Edp, commande et observation des systèmes

Report of Contributions

https://indico.math.cnrs.fr/e/edp-cosy

Contribution ID: **1** Type: **not specified**

Repetitive control for nonlinear systems

Tuesday, October 17, 2023 3:00 PM (1 hour)

In this talk we revise a series of recent advances on the challenging problem of robust periodic output regulation, that is, the problem of tracking periodic references (and/or rejection periodic disturbances) for nonlinear systems, robustly with respect to model uncertainties. This problem is well understood in the context of linear systems thanks to the celebrated "internal-model principle" established during the 70's. But, for nonlinear systems, it is still open. This work aim at clarifying challenging and possible solutions, connecting the theory of repetitive control with output regulation by means of infinite-dimensional dynamic regulators. In this context, a strong connection between the output regulation problem and the theory of repetitive control is established. Finally, we propose a new feedback design for a repetitive control scheme for minimum-phase nonlinear systems. Such a scheme is based on the forwarding approach and allows to deal with systems with high-order relative degree between the input and the regulated output.

Presenter: ASTOLFI, Daniele (LAGEPP)

Contribution ID: **2** Type: **not specified**

Exponential convergence towards consensus for non-symmetric linear first-order systems in finite and infinite dimensions

Tuesday, October 17, 2023 2:00 PM (1 hour)

I will first recall some results on how to achieve consensus for well known classes of systems, like the celebrated Cucker-Smale or Hegselmann-Krause models. When the systems are symmetric, convergence to consensus is classically established by proving, for instance, that the usual variance is an exponentially decreasing Lyapunov function: this is a "L^2 theory". When the systems are not symmetric, no L^2 theory existed until now and convergence was proved by means of a "L^\infty theory".
In this talk I will show how to develop a L^2 theory by designing an adequately weighted variance, and how to obtain the sharp rate of exponential convergence to consensus for general finite and infinite-dimensional linear first-order consensus systems.
If time allows, I will show applications in which one is interested in controlling vote behaviors in an opinion model. This is a work in collaboration with Laurent Boudin and Francesco Salvarani.

Presenter: TRÉLAT, Emmanuel (Sorbonne Université)

Contribution ID: **4** Type: **not specified**

Exponentially stable uncertain systems in infinite dimension: converse Lyapunov characterization and some applications

Friday, October 20, 2023 10:30 AM (1 hour)

We discuss infinite-dimensional forward complete dynamical systems which are subject to uncertainties, representing switching parameters or external disturbances. We characterize the uniform (with respect to uncertainties) local, semi-global, and global exponential stability, in terms of coercive and non-coercive Lyapunov functionals. We illustrate the potential usefulness of the result discussing exponential stability of nonlinear retarded systems with uncertainties and exponential stability preservation under sampling for semilinear control switching systems.

Presenter: SIGALOTTI, Mario (Inria, Laboratoire Jacques-Louis Lions)

Contribution ID: **5** Type: **not specified**

Stabilization of networks of hyperbolic systems with a chain structure

Thursday, October 19, 2023 4:30 PM (1 hour)

In this talk, we focus on recent developments for the stabilization of networks of elementary hyperbolic systems with a chain structure. Such a structure arises in multiple industrial processes such as electric power transmission systems, traffic networks, or torsional vibrations in drilling devices. The objective is to design output feedback control laws that stabilize the chain using the available actuators and sensors. The different systems composing the network are called elementary in the sense that when taken alone, we know how to design stabilizing output-feedback control laws. We will first consider the case where the actuators and sensors are available at one end of the chain. Using appropriate state predictors, we will present a recursive approach to stabilize the whole chain. Then, we will focus on the case where the actuators and sensors are only available at the junction between two subsystems composing the chain. We will show that such a configuration does not always guarantee the controllability of the chain. Under appropriate controllability/observability conditions, we will design simple stabilizing control laws. Our approach will be based on rewriting the system as Integral Delay Equations (IDEs) with pointwise and distributed control terms. Finally, we will show how the proposed techniques can be used to develop output feedback control laws for traffic flow on two cascaded freeway segments connected by a junction.

