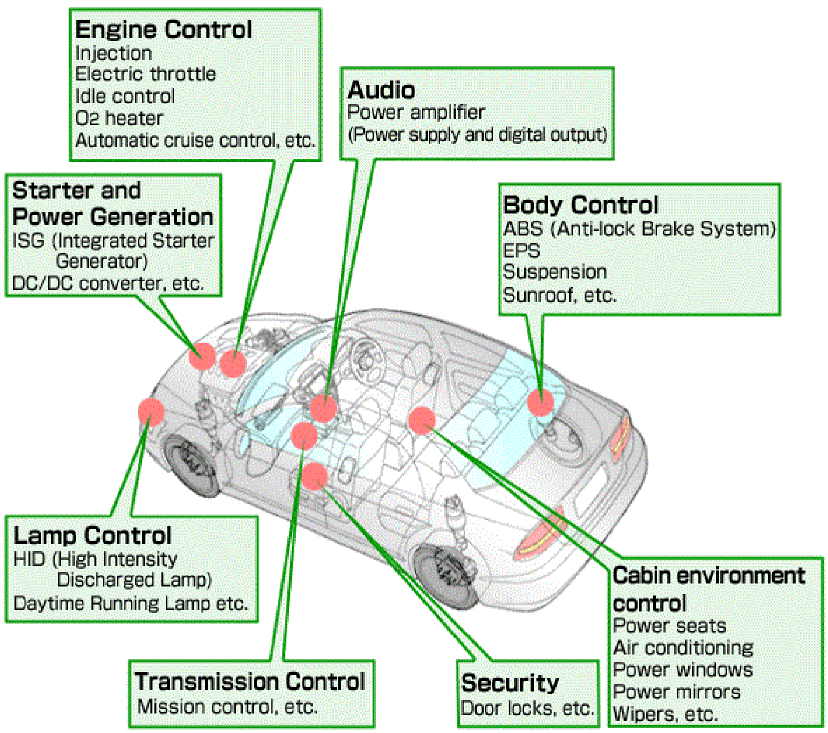
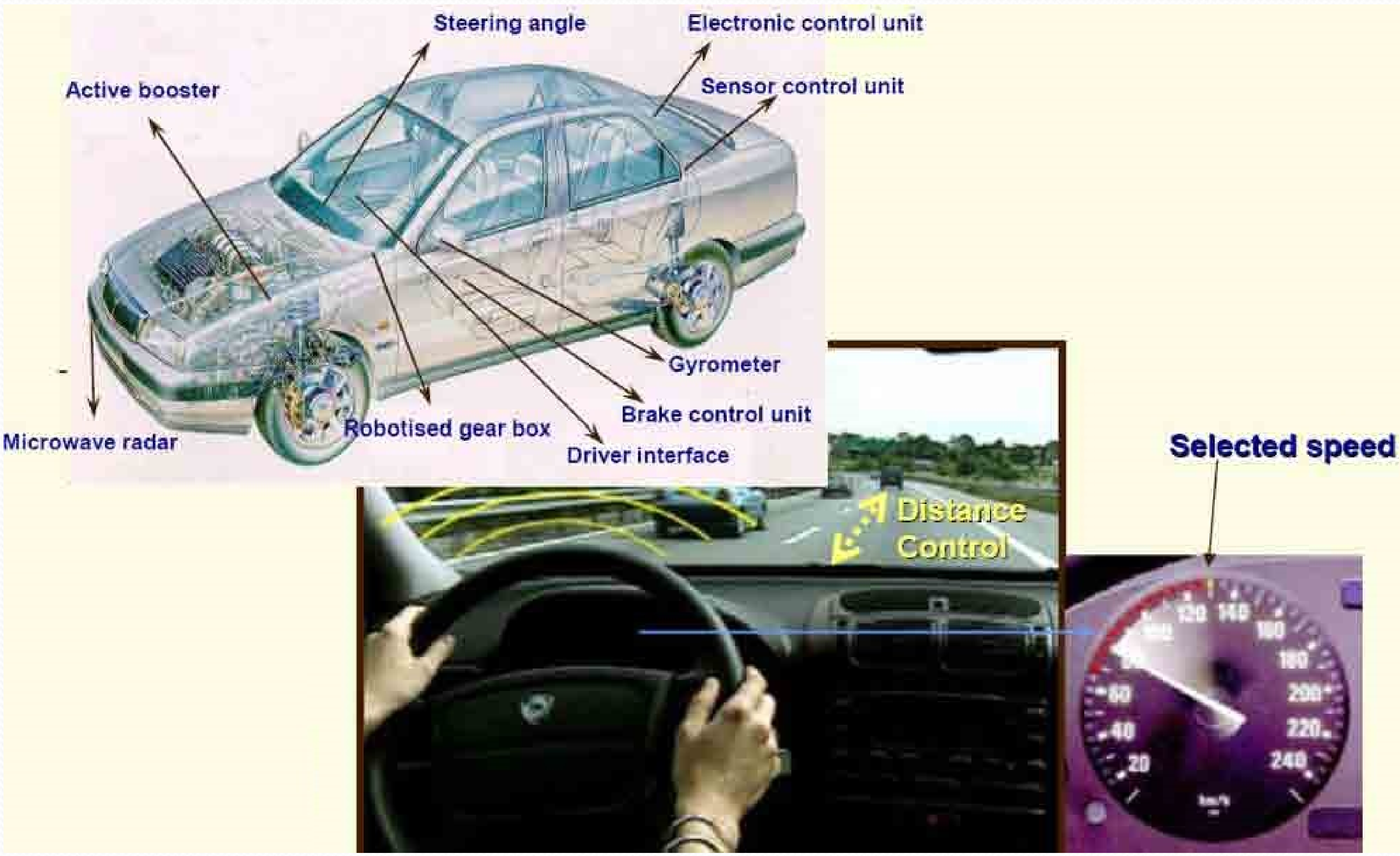
Application areas of control engineering



