Control of Distributed Parameter Systems 2017

Université de Bordeaux

3 to 7 July 2017
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Detailed program

Monday, July 3rd

08:45 - 10:00  Welcome & Coffee

10:00 - 10:45  E. Zuazua: Controllability under constraints

10:45 - 11:30  M. Demetriou: Using modified Centroidal Voronoi Tessellations in feedback kernel partitioning for joint actuator and sensor selection of parabolic PDEs with static output feedback

11:30 - 12:15  L. Weis: The stochastic NLS and Littlewood-Paley Theory

12:15 - 13:45  Lunch Break

13:45 - 14:30  S. Ervedoza: Some results on the controllability of parabolic equations

14:30 - 15:15  L. Miller: Some sharp Lebeau-Robbiano inequalities without Carleman estimates (a retrospect)

15:15 - 16:00  W. Arendt: Diffusion with Non-local Boundary Conditions

16:00 - 16:30  Coffee Break

16:30 - 17:15  S. Avdonin: Control and Inverse Problems for Networks of Singular Strings

17:15 - 18:00  B. Jacob: Input to state stability of evolution equations

Tuesday, July 4th

08:45 - 09:30  T. Takahashi: Local controllability to trajectories of a one dimensional model of turbulence

09:30 - 10:15  K. Morris: The role of sensors and actuators in control of infinite-dimensional systems

10:15 - 10:45  Poster Ads

- Z. Belkhatir: Minimum sampling interval for joint parameters and input estimation of coupled hyperbolic PDE and infinite ODE using adaptive observer

- M. Berbiche: On the global existence of solutions for system of the heat equations and the corresponding damped wave system

- N. Hegoboru: Controllability properties of the Lotka-McKendrick system

- D. Hoang: Observation of a 1D wave equation on non-cylindrical domains
– J. Kleinhans: Well-posedness of infinite-dimensional networks of hyperbolic partial differential equations
– F. Lamoline: Well-Posedness of Infinite-dimensional Stochastic Port-Hamiltonian Systems with Boundary Control and Observation
– R. Nabiullin: Infinite-dimensional input-to-state stability and Orlicz spaces
– J. Humaloja: Robust Regulation of Port-Hamiltonian Systems

10:45 - 11:45 Coffee Break & Posters

11:45 - 12:30 Y. Le Gorrec: Backstepping stabilization of linear port-Hamiltonian systems

12:30 - 14:00 Lunch Break

14:00 - 14:45 O. Glass: Control of the motion of a fluid

14:45 - 15:30 D. Dochain: Properties of tubular reactor models as a case study

15:30 - 16:00 Coffee Break

From 16:00 to 18:00: parallel sessions


16:30 - 17:00 A. Mironchenko: Characterizations of Input-to-State Stability for Wide Classes of Control Systems / R. Zawiski: Admissibility results for retarded delay systems

17:00 - 17:30 P. Laakkonen: A reformulation of the internal model principle using factorization approach / I. Moyano: Spectral inequalities and some applications

17:30 - 18:00 S. Marx: Global Stabilization of a Korteweg-de-Vries Equation with Saturating Distributed Control

19:00 - 20:45 Bordeaux Wine City: Visit and tasting

Wednesday, July 5th

08:45 - 09:30 J. Winkin: Boundary Feedback Control of Linear Hyperbolic Systems

09:30 - 10:15 K. Seip: A survey on analysis for Dirichlet series

10:15 - 10:45 Coffee Break

10:45 - 11:30 H. Zwart: Port-Hamiltonian Differential-Algebraic Equations

11:30 - 12:15 D. Matignon: Fractional Derivatives and Diffusive Representations: Semigroup formulation, Stability issues and Engineering Applications

12:15 - 13:00 Lunch Box

13:00 - 18:00 Excursion: Dune du Pyla and oyster tasting
Thursday, July 6th

08:45 - 09:30  **A. Perrasso**: Some parameter identifiability problems linked to structured models in population dynamics

09:30 - 10:15  **G. Webb**: Spatial Spread of Epidemic Diseases in Geographical Settings

10:15 - 10:45  **Coffee Break**

10:45 - 11:30  **S. Anita**: Regional control for population dynamics

11:30 - 12:15  **M. Krstic**: PDE Stabilization by Sampled-Data Control

12:15 - 13:45  **Lunch Break**

13:45 - 14:30  **Y. Tomilov**: $L^p$-tauberian theorems and energy decay

14:30 - 15:15  **G. Weiss**: Fast switching between infinite-dimensional linear systems

