Teoria sistemelor
Curs 1

Prof. Radu-Emil Precup

Departamentul de Automatică şi Informatică Aplicată, Universitatea Politehnica Timişoara
radu.precup@upt.ro, http://www.aut.upt.ro/~rprecup/

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

References / 2

- 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

References / 3

- 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

References / 4

- S. Preitl, R.-E. Precup, Elements of Automatic Control. Applications to Voltage and Speed Control Systems of Synchronous Generators (in Romanian: Elemente de reglare automata. Aplicatii la sistemele de reglare automata a excitatiei si vitezei generatoarelor sincrone), Editura Orizonturi Universitare Publishers, Timisoara, 2005
- 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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- S. Preitl, R.-E. Precup, Automatic Control (in Romanian: Automatizari), Editura Orizonturi Universitare Publishers, Timisoara, 2001
- R.-E. Precup, S. Preitl, Fuzzy Controllers (in English), Editura Orizonturi Universitare Publishers, Timisoara, 1999
- P. Raica, Systems Theory, Lecture Notes, Technical University of Cluj-Napoca, Cluj-Napoca, 2021, https://cs.utcluj.ro/files/educatie/licenta/2021-2022/22_CALCen_ST.pdf

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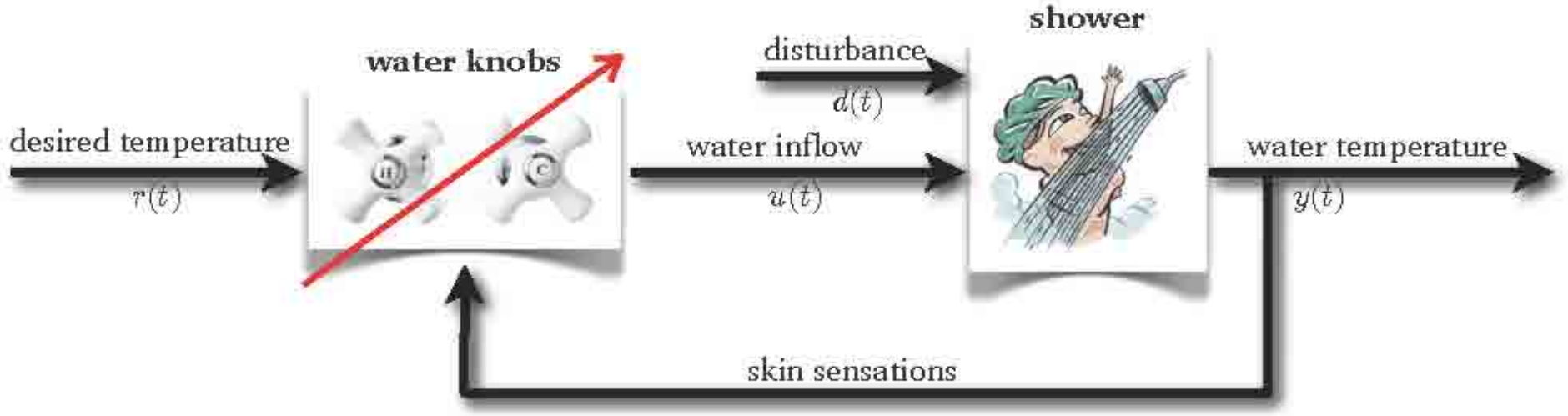
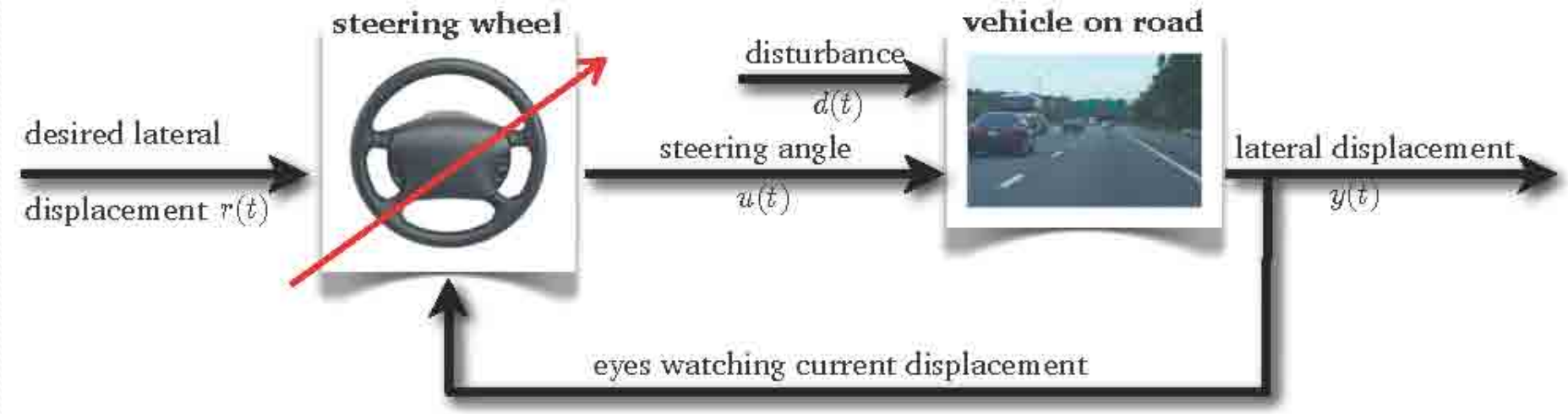
A real-world example of control (Bemporad, 2011)