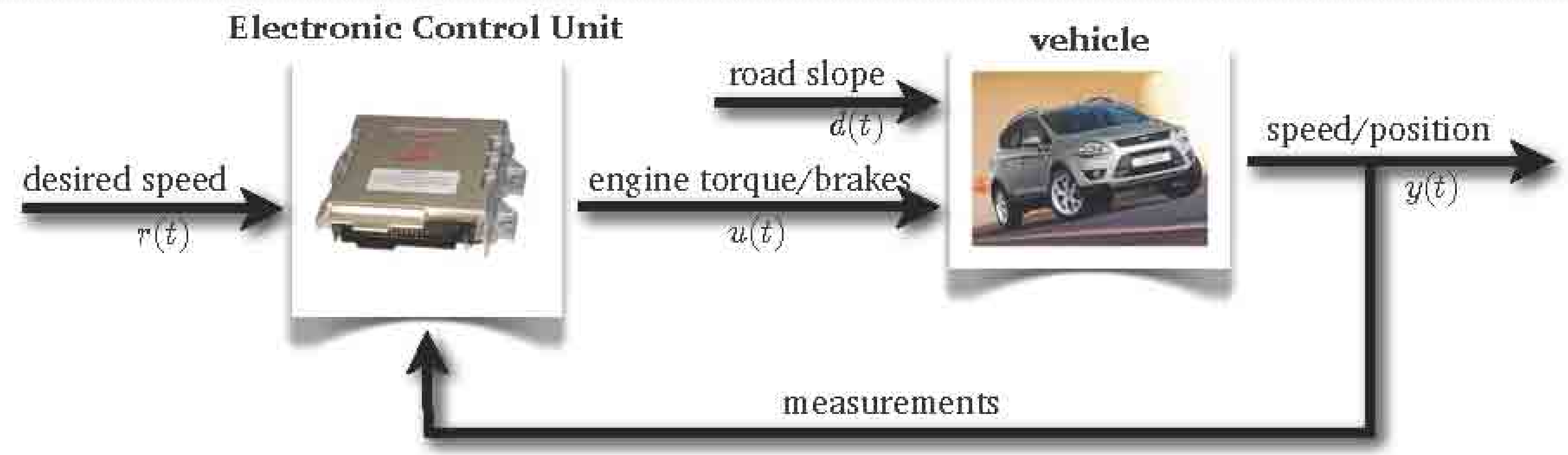
Aeronautics & aerospace, automotive, manufacturing, process control (chemical, pharmaceutical, steel, pulp & paper, ...), power electronics, telecommunications, environmental systems, financial engineering, supply chains, power networks, etc.



