2020 IFAC Open Invited Track
On nonlinear infinite dimensional systems

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Abstract: The goal of this open invited track is to collect in a single track all works dealing with nonlinearities in infinite-dimensional systems, for both control theory and its applications. The topics of this open invited track include the modeling, analysis, control, and observer/estimator design for systems governed by infinite dimensional systems with nonlinear input or output laws. Control techniques include nonlinear semigroup theory, Lyapunov approaches, backstepping techniques, passivity, numerical simulations, model reduction, and scientific computing.

Keywords: Nonlinear control systems, Distributed parameter systems and applications, Nonlinear Models, Lyapunov methods, Backstepping techniques, Numerical simulation.

1. WORKSHOP OUTLINE

Nonlinear infinite dimensional systems include a large variety of dynamical systems, as the ones that are mathematically described by partial differential equations, or that contain a delay, or that have distributed parameter systems. The nonlinearities may either come from the dynamics (e.g., if a nonlinear model is studied), or from the control loop (e.g., when either the sensor of the actuator is subject to a nonlinearity). The broad non-linear control community addresses these challenges with its focus on latest developments in theory and applications as well as related areas of research and engineering. Applications include energy, transport, and communication domains. Advanced control objectives ask to develop optimal controllers and thus linear control theory is sometimes not sufficient. Non-linear control systems have gained importance in many industrial areas and research has undergone significant developments recently. There are significant challenges in various fields of nonlinear control. The open invited track will exhibit how these challenges are met with a focus on the latest developments in theory and applications as well as related areas of research and engineering.

Among the nonlinear models that we talked about above, let us mention Burgers equation, which models many physical phenomena such as traffic flow (see e.g., Blandin et al. [2010], Perrollaz [2012]), or the Korteweg-de Vries equation, which represents long waves in shallow water surfaces (see e.g., Cerpa and Coron [2013]). A typical example of a nonlinearity appearing in the control loop is *saturation*, which appears in many control system and has been analyzed in many papers such as Slemrod [1989], Seidman and Li [2001], Curtain and Zwart [2016], Marx et al. [2017], Kang and Fridman [2018], Ramirez et al. [2017], or Prieur et al. [2016]. This leads to many interesting problems from the theoretical point of view, which have a real practical interest. To cite only a few examples, one might be interested in the decay rate analysis of such systems, the numerical estimation of the region of attraction, or the design of observers.

Obviously, extending finite-dimensional results to the infinite-dimensional case is not an easy task. As illustrated in Mironchenko and Wirth [2019], Lyapunov theory for such systems gives rise to new issues like the lack of coercivity of the involved Lyapunov functionals. Note that there exists several methods for the computation of Lyapunov functionals for linear infinite-dimensional systems, such as semi-definite programming, Valmorbida et al. [2015], Legendre polynomials, Seuret and Gouaisbaut [2015], the infinite-dimensional version of the backstepping method, Krstic and Smyshlyaev [2008], Port-Hamiltonian techniques or some reduced order approximation Dalmas et al. [2016]. However, frequently these techniques are used to study linear systems while extensions to the nonlinear case are still open in many cases. Let us mention some successful extensions of nonlinear methods leading to interesting and promising numerical results, such as the Koopman operator applied to nonlinear flows, Arbabi et al. [2018], the occupation measure formulation for scalar nonlinear conservation laws, Marx et al. [2019], or high-gain observer techniques for hyperbolic PDEs, Kitsos et al. [2018].

This open invited track will provide a forum for innovative techniques for the stability analysis of or the feedback design for nonlinear infinite dimensional systems. The topics of this open invited track include modeling, analysis, control, and observer/estimator design for systems governed by infinite dimensional systems with nonlinear input or output laws. Control techniques include nonlinear semigroup theory, Lyapunov approach, backstepping techniques, passivity, numerical simulations, model reduction, and scientific computing.

2. POTENTIAL CONTRIBUTING AUTHORS

We expect a large audience in this open invited track. For this session, we are planning to contact the following researchers (this is not an exhaustive list):

- Vincent Andrieu
- Fatiha Alabau-Boussouira
- Lucie Baudouin
- Gildas Besancon
- Andrea Cristofaro
- Joachim Deutscher
- Francesco Ferrante
- Lars Gruene
- Hiroshi Ito
- Pauline Kergus
- Miroslav Krstic
- Milan Korda
- Andreas Kugi
- Yann Le Gorrec
- Pierre Lissy
- Bernhard Maschke
- Thomas Meurer
- Andrii Mironchenko
- Charles Poussot-Vassal
- Pierre Rouchon
- Jacquelien Scherpen
- Kurt Schlacher
- Rodolphe Sepulchre
- Aneel Tanwani
- Sophie Tarbouriech
- Luz de Teresa
- Marius Tucsnak
- Arjan van der Schaft
- Rafael Vazquez
- George Weiss
- Enrique Zuazua
- Hans Zwart

3. SPONSORING TC

We suggest the TC 2.3. Non-Linear Control Systems for the organization of the reviewing process. Maybe members of this TC are working in the field of this open invited track, thus it is expected that the review process will be very natural.

4. LIST OF ORGANIZERS WITH A SHORT BIO

Swann Marx received his PhD from the Gipsa-lab, Grenoble, France, in 2017. He spent two years as a post-doctoral researcher at LAAS-CNRS, Toulouse, France. He is currently a junior CNRS researcher at LS2N, Nantes, France. His current interests include stability analysis and feedback law design of nonlinear infinite-dimensional systems and numerical analysis of nonlinear PDEs with a polynomial optimization viewpoint.

Fabian Wirth received his PhD from the Institute of Dynamical Systems at the University of Bremen in 1995. He has since held positions at the Centre Automatique et Systèmes of Ecole des Mines, the Hamilton Institute at NUI Maynooth, Ireland, the University of Wuerzburg and IBM Research Ireland. He now holds the chair for Dynamical Systems at the University of Passau. His current interests include stability theory, switched systems and large scale networks with applications to networked systems and in the domain of smart cities.

Christophe Prieur is currently a senior researcher of the CNRS at the Gipsa- lab, Grenoble, France. He is currently a member of the EUCA-CEB, an associate editor for the AIMS Evolution Equations and Control Theory and IEEE Trans. on Control Systems Technology, a senior editor for the IEEE Control Systems Letters, and an editor for the IMA Journal of Mathematical Control and Information. He was the Program Chair of the 9th IFAC Symposium on Nonlinear Control Systems (NOLCOS 2013) and of the 14th European Control Conference (ECC 2015). His current research interests include nonlinear control theory, hybrid systems, and control of partial differential equations.

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