- 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 $y(t) \approx r(t)$
- 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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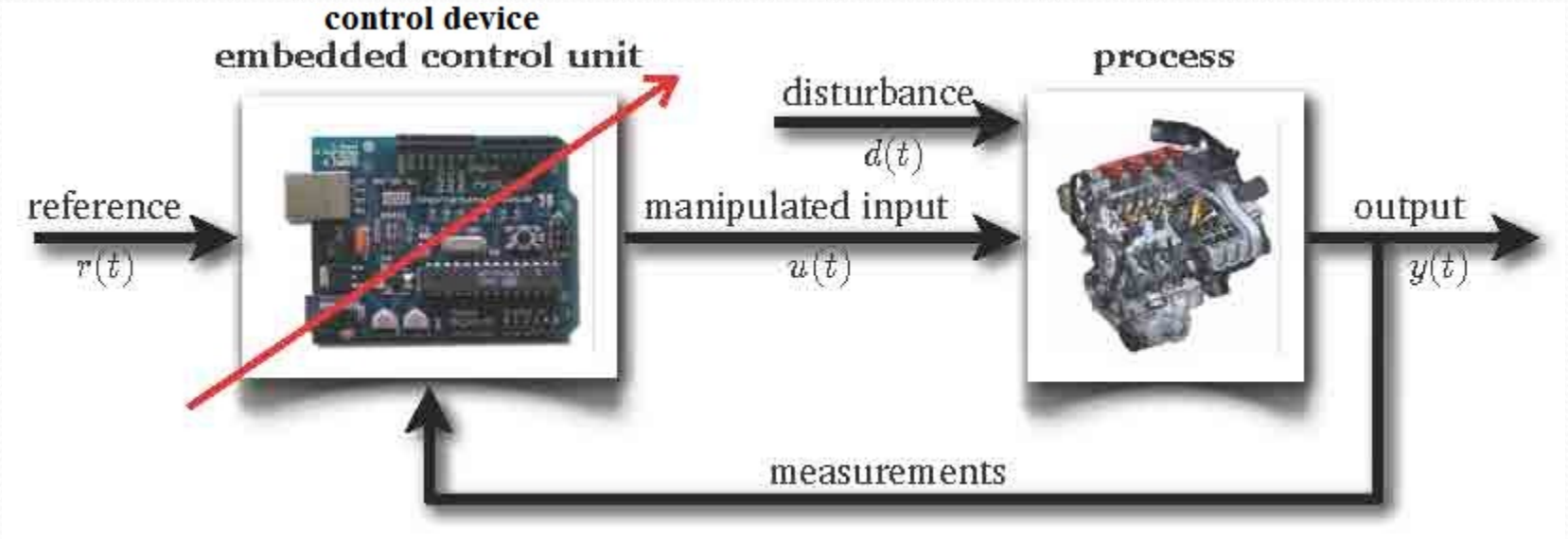
What is automatic control?



- *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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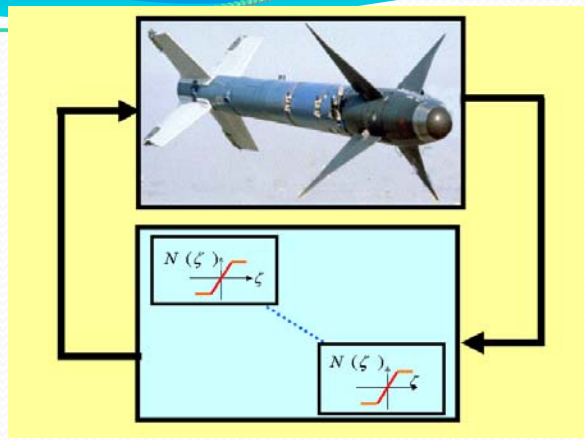
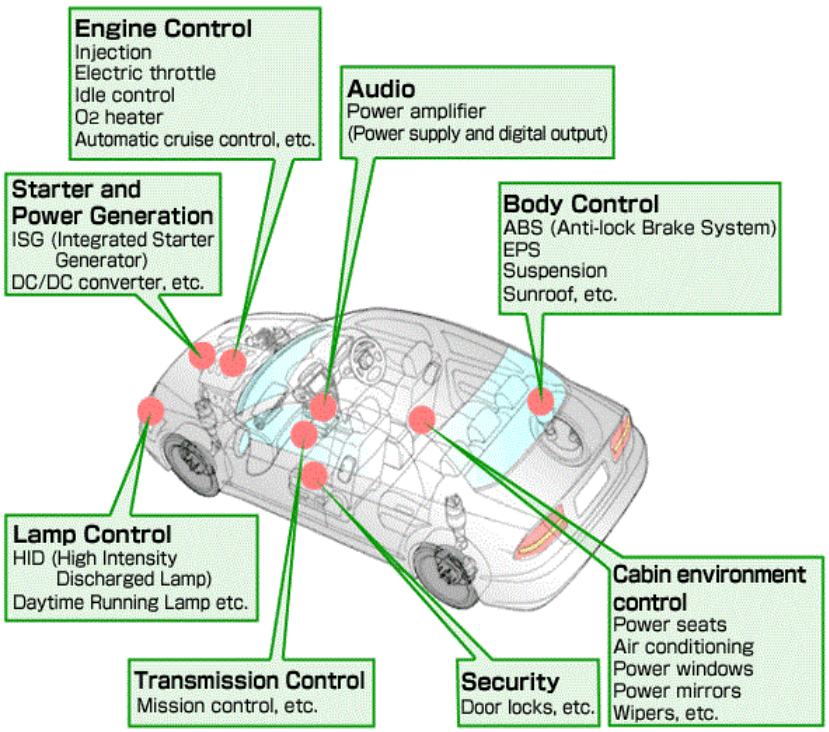
Application areas of control engineering