15:15 - 16:00  **Y. Privat**: Optimal control of resources for species survival

16:00 - 16:30  **Coffee Break**

16:30 - 17:15  **B-Z. Guo**: Active Disturbance rejection Control to Partial Differential Equations

17:15 - 18:00  **J. Leblond**: Inverse boundary value problems for Laplace equation and holomorphic functions

Friday, July 7th

08:45 - 09:30  **L. de Tereza**: Hyperbolic phenomena on the controllability of coupled parabolic equations

09:30 - 10:15  **L. Paunonen**: Robust output regulation of regular linear systems

10:15 - 10:45  **Coffee Break**

11:30 - 12:15  **S. Micu**: On the boundary control of the wave equation with a potential

12:15 - 13:45  **Lunch Break**

13:45 - 14:30  **H. Logemann**: Transfer Functions of Infinite-Dimensional Systems: Positive Realness and Stabilization

15:15 - 16:00  **J. Wang**: Stabilization of Coupled Systems with Dynamic PDE Feedback Controls

16:00 - 16:30  **Coffee Break**
Abstracts

Regional control for population dynamics
Sebastian Anita
University Alexandru Ioan Cuza and Octav Mayer Institute of Mathematics of the Romanian Academy, Romania

This work deals with some control problems related to structured population dynamics with diffusion. Firstly, we investigate the regional control for an optimal harvesting problem (the control acts in a subregion \( \omega \) of the whole domain \( \Omega \)). Using the necessary optimality conditions, for a fixed \( \omega \), we get the structure of the harvesting effort which gives the maximum harvest; with this optimal effort we investigate the best choice of the subregion \( \omega \) in order to maximize the harvest. We introduce an iterative numerical method to increase the total harvest at each iteration by changing the subregion where the effort acts. Numerical tests are used to illustrate the effectiveness of the theoretical results. We also consider the problem of eradication of a structured pest population dynamics with diffusion and logistic term, which is a zero-stabilization problem with constraints. We derive a necessary condition and a sufficient condition for zero-stabilizability. We formulate a related optimal control problem which takes into account the cost of intervention in the subregion \( \omega \).

Key words: Optimal harvesting; population dynamics; diffusive models; regional control; numerical methods.

Diffusion with Non-local Boundary Conditions
Wolfgang Arendt
University of Ulm, Germany

Non-local boundary conditions are quite natural and occur for several models. A particle reaching the boundary is sent back to the interior with a probability which depends on the distribution in the interior at the given moment. Mathematically there are several challenges. One is the space: Hilbert spaces seem not appropriate and spaces of continuous functions turn out to give the right framework. The most difficult is the holomorphic estimate. We will show that the Laplacian with non-local Dirichlet and non-local Robin boundary conditions generates a holomorphic semigroup. However, these semigroups are never strongly continuous at 0. Compactness can be proved using the Feller property. Concluding, as a final result one obtains existence and uniqueness as well as regularity and a precise description of the asymptotic behaviour.

This is joint work with Stefan Kunkel and Markus Kunze.


Control and Inverse Problems for Networks of Singular Strings
Sergei Avdonin
University of Alaska Fairbanks, United States

We consider boundary control and inverse problems for a nonhomogeneous string with masses attached at interior points. We prove the exact controllability of the string in a sharp time interval with respect to an asymmetric Sobolev space with the regularity increasing at each ‘mass’ point. Using the boundary control approach to inverse problems, we demonstrate that the density of the string, masses and their locations can be recovered using the dynamical Dirichlet-to-Neumann map associated with the boundary point of the string. We extend our approach to graph-like networks of elastic strings with attached masses to prove sharp regularity, controllability and identifiability results.

Sensitivity Analysis with Respect to Boundary Data in Poro-Elastic and Poro-Visco-Elastic Models
H.T. Banks
Center for Research in Scientific Computation, N.C. State University, United States

We consider boundary control and inverse problems for a nonhomogeneous string with masses attached at interior points. We prove the exact controllability of the string in a sharp time interval with respect to an asymmetric Sobolev space with the regularity increasing at each ‘mass’ point. Using the boundary control approach to inverse problems, we demonstrate that the density of the string, masses and their locations can be recovered using the dynamical Dirichlet-to-Neumann map associated with the boundary point of the string. We extend our approach to graph-like networks of elastic strings with attached masses to prove sharp regularity, controllability and identifiability results.