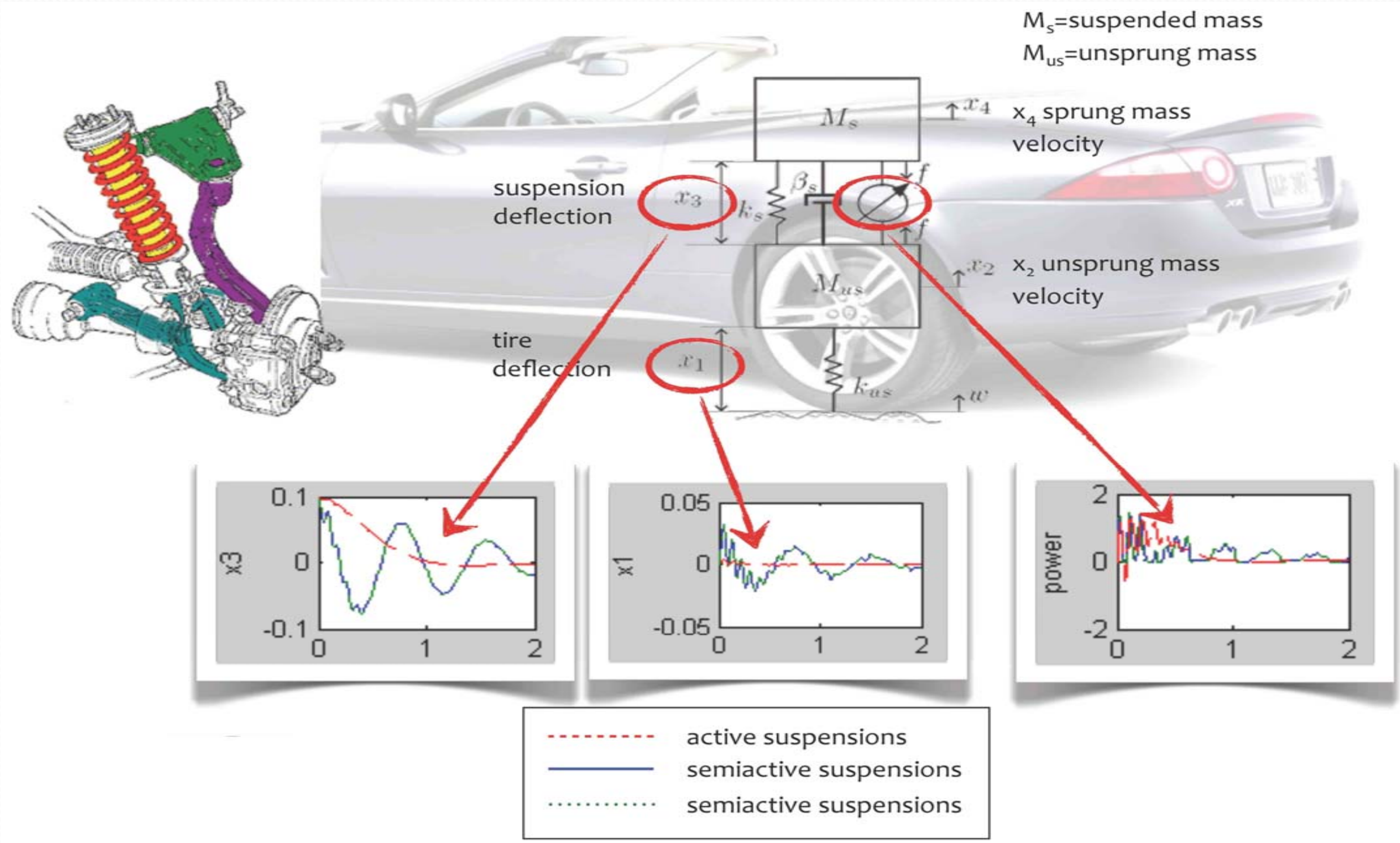
A real-world example of automatic control: Automatic Cruise Control (ACC) (Bemporad, 2011) / 1



A real-world example of automatic control: Automatic Cruise Control (ACC) (Bemporad, 2011) / 2