Presenter: AURIOL, Jean (L2S - CNRS)

Contribution ID: **6** Type: **not specified**

Clustering in large language models: an interacting particle systems perspective

Friday, October 20, 2023 9:00 AM (1 hour)

With remarkable empirical success, Transformers enable large language models to compute succinct representations of data using the self-attention mechanism. We model these architectures as interacting particle systems in the spirit of models in collective behaviour and opinion dynamics, allowing us to show the appearance of various clustering/coagulation phenomena. Associated control problems will also be discussed. Based on joint work with Cyril Letrouit, Yury Polyanskiy, and Philippe Rigollet.

Presenter: GESHKOVSKI, Borjan

Contribution ID: **7** Type: **not specified**

Mortensen observer for sub-differential dynamics

Wednesday, October 18, 2023 11:30 AM (1 hour)

In his 1968 article, Mortensen proposed a recursive method to compute a causal estimator for observed deterministic dynamics. Using tools from control theory, his approach relies on a "cost-to-come"value function that solves a Hamilton-Jacobi-Bellman (HJB) equation in the viscosity sense. This latter function can also be computed from the stochastic filtering setting using a vanishing noise procedure. This talk proposes an adaptation of Mortensen's approach to sub-differential dynamics defined through variational inequalities. We introduce a suitable notion of cost-to-come function that solves a HJB equation with Neumann boundary condition in the viscosity sense, and we define a Mortensen observer from it. We eventually link the cost-to-come function for this constrained setting to its stochastic filtering counterpart.

Presenter: CHAINTRON, Louis-Pierre

Contribution ID: **8** Type: **not specified**

Controllability criteria for 1D hyperbolic systems

Wednesday, October 18, 2023 9:00 AM (1 hour)

This talk deals with the controllability of linear 1D hyperbolic systems. Reformulating the problem in terms of linear difference equations and based on infinite-dimensional realization theory, we obtain both necessary and sufficient conditions for the approximate and exact controllability, expressed in the frequency domain as well as an upper bound for the controllability times. The results are applied to dynamic network systems. This is a joint work with S. Fueyo, G. Mazanti and M. Sigalotti.

Presenter: CHITOUR, Yacine (L2S)

Contribution ID: **9** Type: **not specified**

Carleman-based reconstruction algorithm on a wave network

Tuesday, October 17, 2023 4:30 PM (1 hour)

In this presentation, we will be interested in an inverse problem set on a tree shaped network where each edge behaves according to the wave equation with potential, external nodes have Dirichlet boundary conditions and internal nodes follow the Kirchoff law. The main goal is the reconstruction of the potential everywhere on the network, from the Neumann boundary measurements at all but one external vertices. Leveraging from the Lipschitz stability of this inverse problem, we aim at providing an efficient reconstruction algorithm based on the use of an appropriate global Carleman estimate. This is a joint work with Lucie Baudouin, Maya de Buhan and Emmanuelle Crépeau.

Presenter: VALEIN, Julie (Université de Lorraine)

Contribution ID: **10** Type: **not specified**

Design of low-dimensional controllers for high-dimensional systems

Thursday, October 19, 2023 2:00 PM (1 hour)

This talk presents the design of reduced-order controllers for large-scale dynamical systems. The objective is to develop efficient control strategies that ensure stability and robustness with reduced computational complexity. By leveraging the concept of partial pole placement, which involves placing a subset of the closed-loop system's poles, this study aims to strike a balance between reduced-order modeling and control effectiveness. The proposed approach addresses the challenges posed by high-dimensional systems and provides a systematic framework for controller design. Two case studies are investigated in detail: time-delay systems and ODE-reaction-diffusion interconnections.