Minimum sampling interval for joint parameters and input estimation of coupled hyperbolic PDE and infinite ODE using adaptive observer
Zehor Belkhatir
King Abdullah University of Science and Technology (KAUST), Saudi Arabia

In the present work, an estimation problem for coupled hyperbolic PDE and infinite-dimensional ODE system is considered. This problem is motivated by the characterization of the cerebral spatiotemporal hemodynamic response from non-invasive Blood Oxygenation Level Dependent (BOLD) measurements provided by functional Magnetic Resonance Imaging (fMRI) modality. The proposed methodology to solve this estimation problem is to design an adaptive observer for the joint estimation of the state, the parameters and the input of the system.

This is joint work with Sarah Mechhoud and Taous Meriem Laleg-Kirati (KAUST).
On the global existence of solutions for system of the heat equations and the corresponding damped wave system

Mohamed Berbiche
Université de Biskra, Algeria

We consider the Cauchy problem for a strongly coupled semi-linear heat equations with some kind of nonlinearity in multi-dimensional space $\mathbb{R}^N$. We see under some conditions on the exponents and on the dimension, that the time-global existence, uniqueness of solutions for small data and their asymptotic behaviors are obtained. This observation will be applied to the corresponding system of the damped wave equations in low dimensional space.

Hyperbolic phenomena on the controllability of coupled parabolic equations

Luz de Teresa
Instituto de Matemáticas UNAM, Mexico

In this conference I will present what we have called ‘hyperbolic phenomena” in the controllability of coupled parabolic equations. That is, we will present some situations in which a minimal time of controllability is required or a geometric condition is imposed to the control region.

To be more specific. We consider the null controllability problem for two coupled parabolic equations with a space-depending coupling term. We analyze both boundary and distributed null controllability. In each case, we exhibit a minimal time of control, that is to say, a time $T_0 \in [0, \infty]$ such that the corresponding system is null controllable at any time $T > T_0$ and is not if $T < T_0$. In the distributed case, this minimal time depends on the relative position of the control interval and the support of the coupling term. We also prove that, for a fixed control interval and a time $\tau_0 \in [0, \infty]$, there exist coupling terms such that the associated minimal time is $\tau_0$.

The main part of the research was done with Farid Ammar Khodja, Assia Benabdallah and Manuel González-Burgos.

Using modified Centroidal Voronoi Tessellations in feedback kernel partitioning for joint actuator and sensor selection of parabolic PDEs with static output feedback

Michael A. Demetriou
Worcester Polytechnic Institute, United States

This work utilizes computational geometry methods to design controllers and actuators in spatially distributed systems governed by partial differential equations. Using earlier works on the modification of Centroidal Voronoi Tessellations (CVT), a methodology is presented that simultaneously designs the actuator and sensor locations, and the corresponding static output feedback. This approach which significantly reduces the control design complexity first assumes a virtual idealized actuator to design the optimal feedback gain. Then the modified CVT method is applied to both the virtual idealized actuator and the associated feedback kernel to obtain simultaneously both the actuator and sensor locations, respectively. Subsequently, a static feedback gain matrix is designed in order to implement a static output feedback that approximates the idealized input and optimal gain with full state information. Such a static feedback gain is found using least squares schemes. Extensive and detailed numerical studies are included to illuminate the various aspects of the proposed methodology.
Properties of tubular reactor models as a case study

Denis Dochain
UCL, Belgium

Tubular reactor models are reference models in chemical engineering. They are also very rich models with respect to distributed parameter systems. First of all they cover two classes of partial differential equations: hyperbolic with the plug flow reactor model, and parabolic with the convective-diffusive-reaction model. It may be either linear or nonlinear. The present talk will present a number of results on the analysis (observability, controllability, sensor location, stability, equilibrium multiplicity) of tubular reactor models, with a particular emphasis on the link with the well-known results in finite dimension.

Some results on the controllability of parabolic equations

Sylvain Ervedoza
Université Paul Sabatier, Toulouse, France

The goal of this talk is to present some recent results on control issues for parabolic equations. In particular, we shall present a new proof of the controllability of the heat equation in 1d yielding new results on the cost of controllability of the heat equation in 1d. If time allows, we will also explain how this can be developed to answer some time optimality issues in the context of Grushin equations.

These are joint works with Karine Beauchard and Jérémie Dardé.