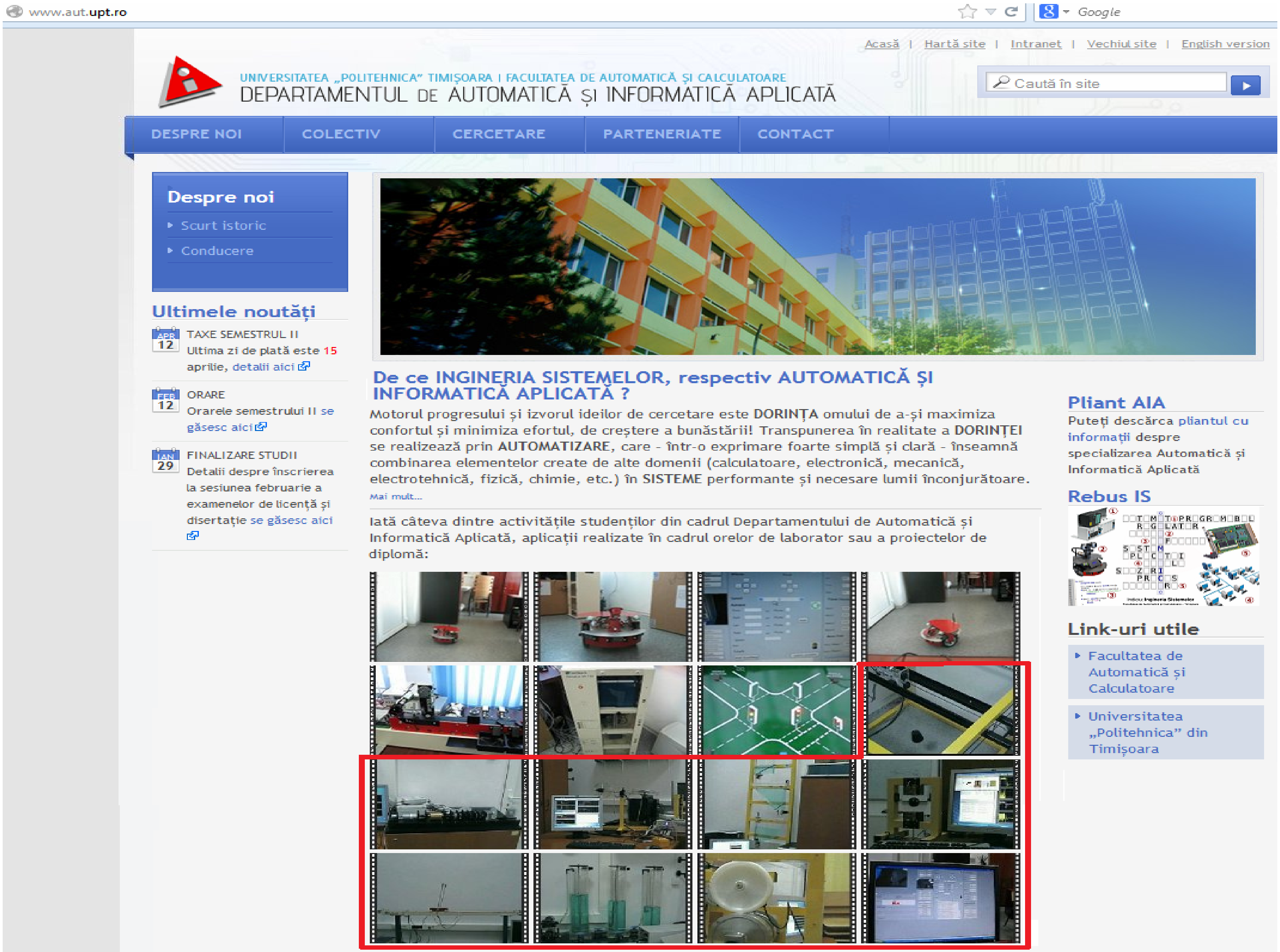


Another real-world example of automatic control: active suspension system (Bemporad, 2011)



Application examples in the process control systems labs

- Inverted pendulum systems including a rotary one
- Crane system & 3D crane system
- Magnetic levitation systems
- Modular servo systems
- Anti-lock Braking Systems (ABSs)
- Multi-tank systems
- Twin-rotor systems (helicopters)
- Temperature and air stream control system
- DC- and brushless DC-based drives with elastic coupling
- Active suspension system
- Active mass damper system
- Mobile robots (LEGO, unstable transporters, turtle, arm)
- Movies at http://www.aut.upt.ro



www.aut.upt.ro

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Caută în site

UNIVERSITATEA „POLITEHNICA" TIMIȘOARA | FACULTATEA DE AUTOMATICĂ ȘI CALCULATOARE

DEPARTAMENTUL DE AUTOMATICĂ ȘI INFORMATICĂ APLICATĂ

DESPRE NOI | COLECTIV | CERCETARE | PARTENERIATE | CONTACT

Despre noi

- Scurt istoric
- Conducere

Ultimele noutăți

APR 12 — TAXE SEMESTRUL II
Ultima zi de plată este 15 aprilie, detalii aici

FEB 12 — ORARE
Orarele semestrului II se găsesc aici

IAN 29 — FINALIZARE STUDII
Detalii despre înscrierea la sesiunea februarie a examenelor de licență și disertație se găsesc aici

De ce INGINERIA SISTEMELOR, respectiv AUTOMATICĂ ȘI INFORMATICĂ APLICATĂ ?

Motorul progresului și izvorul ideilor de cercetare este DORINȚA omului de a-și maximiza confortul și minimiza efortul, de creștere a bunăstării! Transpunerea în realitate a DORINȚEI se realizează prin AUTOMATIZARE, care - într-o exprimare foarte simplă și clară - înseamnă combinarea elementelor create de alte domenii (calculatoare, electronică, mecanică, electrotehnică, fizică, chimie, etc.) în SISTEME performante și necesare lumii înconjurătoare.
Mai mult...

Iată câteva dintre activitățile studenților din cadrul Departamentului de Automatică și Informatică Aplicată, aplicații realizate în cadrul orelor de laborator sau a proiectelor de diplomă:

Pliant AIA

Puteți descărca pliantul cu informații despre specializarea Automatică și Informatică Aplicată

Rebus IS

Link-uri utile

- Facultatea de Automatică și Calculatoare
- Universitatea „Politehnica" din Timișoara

Links to movies / 1

- https://uptro29158-my.sharepoint.com/:f:/g/personal/raul-cristian_roman_upt_ro/Em1ebAsgSXVFpIF-bsGIHBEBx_SSE65bw25-H2ge6yyNnA?e=JBKE5i
- https://uptro29158-my.sharepoint.com/:v:/g/personal/claudia_dragos_upt_ro/EYcMfzSpjhxPu1YvX7Q7X00BfZ92SB72Yu3tTT7Asifoog?e=zWMcYc
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Links to movies / 3