Presenter: BAJODEK, Mathieu

Contribution ID: **11** Type: **not specified**

Different approaches to integral action in infinite-dimensional nonlinear dynamics

Wednesday, October 18, 2023 2:00 PM (1 hour)

We discuss some recent advances in set-point output regulation for nonlinear systems in infinite dimension. We investigate two distinct approaches: (i) passivity arguments and constrained integral control; (ii) Lyapunov techniques and forwarding-based control. For nonlinear plants modelled by monotone differential inclusions, the passivity-based approach allows us to achieve constant reference tracking with simple output feedback control. Additionally, the integrator state can be constrained into a desired convex subset of the output space. On the other hand, the forwarding-Lyapunov approach does not require impedance passivity of the system, and relies instead on the existence of a suitable invariant manifold for the plant-integrator cascade. This motivates the introduction of a new class of nonlinear operator Sylvester equations, which we are able to handle in some relevant particular cases. Both approaches are applied to selected nonlinear PDE models. Joint work with Lucas Brivadis, Pietro Lorenzetti, Lassi Paunonen and George Weiss.

Presenter: VANSPRANGHE, Nicolas

Contribution ID: **12** Type: **not specified**

Stabilization results for KdV equations with delay

Wednesday, October 18, 2023 3:00 PM (1 hour)

In this talk, the exponential stability of the nonlinear Korteweg-de Vries equation with delayed terms is considered both in the case of a bounded interval and a tree-shape network. We will give two types of proof, one constructive with some Lyapunov techniques and the other more general with observability results. We will also discuss the results from a numerical point of view. This is joint work with L. Baudouin, J. Valein, C. Prieur and H. Parada.

Presenter: CRÉPEAU, Emmanuelle

Contribution ID: **13** Type: **not specified**

Global stabilization of the cubic defocusing nonlinear Schrödinger equation on the torus

Wednesday, October 18, 2023 4:30 PM (1 hour)

In this talk, I will focus on the stabilization of defocusing nonlinear Schrödinger equations on manifolds, arising naturally as models of wave propagation in fiber optics. I will first recall local and semi-global results that have been obtained since the beginning of the 2000's. Then, I will introduce a method that I have developed in collaboration with Jérémy Martin to prove the (uniform) global stabilization of the cubic defocusing nonlinear Schrödinger equation on the d-dimensional torus, d=1, 2 or 3.

Presenter: LE BALCH, Kevin

Contribution ID: **14** Type: **not specified**

Null-controllability of underactuated linear parabolic-transport systems with constant coefficients

Thursday, October 19, 2023 3:00 PM (1 hour)

I will present controllability properties of mixed systems of linear parabolic-transport equations, with possibly nondiagonalizable diffusion matrix, on the 1D torus, coupled by constant coupling terms. The distributed control acts through a constant matrix, with possibly less controls than equations. In small time or for not regular enough initial data, these systems are never controllable, whereas in large time, null-controllability holds, for regular initial data, iff a spectral Kalman rank condition is verified. This is a joint work with Armand Koenig.

Presenter: LISSY, Pierre

Contribution ID: **15** Type: **not specified**

Systems subject to input saturation: from ODEs to PDEs

Friday, October 20, 2023 11:30 AM (1 hour)

In this talk some results dealing with the control of some PDEs (such as the wave equation) subject to input nonlinearities (such as saturations) are considered. Leveraging the results obtained in the ODE context, stability analysis and control design conditions are proposed by using adequate Lyapunov functions and quadratic abstractions of the input nonlinearity. Static and dynamic controllers are discussed. Recent extensions to the more complex case resulting from the cascade of an ODE, a nonlinearity and a PDE are also discussed.

Presenter: TARBOURIECH, Sophie

Contribution ID: **16** Type: **not specified**

Lie brackets and interpolation for controllability

Thursday, October 19, 2023 9:00 AM (1 hour)

This talk will survey old and recent results on the local controllability of control systems modeled by ODEs, focussing on results stated using Lie brackets of the vector fields defining the dynamics. We will propose a unified approach to determine and prove obstructions to local controllability. This approach relies on a recent Magnus-type representation formula of the state, a new Hall basis of the free Lie algebra over two generators and Gagliardo-Nirenberg interpolation inequalities. This approach allows to recover the known necessary conditions, but also to prove a conjecture of 1986 due to Kawski and many other new necessary conditions. Finally, we will see how these results translate for PDEs. This is a joint work with Frederic Marbach, Jeremy Le Borgne and Mégane Bournissou.