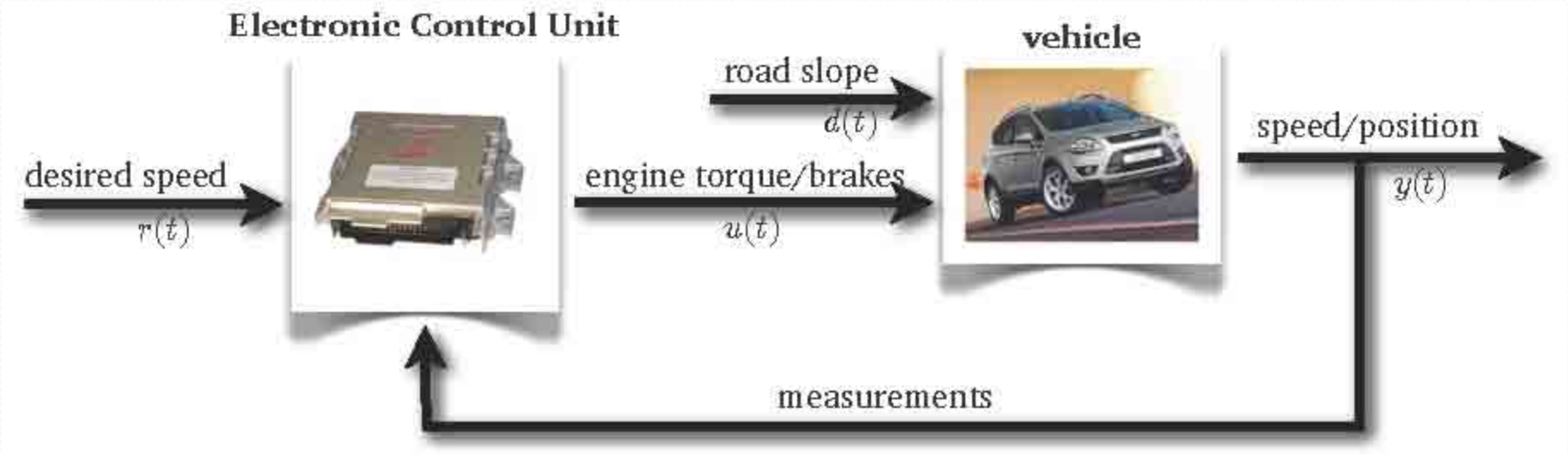
Aeronautics & aerospace, automotive, manufacturing, process control (chemical, pharmaceutical, steel, pulp & paper, ...), power electronics, telecommunications, environmental systems, financial engineering, supply chains, power networks, etc.