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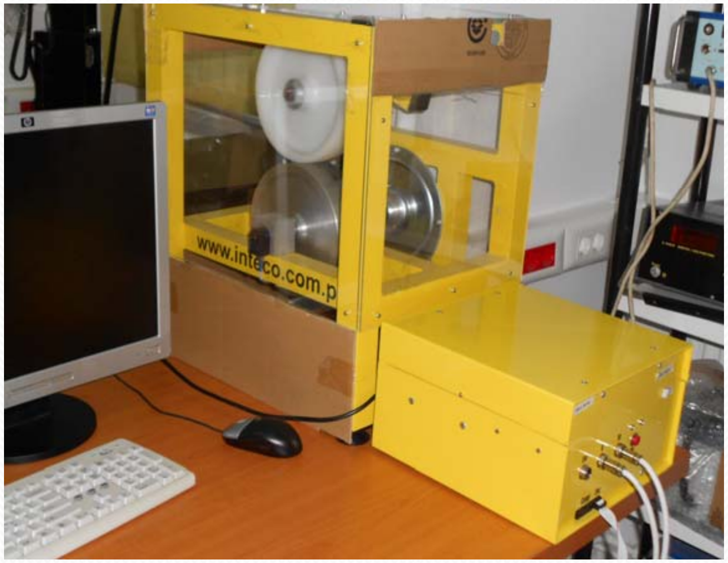
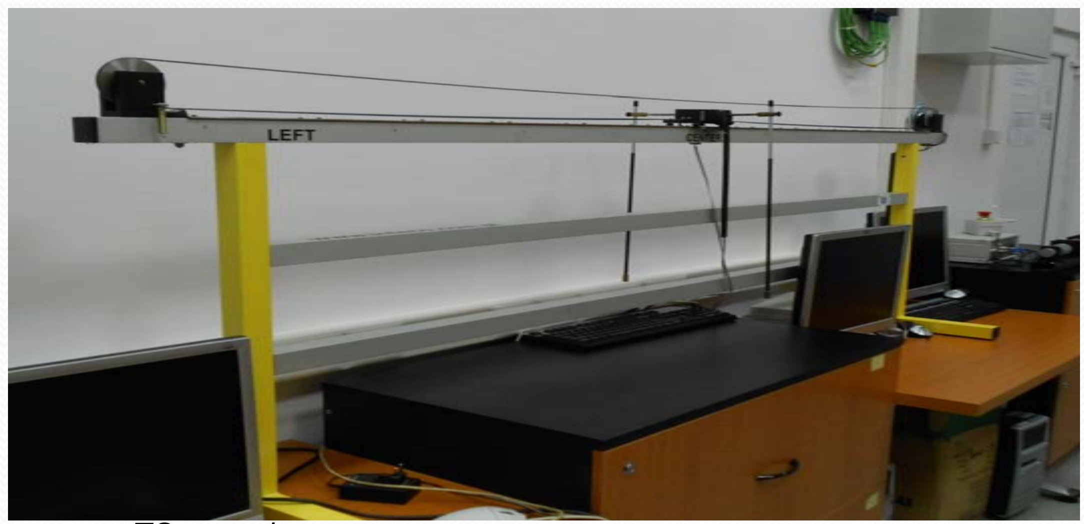
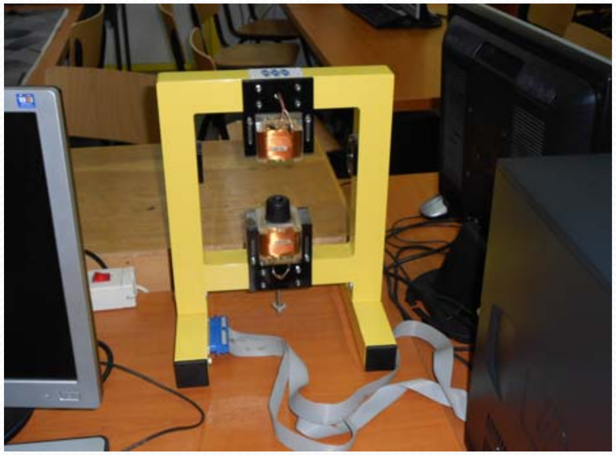
Lab / 1

