Advanced Control Systems

Prof. Alireza Karimi

Laboratoire d'Automatique

Room: ME-C2 407
email:alireza.karimi@epfl.ch

Spring 2025

Course Subject

Classical Control:

A mathematical model, G, of the system is given, compute a controller that ensures the desired performance and guarantees closed-loop stability.

Advanced Control:

Design a controller that ensures the desired performance and guarantees closed-loop stability under the following conditions:

- when the exact model G of the system is unknown but belongs to a known set, i.e., $G \in \mathcal{G}$.

ROBUST CONTROL

- when the model of the system is time varying.

ADAPTIVE CONTROL

Required background: Students should have a strong grasp of classical control methods, including Loop Shaping, LQR, and Pole Placement, for both SISO and MIMO systems in discrete- and continuous-time, using input-output and state-space representations.

Contents

1. Stability, Performance and Robustness
   - Feedback loop, internal stability
   - Norm for signals and systems, asymptotic tracking
   - Model uncertainty, robust stability, robust performance
   - Limit of performance
2. Robust Controller Design
   - Introduction to convex optimization
   - Model-based H_2 and H_∞ controller design
   - Data-driven H_2 and H_∞ controller design
3. Robust Adaptive Control
   - Digital control, RST structure
   - Robust pole placement
   - Adaptive control (direct, indirect)
   - Switching adaptive control
   - Gain-scheduled control

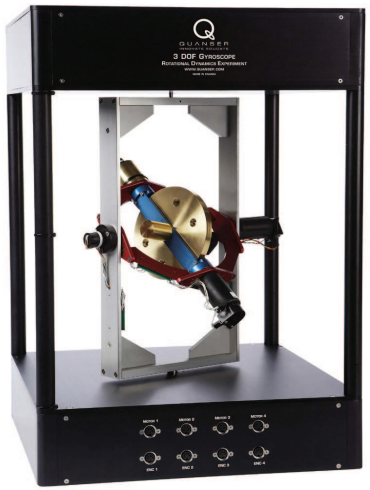
Course Schedule

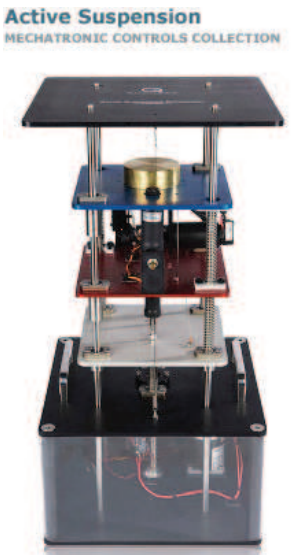
Advanced Control Systems, Spring 2025		
Wednesday	9:15 – 11:00	11:15– 12:00
Place	MEB 331	MED 21120
19 Feb.	Lecture	Lecture
26 Feb.	Lecture	CE-1
05 Mar.	Lecture	CE-1
12 Mar.	Lecture	CE-1
19 Mar.	Lecture	CE-2
26 Mar.	Lecture	CE-2
02 Apr.	Lecture	CE-2
09 Apr.	Lecture	CE-2
16 Apr.	Lecture	CE-2
30 Apr.	Lecture	CE-3
07 May	Lecture	CE-3
14 May	Lecture	CE-3
21 May	Lecture	CE-3
28 May	Lecture	CE-3

Computer Exercises

Objectives:

- Uncertainty modelling
- Robustness analysis
- H_2 and H_∞ controller design for a Mechatronic system
- Robust and Adaptive RST controller design by pole placement for a Mechatronic system





Evaluation and References

Evaluation

- Reports for CEs 30% (38 points)
- Written exam 70% (82 points)

Grading

Points	111-120	106-110	···	76-80	71-75	66-70	···	11-15	0-10
Grade	6.00	5.75	···	4.25	4.0	3.75	···	1.00	NA

Main References:

- *Feedback Control Theory* by J. C. Doyle, B. A. Francis, A. R. Tannenbaum, McMillan Publ., New York 1992.
- *Adaptive Control. Algorithms, Analysis and Applications* by I. D. Landau, R. Lozano, M. M'Saad and A. Karimi, 2nd Edition, Springer 2011.
- *Advanced Control Systems* by A. Karimi, 2025 (course notes available on Moodle)