TIME DELAY SYSTEMS

Webinar TDS

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Partial poles placement for infinite-dimensional systems: New perspectives via hypergeometric functions

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Event will take place via Zoom

ABSTRACT: Recent advances in the study of exponential stability for systems governed by functional differential equations have revealed a novel connection between degenerate hypergeometric functions and the zero distribution of the characteristic function associated with linear time-invariant delay–differential equations. This finding has enabled a precise characterization of a key spectral property of delay systems known as multiplicity-induced dominancy, later generalized to the so-called coexistent-real-roots-induced dominancy. These developments open promising prospects for the design of low-complexity controllers for infinite-dimensional systems—not only for delay systems but also for certain classes of partial differential equations—through the concept of partial pole placement.

In this talk, after reviewing essential background notions, we will present the foundations of the partial pole-placement methodology for delay systems and its extension to partial differential equations via boundary, pointwise, or internal prescribed stabilization of the wave equation. Applications such as active vibration control in flexible structures and modeling of the central nervous system's action in human postural control will illustrate the effectiveness of the proposed strategy. Finally, we will introduce and discuss the main features of the dedicated software tool P3δ (https://cutt.ly/p3delta).

This presentation is primarily based on joint methodological work on delay systems with Silviu Niculescu (L2S, Université Paris-Saclay), Guilherme Mazanti (L2S, Université Paris-Saclay), Wim Michiels (NUMA, KU Leuven), Fazia Bedouhène (UMMTO, Tizi-Ouzou), Timothée Schmoderer (Université d'Orléans), Karim Trabelsi (IPSA) et Cyprien Tamekue (Washington University in St. Louis), with extensions to partial differential equations in collaboration with Kaïs Ammari (University of Monastir), and on applied research conducted jointly with Sami Tliba (L2S, Université Paris-Saclay), Tamas Insperger (MTA-BME, Budapest University of Technology and Economics), and Tomas Vyhlidal (Czech Technical University in Prague). Last but not least, the development of the dedicated software tool was carried out in collaboration with many talented Cyb'Air students from IPSA.

BIO: Islam Boussaada is a Full Professor at IPSA, a leading French engineering school specializing in aeronautics and aerospace. He is also an associate researcher at the Laboratory of Signals and Systems (L2S) – Université Paris-Saclay, CNRS, CentraleSupélec – and with the DISCO team at Inria Saclay, where he was on research secondment from 2018 to 2020. He received his Maîtrise in Mathematics from the University of Carthage (Faculty of Sciences of Bizerte) in 2003, an M.Sc. (DEA) in Pure Mathematics from Université Paris Cité in 2004, a Ph.D. in Mathematics from the University of Rouen Normandy in 2008, and his Habilitation à Diriger des Recherches in Physics from Université Paris-Saclay in 2016. His research focuses on the qualitative theory of dynamical systems and partial differential equations, with applications in control theory—particularly time-delay systems, parametric and non-hyperbolic dynamics, and the control of vibrations. He is co-author of a monograph, co-editor of two contributed volumes, and has authored more than 150 peer-reviewed publications. He also leads the P3δ project, dedicated to delay-based control design. Prof. Boussaada has organized several international workshops and thematic sessions at major conferences. He served as IPC Co-Chair of the IFAC Workshop on Time-Delay Systems 2024 in Udine, Italy, and Co-General Chair of the IFAC Joint Conference 2025 held in Gif-sur-Yvette, France, which includes the 9th Symposium on System Structure and Control (SSSC), the 19th Workshop on Time-Delay Systems (TDS), and the 2nd Workshop on Control of Complex Systems (COSY). From 2018 to 2023, he co-led the national research group on infinite dimensional systems GT OSYDI, and from 2019 to 2021, served as Deputy Director of the IRS iCODE Institute at Université Paris-Saclay, and from 2019 to 2025, served as member of administration council of SAGIP (the french IFAC NMO). In 2024, he was named laureate of the CNRS–Africa Joint Research Program for the project SPECTRE-EDP, in recognition of his contributions to international research collaboration in mathematical control theory.

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