2025
International Graduate School on Control

www.eeci-igsc.eu

M03 PARIS-SACLAY
17/03/2025 - 21/03/2025

Analysis and Design Methods for Time-Delay Systems

Wim Michiels
Department of Computer Science
KU Leuven, Belgium
https://www.kuleuven.be/wieiswie/en/person/00011378
Wim.Michiels@cs.kuleuven.be

Silviu-Iulian Niculescu
Université Paris-Saclay, CNRS, CentraleSupélec
Laboratoire des Signaux et Systèmes (L2S)
Inria team «DISCO»
https://cv.archives-ouvertes.fr/silviu-iulian-niculescu
Silviu.Niculescu@centralesupelec.fr

Summary of the course

The aim of this course is to describe fundamental properties of systems including time-delays in their representation, and to present an overview of methods and techniques for the analysis and control design. The focus lies on systems described by functional differential equations and on frequency-domain techniques, grounded in numerical linear algebra (e.g., eigenvalue computations) and optimization, but the main principles behind time-domain methods are addressed as well. Several examples (from chemical to mechanical engineering, from haptics systems and tele-operation to communication networks, from biological systems to population dynamics and genetic regulatory networks) complete the presentation. In particular, the synergies of analytic and computational tools for analysis and design are highlighted. The course is complemented with home-works where analysis and control design problems are solved using dedicated software tools.

Outline

Theory:

- Classification and representation
- Definition and properties of solutions of delay systems
- Spectral properties of linear time-delay systems

Analysis:

- Frequency-domain approaches
- Stability domains in parameter spaces
- Relative stability and synchronization
- Robustness and performance measures
- Time-domain, Lyapunov based criteria, Lyapunov matrices and converse theorems

Control design:

- Fundamental limitations of delays in control loops
- Structured stabilizing and optimal H-2 and H-infinity controllers (fixed-order, PID, decentralized,…)
- Delay compensation using predictor and periodic feedback
- Improving stability and performance by using delays as control parameters