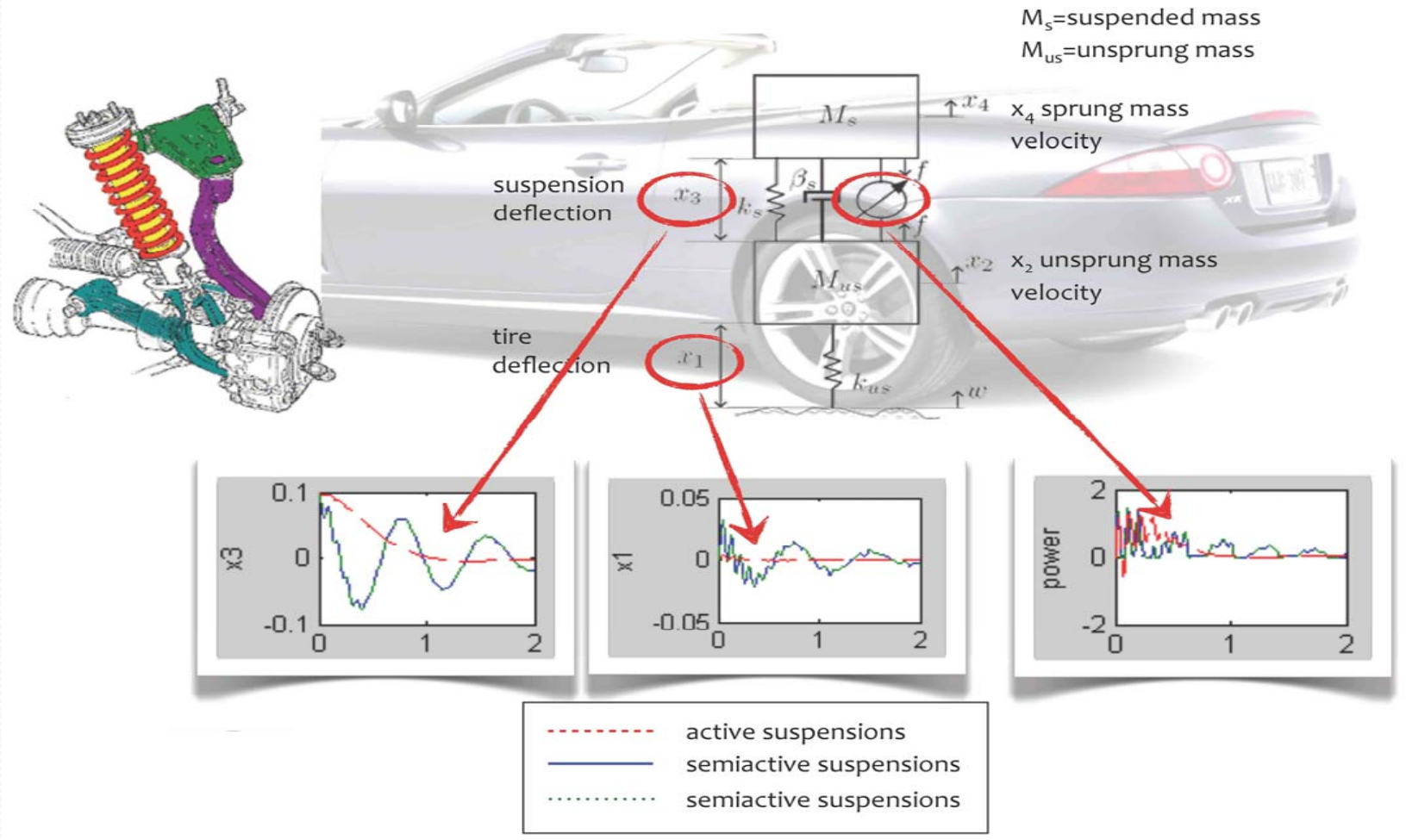


A real-world example of automatic control: Automatic Cruise Control (ACC) (Bemporad, 2011) / 1

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)
- Bionic robot
- Movies at http://www.aut.upt.ro

www.aut.upt.ro

Google

UNIVERSITATEA „POLITEHNICA" TIMIŞOARA | FACULTATEA DE AUTOMATICĂ ŞI CALCULATOARE

DEPARTAMENTUL DE AUTOMATICĂ ŞI INFORMATICĂ APLICATĂ

Caută în site

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 ŞI 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/:v:/g/personal/raul-cristian_roman_upt_ro/ERJartlJgmhHu2UrIVI070ABBDKlpX3bwkXmQJxLJTp-Lg?e=s66FqE
- https://uptro29158-my.sharepoint.com/:v:/g/personal/claudia_dragos_upt_ro/EYcMfzSpjhxPu1YvX7Q7X00BfZ92SB72Yu3tTT7Asifoog?e=zWMcYc
- https://uptro29158-my.sharepoint.com/:v:/g/personal/claudia_dragos_upt_ro/ESUHt2FZsShIqL08k6Q0PI0B7Xo0T0u2IqOTsqLD1qM-_w?e=znOF8g
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Links to movies / 2

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- https://uptro29158-my.sharepoint.com/:v:/g/personal/raul-cristian_roman_upt_ro/ETH4EE0h-mpDhV2PdNoKVmwBkUkr1to0yt9_KqBL3S7Qfg?e=o2tYaz