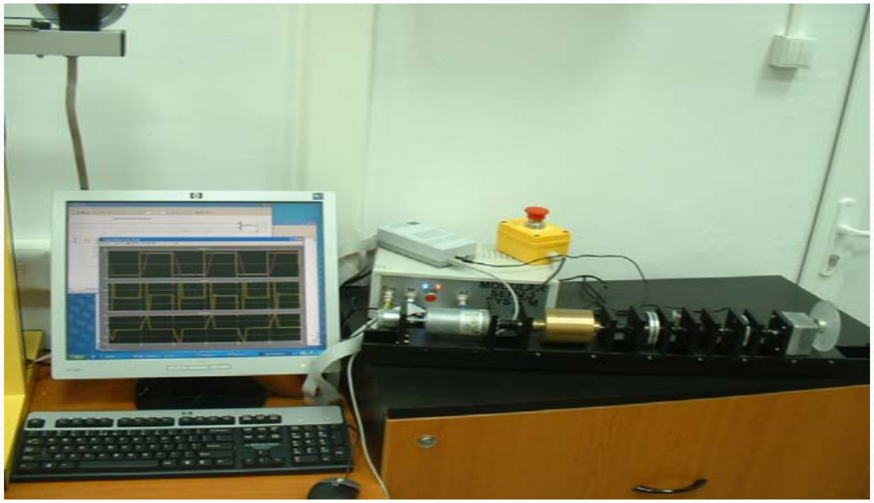


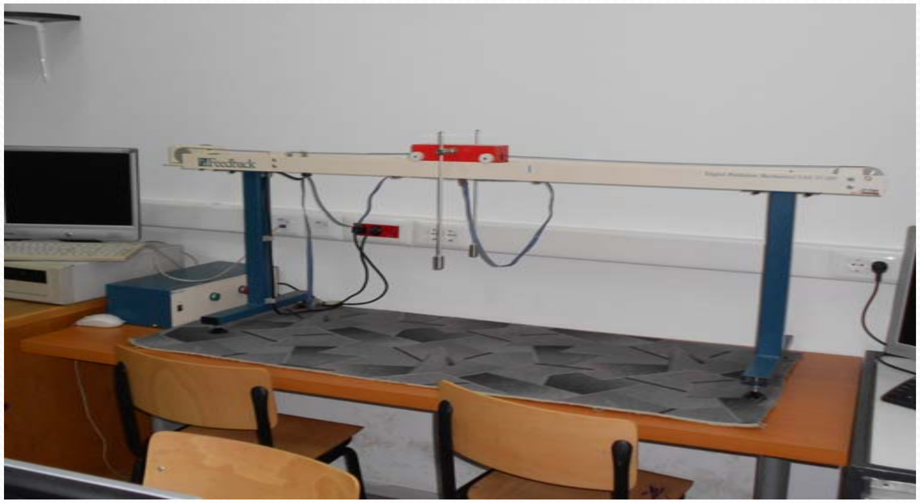


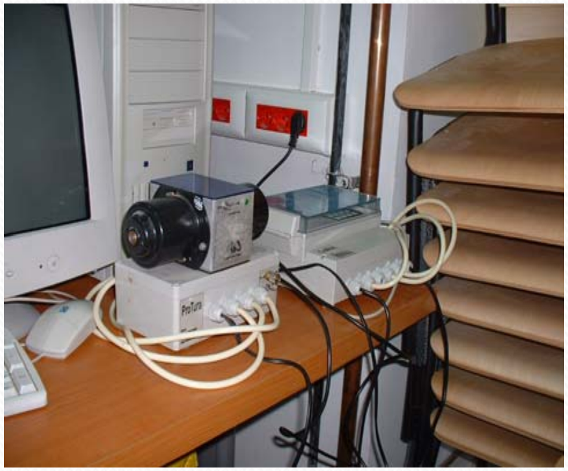
Lab / 2



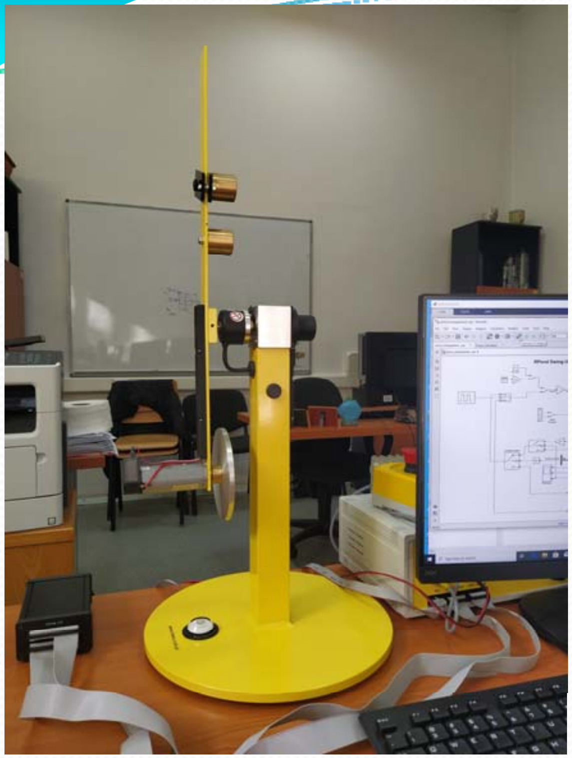
Lab / 3

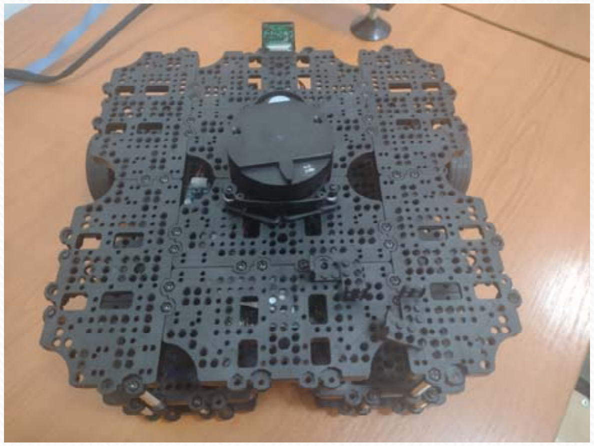


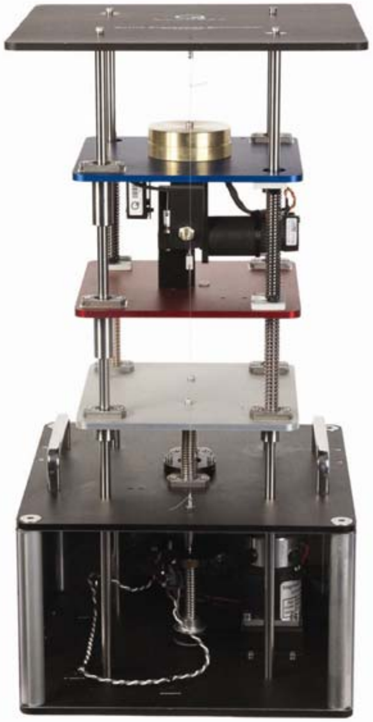




Lab / 4



> 450000 EUR ...

