Master's Department of Engineering Sciences

MSc in Automation Engineering and Robotics

Name of the unit: Nonlinear Control

Lecturer: Pascal Morin (pascal.morin@sorbonne-universite.fr)
Course code: MU5RBR30-NL
Student workload: 12 h of lectures, 8 h of tutorials, 8 h of labs
Credits: 3 ECTS
Specialization tracks: ☒ ROBOT (elective) ☐ SI ☐ MeDH
Semester offered: ☐ S1 ☐ S2 ☒ S3 ☐ S4
Language of instruction: ☐ French ☒ English
Targeted audience: ☒ Engineering Sciences students ☒ Other (specify): ENSAM
Localization : ☒ PMC Campus ☐ Other (specify):

Course Overview

The objective of this course unit is to present the main control techniques used to stabilize nonlinear control systems. The course is divided into three parts. The first covers techniques based on exact linearization, the second covers Lyapunov-based approaches, and the third covers model predictive control. Strong emphasis is placed on numerical tools (Matlab, Simulink, etc.) for implementing and assimilating the techniques.

Keywords: Nonlinear control systems, output-feedback linearization, state-feedback linearization, Lyapunov functions, predictive control.

Prerequisites

Students should have previously acquired the following prerequisites to follow this course:

- Linear control in state-space form (equilibrium points, tangent linearized systems, controllability, observability, controller design by pole placement, linear-observer design, LQR control).
- Matlab/Simulink, Python

Intended Learning Outcomes

By the end of this course, students will be able to:

1. Analyze and control a system using its tangent linearization
2. Master Matlab/Simulink tools for designing linear state-feedback controllers
3. Control a system using exact output-feedback linearization
4. Control a system using exact state-feedback linearization
5. Analyze the stability of a linear system using a Lyapunov function
6. Design a state-feedback controller from a candidate Lyapunov function
7. Master the implementation of nonlinear controllers using Matlab/Simulink
8. Understand predictive-control algorithms
9. Implement predictive control using Python toolboxes

Indicative Teaching Sequence and Methods

Week	C/TD/TP*	Content	Preparation	Learn. outc.
S1	C1	Review of linear state-space control		AAV1
S2	TD1	Covers C1		AAV1
S3	TP1	Matlab-Simulink practical: control using tangent linearization	Practical-session preparation	AAV1-AAV2
S4	C2	Exact-linearization control methods (Part I)		AAV3
S5	C3	Exact-linearization control methods (Part II)		AAV4
S6	TD2	Covers C2-C3		AAV3-AAV4
S7	C4	Lyapunov-based techniques (Part I)		AAV5
S8	C5	Lyapunov-based techniques (Part II)		AAV6
S9	TD3	Covers C2-C5		AAV3-AAV6
S10	TD4	Covers C4-C5		AAV5-AAV6
S11	TP2	Matlab-Simulink practical: control using Lyapunov techniques	Review C4-C5 and TD4	AAV1-AAV7
S12	C6	Predictive control		AAV8
S13	TP3 (4h)	Numerical practical on C6	Review C6 and prepare for the practical session	AAV8-AAV9

* C/TD/TP respectively corresponds to lectures, tutorials and lab sessions.

Indicative Assessment of Intended Learning Outcomes (1st session)

Week	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
S11	Individual	In-person	Other	AAV1-AAV7	30 %
S15	Individual	Remote	Other	AAV8-AAV9	20 %
S14	Individual	In-person	Written exam	AAV1-AAV9	50 %

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Session	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %

Date of generation of this unit description: October 6, 2026