Links to movies / 3

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Links to movies / 4

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Links to movies / 5

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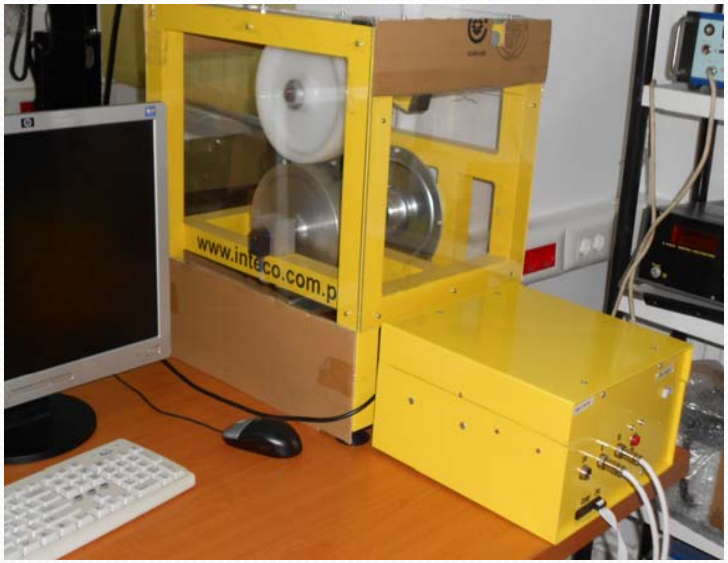
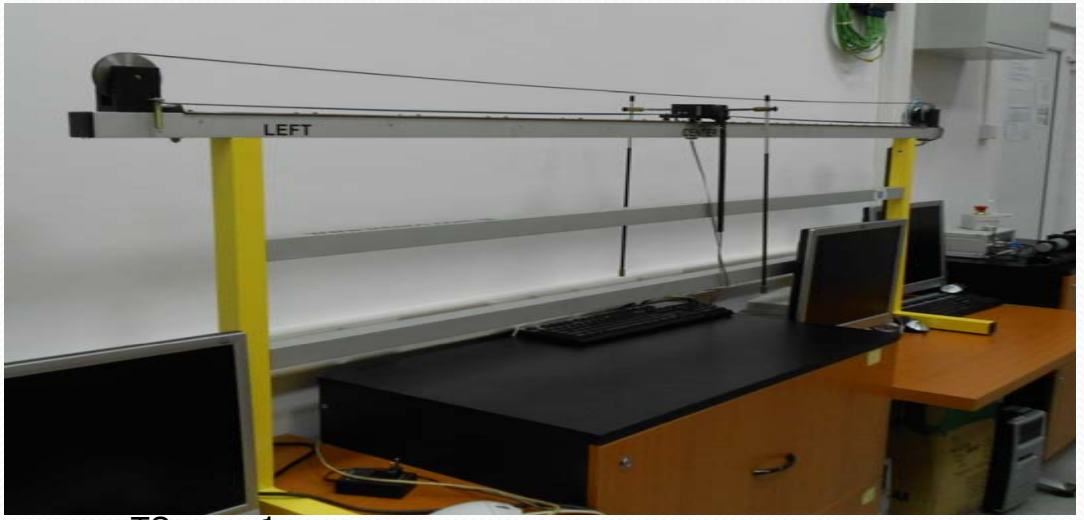
- https://uptro29158-my.sharepoint.com/:v:/g/personal/radu_precup_upt_ro/EWaItmIdx_JFs_juVTbxtBIB6f5Gdc4dpOjuF2yyhFod5A?nav=eyJyZWZlcnJhbEluZm8iOnsicmVmZXJyYWxBcHAiOiJPbmVEcml2ZUZvckJ1c2luZXNzIiwicmVmZXJyYWxBcHBQbGF0Zm9ybSI6IldlYiIsInJlZmVycmFsTW9kZSI6InZpZXciLCJyZWZlcnJhbFZpZXciOiJNeUZpbGVzTGlua0NvcHkifX0&e=zzFuoD

Movies of two labs

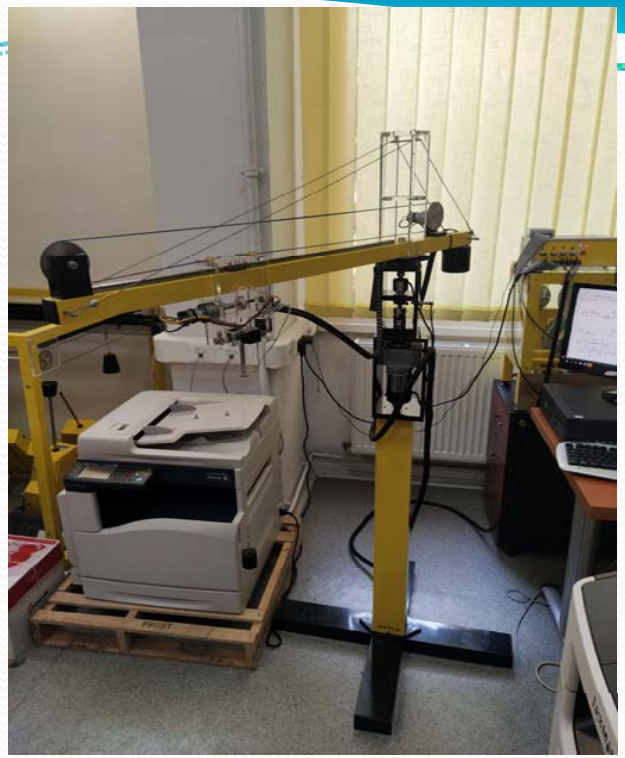
- B014: https://uptro29158-my.sharepoint.com/:v:/g/personal/radu_precup_upt_ro/EXharPS4Q55FqYYsJeqkO7wBT9xtWqvf5y7rmnY0KN8-Dg?e=FTQjIR
- B018: https://uptro29158-my.sharepoint.com/:v:/g/personal/radu_precup_upt_ro/EaTDbTYVyftPscjPHqqIDqABdVhNxOd6jzmIwaxnYfeetw?e=IyOtBN
- But B029 as well …