Many attractive applications reported by Raffaello D’Andrea and his team

- Institute for Dynamic Systems and Control, Swiss Federal Institute of Technology Zürich, Switzerland (ETH Zürich)
- http://raffaello.name/

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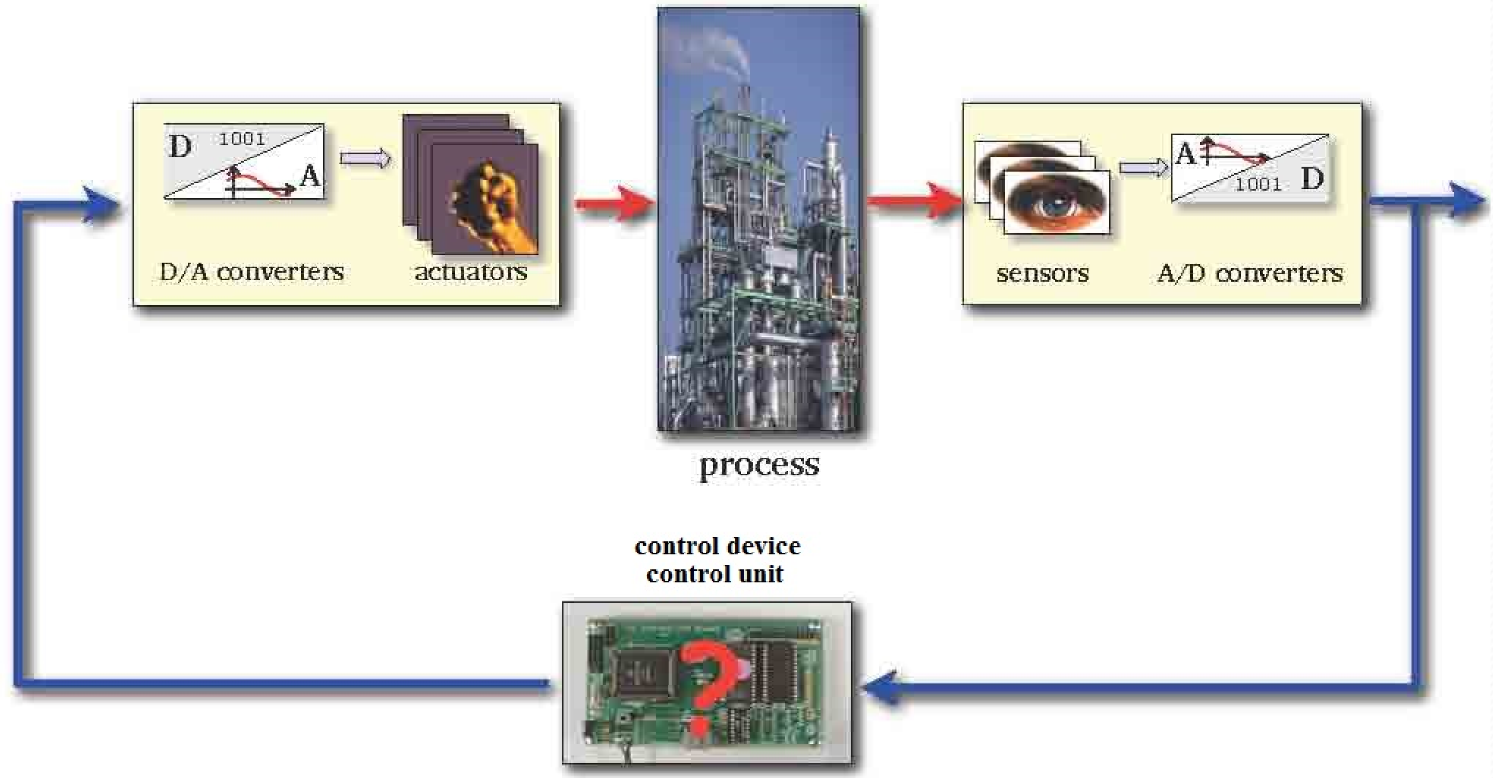
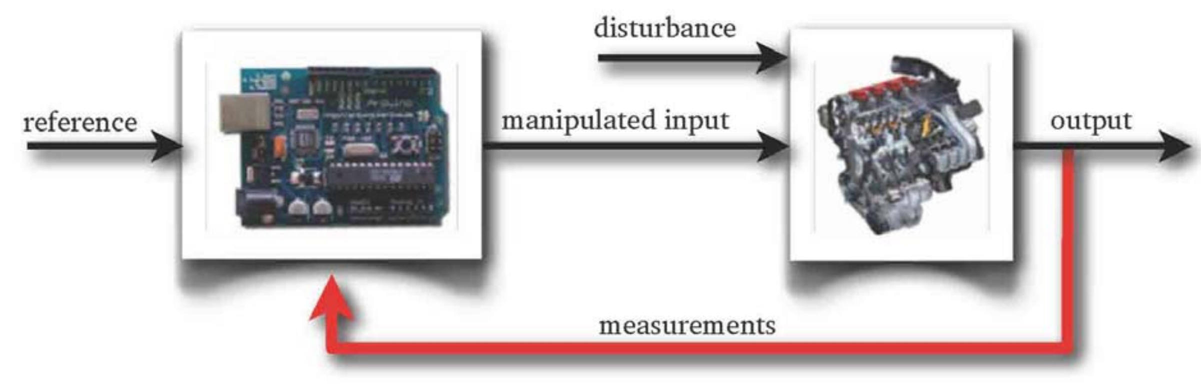
A typical control system



