Seminar on Control Theory at Fukuoka

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@ ACROS Fukuoka

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14:00-15:00

Physics-informed identification of nonlinear dynamical systems: A unified framework for interpretable and reliable modeling

Cesare Donati (CNR-IEIIT, Italy)

Abstract: Modern engineering and scientific discovery increasingly rely on the ability to model complex, nonlinear dynamical systems. While traditional first-principles models offer interpretability, they often fail to capture unmodeled dynamics. Conversely, pure black-box machine learning models excel at data fitting but often lack physical consistency and fail in long-term forecasting.

This seminar presents a unified modeling framework designed to bridge this gap. By integrating partial physical knowledge with corrective data-driven components (such as sparse basis functions or kernel methods), we achieve models that are both physically grounded and high-performing. The proposed methodology shifts from classical one-step-ahead identification to a multi-step framework that minimizes cumulative error over extended horizons, ensuring reliability for control and forecasting applications. To capture missing dynamics without loosing interpretability, we introduce a sparse augmentation strategy that isolates residual effects through theoretical bounds and sparsity recovery. This approach is further hardened against the irregularities of real-world data, such as missing samples and aggregated measurements, by deriving robust estimation bounds for non-uniform observations. The effectiveness of these methods is demonstrated through diverse applications, ranging from spacecraft

inertia identification and chemical reactors to ecological population dynamics.

Bio: Cesare received the B.Sc. degree in Computer Engineering and the M.Sc. degree (cum laude) in Computer Engineering from Politecnico di Torino, Italy, where he also completed his Ph.D. in Electrical, Electronics, and Communication Engineering in early 2026. In 2024, he was a Visiting Scholar at The Pennsylvania State University. He is currently a postdoctoral research fellow at the Institute of Electronics, Computer and Telecommunication Engineering of the Italian National Research Council (CNR-IEIIT). He is a member of the IEEE committee on System Identification and Adaptive Control. His research interests include system identification, physics-based modeling, machine learning, filtering/estimation, and optimization.

15:15-16:15

Linear Complementarity Systems and an SDP-based test for P-matricty

Pieter Van Holm

(Universite Paris-Saclay, CentraleSupelec, France)

Abstract: Piecewise affine (PWA) dynamical models arise in a wide range of applications, including hybrid systems, model predictive control, neural networks, and non-linear circuit design and simulation. In this talk, we motivate the use of a ramp-based implicit representation of PWA systems, which avoids explicit enumeration of polyhedral regions and simplifies the study of system properties such as stability. We then introduce the Linear Complementarity Problem (LCP) and show how the ramp-based implicit PWA systems can be formulated as a Linear Complementarity System (LCS). The well-posedness of the underlying LCP is guaranteed when an associated matrix satisfies the P-matrix property. To certify P-matricity, we present a semidefinite programming (SDP)-based test relying on a Sum-Of-Squares (SOS) feasibility formulation. We show that the first relaxation yields known sufficient conditions for P-matricity, while higher relaxations allow us to certify a larger set of P-matrices.

Bio: Pieter Van Holm is a Phd. student at the L2S laboratory of Centralesupelec, which is part of the Paris-Saclay University in France. He obtained his Bachelor in Electromechanical engineering from the Vrije Universiteit Brussel (VUB), Belgium. He obtained his master in Aeronautical engineering from the Vrije Universiteit Brussels (VUB) and the Universite Libre de Bruxelles (ULB), Belgium. He spent his second master year at ISAE-Supaero in Toulouse. His thesis topic is titled ”Learning and Observing Linear Complementarity Systems”.

16:30-17:30

A Method of Reducing Activation Functions of Continuous-Time Recurrent Neural Networks for Stability Analysis

Tsuyoshi Yuno (Kyushu University, Japan)

Abstract: We present a method of reducing the number of activation functions of a continuous-time recurrent neural network for its stability analysis. The proposed method takes advantages of the Lyapunov stability theory for perturbed systems. An SDP-based method of reducing the conservatism of the proposed reduction method is also presented.

Bio: Tsuyoshi Yuno received his B.Eng. degree from Kumamoto University, Japan, in 2010. He received his M.Eng. degree and Ph.D. degree from Osaka University, Japan, in 2012 and 2015, respectively. In 2015, he joined Kyushu University, Japan, as an assistant professor at the Faculty of Information Science and Electrical Engineering. His research interests include algebraic methods in nonlinear control theory, real-time optimization in vehicle control, and stability analysis of neural networks. He is a member of IEEE, SICE, and JSAE.