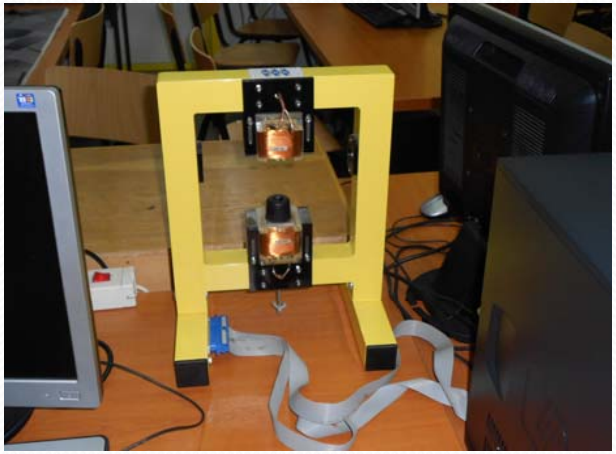
Our labs / 1



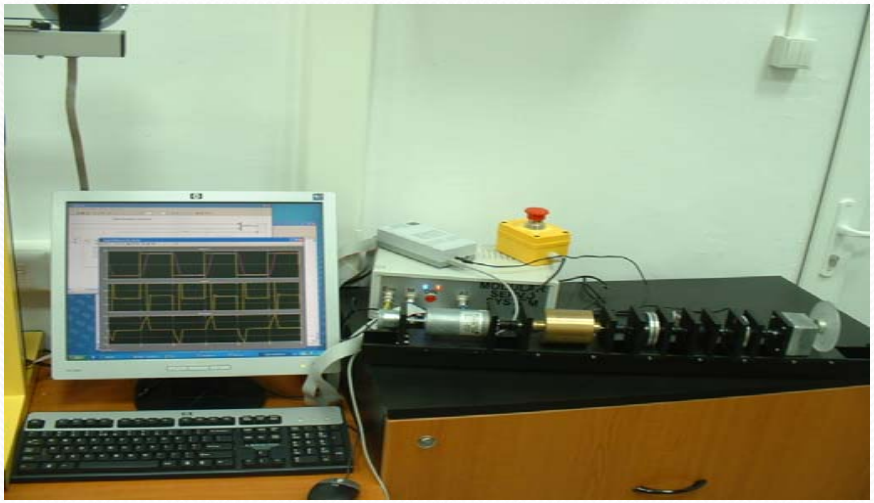


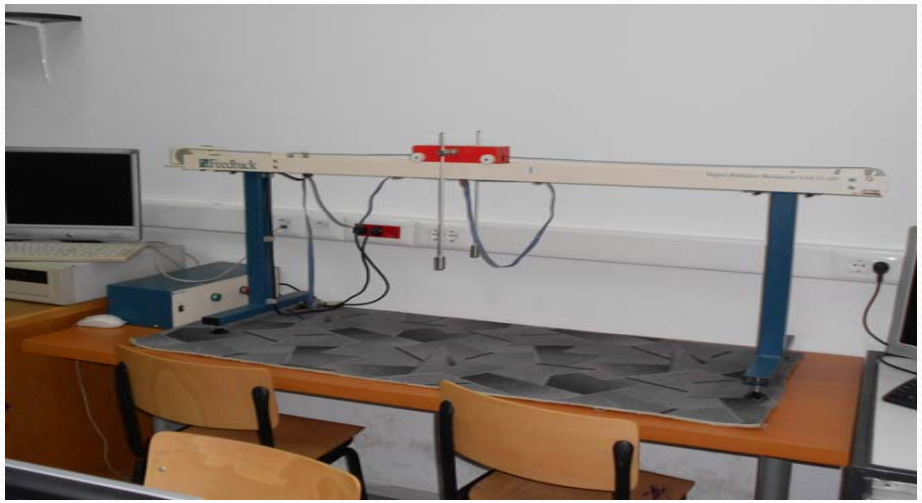
Our labs / 2



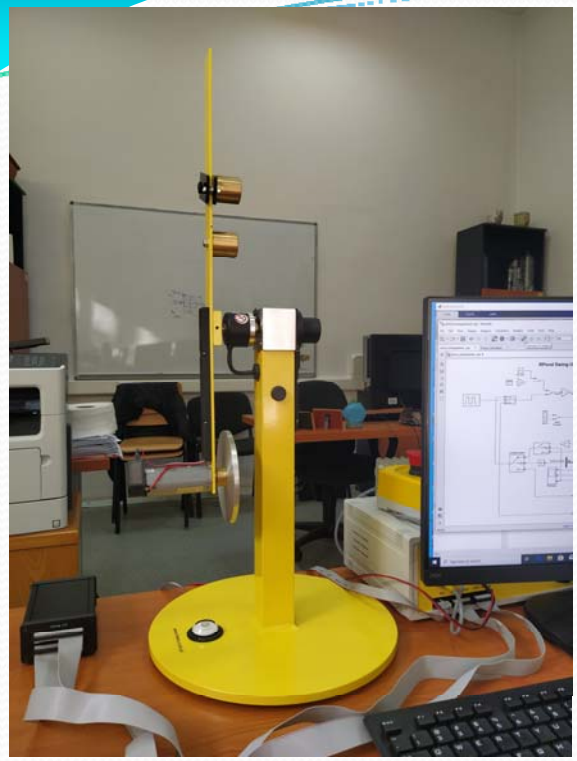


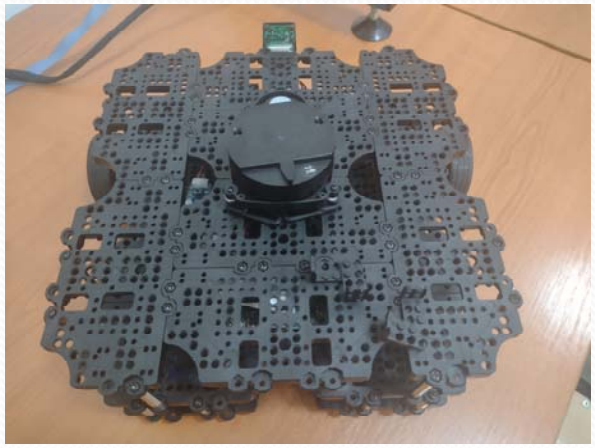
Our labs / 3



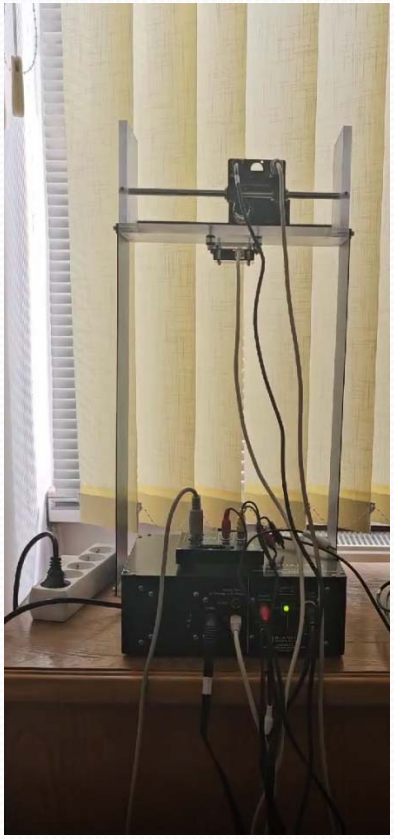


Our labs / 4