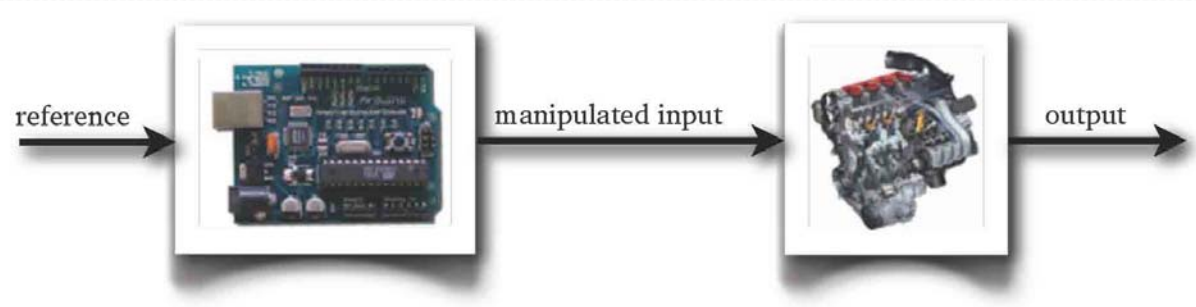
- Typical sensors: temperature, pressure, flow, level, velocity, position, acceleration, force (strain) / deformation, etc.
- Typical actuators: electrical motors (DC, brushless, step), pumps, valves, heaters, etc.

Open-loop vs. closed-loop control

- **Closed-loop control** (**feedback control**): measurements of the output variables are *fed back* to the process through the controller



- **Open-loop control** (**feedforward control**): the manipulated input variable (the control signal) is generated without measuring the output variable



Overview

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How to design a control system

- Understand the **automation problem**:

 - Which variables can be *manipulated* by actuators ?
 - What are the *output* variables of interest ?
 - What should we *measure* ?
 - Which are the *disturbances* ?

- Get a reliable **simulation model** (detailed mathematical model of the process)

- Get a simplified **mathematical model** of the main process dynamics

- Design the **control algorithm** (the **controller**) using appropriate design techniques

- **Test** in simulation, **validate** on real-world process

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What will you learn in this course

- the study of the fundamental problems of system theory with focus on continuous-time and discrete-time dynamical systems
- gaining an understanding of the functional operation of a variety of techniques specific to automation with focus on process control
- the study of the theoretic foundations of control systems
- learning analytical approaches to analyze and study systems properties
- gaining experience in the design and implementation of control systems
- computer-aided tools for analysis, simulation and control of dynamical systems (Matlab & Simulink)

Thank you very much
for your attention!