Presenter: BEAUCHARD, Karine

Contribution ID: **17** Type: **not specified**

Placement partiel des pôles de systèmes de dimension infinie : nouvelles perspectives de fonctions hypergéométriques

Thursday, October 19, 2023 10:30 AM (1 hour)

Récemment, dans le cadre de l'étude de la stabilité exponentielle des systèmes gouvernés par des équations différentielles fonctionnelles, un nouveau lien entre les fonctions hypergéométriques dégénérées et la distribution des zéros de la fonction caractéristique associée aux équations différentielles linéaires à retard a été mis en évidence. Cela a permis la caractérisation d'une propriété des systèmes à retard connue sous le nom de "la dominance induite par la multiplicité", ce qui a ouvert une nouvelle direction dans la conception de commande de faible complexité non seulement pour les systèmes à retard mais aussi pour certaines classes d'équations aux dérivées partielles en utilisant une idée de placement partiel des pôles. Dans cet exposé, après avoir rappelé quelques pré-requis, les fondements d'une méthodologie de placement de pôles seront présentés, puis des questions ouvertes seront abordées. Certaines applications telles que le contrôle actif des vibrations intervenant dans les structures flexibles et la modélisation de l'action du système nerveux central sur l'équilibre humain mettront l'accent sur les bénéfices de la stratégie de contrôle proposée. Enfin, des fonctionnalités d'un nouveau logiciel dédié appelé "P3δ" (https://cutt.ly/p3delta) seront présentées. Cet exposé reprend essentiellement des résultats de travaux méthodologiques en commun avec Silviu Niculescu (L2S, Université Paris-Saclay), Guilherme Mazanti (L2S, Université Paris-Saclay) et Wim Michiels (NUMA, KU Leuven), et des résultats de travaux applicatifs en commun avec Sami Tliba (L2S, Université Paris-Saclay), Tamas Insperger (MTA-BME, Budapest University of Technology and Economics) et Tomas Vyhlidal (Czech Technical University in Prague).

Presenter: BOUSSAADA, Islam

Contribution ID: **19** Type: **not specified**

Set-valued KKL observer design for non observable systems

Thursday, October 19, 2023 11:30 AM (1 hour)

We present the theory of KKL observer design, which consists in finding a smooth change of coordinates transforming the system dynamics into a linear filter of the output. Its interest is that the state of the original system can then be reconstructed by implementing this filter from any initial condition and left-inverting the transformation, if the system is backward-distinguishable. But we show that this theory is still relevant when the latter assumption does not hold, namely when distinct solutions may generate the same output, and thus be indistinguishable : the system state could then be reconstructed modulo its indistinguishable class. More precisely, the KKL transformation is no longer injective and its "left-inverse"is allowed to be set-valued, yielding a set-valued KKL observer. Assuming the transformation is full-rank and its preimage has constant cardinality, we show the existence of a globally defined set-valued left-inverse that is Lipschitz in the Hausdorff sense and that is linked to the backward-indistinguishable sets, so that the set-valued KKL observer converges in the Hausdorff sense to the backward-indistinguishable set of the system solution. When, additionally, a given output is generated by a specific number of solutions not converging to each other, we show that the designed observer asymptotically reconstructs each of those solutions.

Presenter: BERNARD, Pauline

Contribution ID: **20** Type: **not specified**

Sequential data assimilation for oncology

Wednesday, October 18, 2023 10:30 AM (1 hour)

The development of PDE models capable of describing tumor growth may help monitor disease progression or predict the efficacy of different therapeutic strategies. However, to be truly informative or predictive, these models need to be corrected and/or parameterized with available observations. The goal of this talk is to present some sequential data assimilation strategies that address these types of problems. More specifically, in the first part we focus on a Luenberger observer that can handle 3D tumor front data. In the second part, we focus on the combination of a Luenberger observer with a population-based Kalman observer, which allows the use of repeated measurements in configurations with common priors (e.g., multiple subjects in a clinical trial or repeated biological measurements) when data are sparse or corrupted by noise. Theoretical results and numerical illustrations with synthetic and real data are presented for both parts.

Presenter: COLLIN, Annabelle