Our labs / 5



> 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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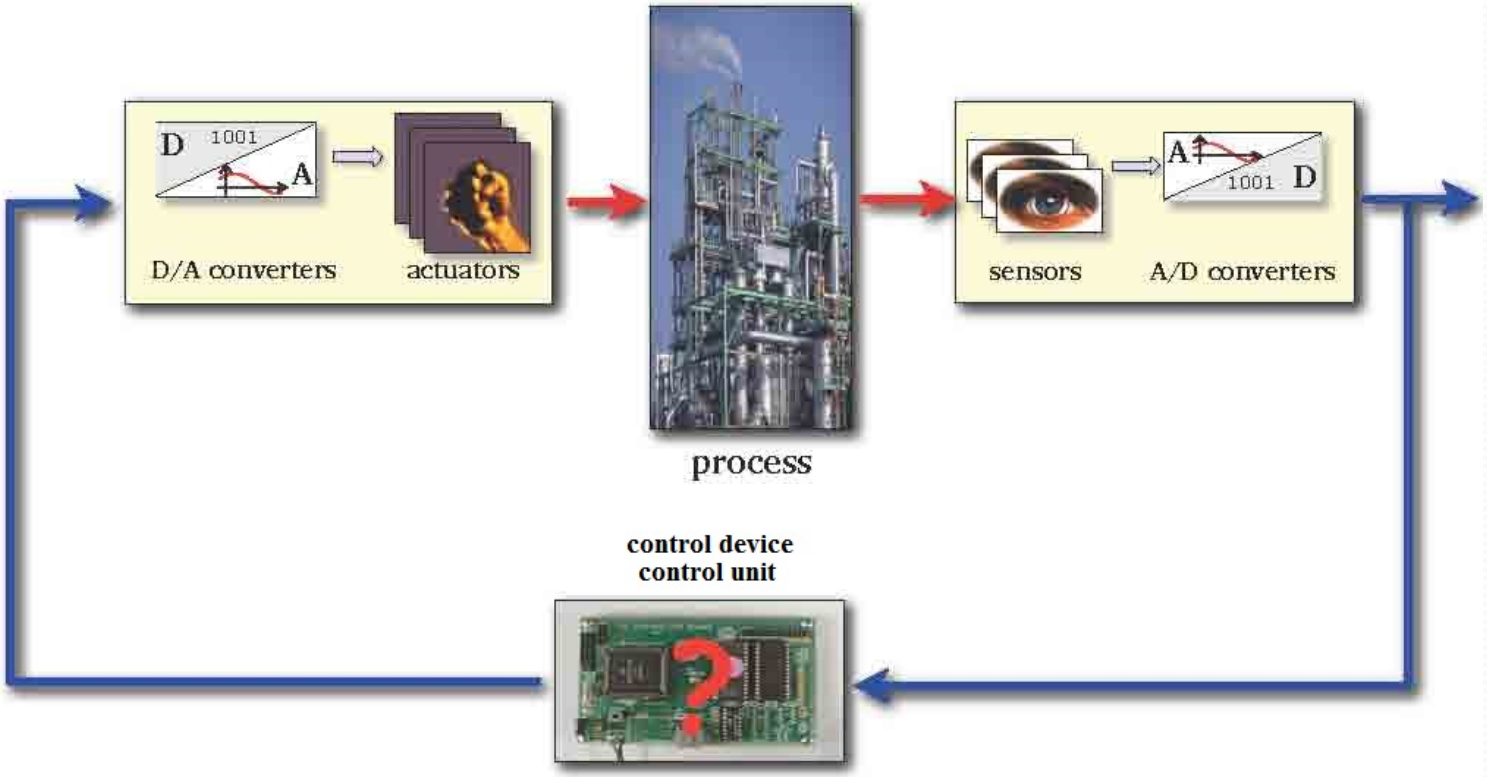
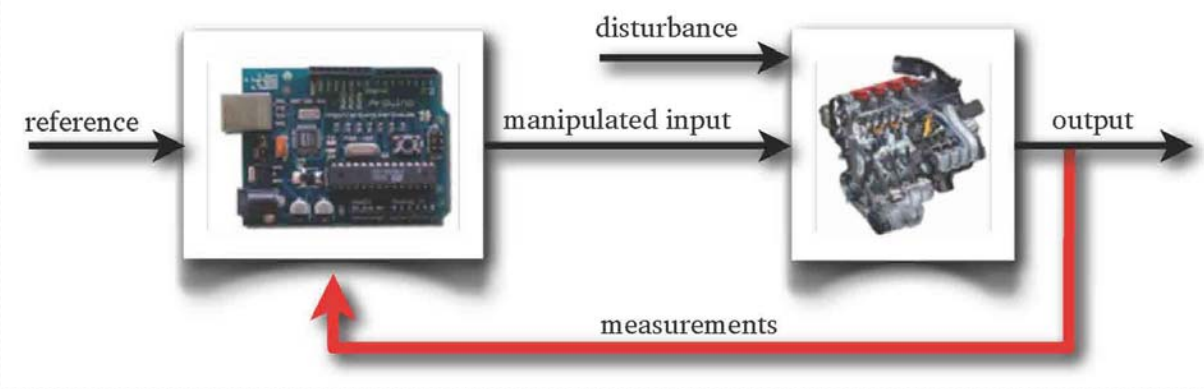
A typical control system



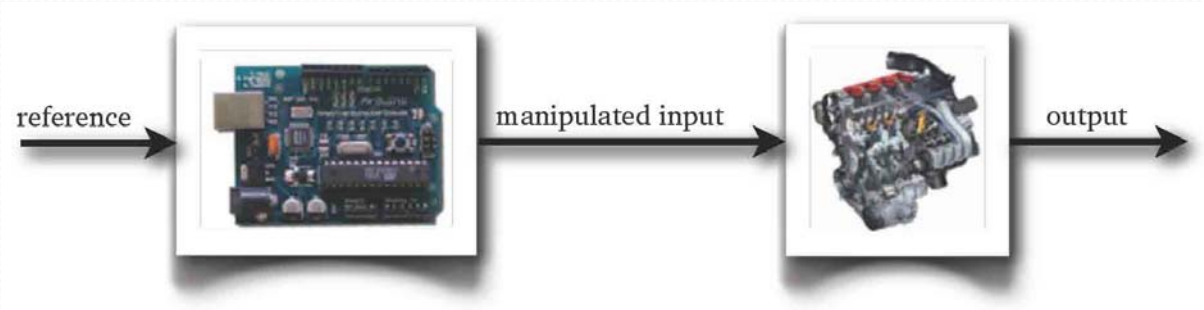
- Typical sensors: temperature, pressure, flow, level, velocity, position, acceleration, force (strain) / deformation, etc.
- Typical actuators: electrical motors (DC, brushless, step), pumps, valves, heaters, etc.

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 **controlle**r) 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!