Control of the motion of a fluid

Olivier Glass
Université Paris-Dauphine, France

I will describe results obtained with Thierry Horsin (Conservatoire National des Arts et Métiers, Paris), concerning the possibility of prescribing the motion of a zone of a fluid inside a domain, by means of a boundary control. This generates problems of controllability type which are actually of very different nature than usual controllability issues. We obtain results proving that prescribing this motion is indeed possible in an approximate way when the fluid is either inviscid (and modeled by the incompressible Euler equation) or very viscous (and modeled by the incompressible Euler equation).
Backstepping stabilization of linear port-Hamiltonian systems

Yann Le Gorrec
ENSMM, Besançon, France

In this work we consider the stabilization of a class of boundary controlled port-Hamiltonian systems proposed in [1, 2] with constant parameters i.e. systems described by the PDE

$$\frac{\partial x}{\partial t}(t, \zeta) = P_1 \frac{\partial}{\partial \zeta}(Lx(t, \zeta))$$

(1)

with $x \in \mathbb{R}^n$, $\zeta \in [a, b]$, $P_1 = P_1^T$ invertible, $L$ a bounded matrix such that $L = L^T$ and $L \geq \kappa I$, with $\kappa > 0$ and the input/output

$$\begin{bmatrix} u(t) \\ 0 \end{bmatrix} = \begin{bmatrix} W_{B,1} & \tilde{x}(t, 1) \\ W_{B,2} & \tilde{x}(t, 0) \end{bmatrix} \begin{bmatrix} \tilde{x}(t, 1) \\ \tilde{x}(t, 0) \end{bmatrix}, \quad y(t) = W_C \begin{bmatrix} \tilde{x}(t, 1) \\ \tilde{x}(t, 0) \end{bmatrix}.$$  

(2)

where $W_{B,1}, W_{B,2}$ and $W_C$ are matrices of appropriate dimension. For that purpose we apply the Backstepping approach proposed in [3] that consists in mapping the original system into an exponentially stable target system by an appropriate choice of reversible coordinate transformations. Contrary to the conventional approach involving Volterra integral terms, we show that for the considered class of systems a coordinate transformation with a multiplicative function suffices to exponentially stabilise the closed-loop system. This result follows from two main reasons, the port-Hamiltonian representation of the hyperbolic partial differential equation, and allowing a general class of coordinate transformation in the control synthesis. The result is illustrated on the example of a vibrating string on a 1D spatial domain.

This is joint work with H. Ramirez, A. Maccheli and H. Zwart.


Active disturbance rejection control to partial differential equations

Bao-Zhu Guo
Academy of Mathematics and Systems Science Academia Sinica, Beijing, China

Active disturbance rejection control is an emerging control technology which has been applied in engineering control for two decades. In the past few years, progresses have been made from a theoretical perspective for nonlinear systems and some stochastic systems, both on stabilization and output tracking. The generalization to partial differential equation systems is, however, complicated. In this paper, we present some recent results on stabilization of PDEs by active disturbance rejection control. Particular attention will be focused on removing the high gain restriction in design of extended state observer, the key component the active disturbance rejection control.


[3] Active disturbance rejection control: from ODEs to PDEs, Annual Reviews in Control, in press.


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**Controllability properties of the Lotka-McKendrick system**

Nicolas Hegoboru

Université de Bordeaux, France

This work considers the linear Lotka-McKendrick system from population dynamics with control active on individuals in a prescribed age range. The main results assert that given \( \tau \) large enough (but possibly smaller than the life expectancy), there exists controls driving the system to any equilibrium state or any uncontrolled trajectory in time \( \tau \). Moreover, if the initial and final states are positive then the constructed controls preserve the positivity on the whole time interval \([0, \tau]\).

This is a joint work with Pierre Magal and Marius Tucsnak.

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**Observation of a 1D wave equation on non-cylindrical domains**

Duc-Trung Hoang

Université de Bordeaux, France

We discuss properties of solutions, and various situations of exact observation and simultaneous observation of a 1D wave equation on a time-varying domain.

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**Robust Regulation of Port-Hamiltonian Systems**

Jukka-Pekka Humaloja

Tampere University of Technology, Finland

We will give sufficient conditions under which a controller achieves robust output regulation for boundary control systems, and we will give the parameter choices for a minimal order robust controller by utilizing these conditions. The controller is designed especially for impedance passive port-Hamiltonian systems.

This is joint work with Laasi Paunonen.
Input to state stability of evolution equations
Birgit Jacob
University of Wuppertal, Germany

In this talk we study the notions of input to state stability (ISS) and integral input to state stability (iISS) for boundary control systems, which are stronger notions than exponential stability of the corresponding semigroup and include stability with respect to input functions as well. It will be shown that if the semigroup is exponentially stable, then ISS is equivalent to admissibility of the input operator with respect to $L^\infty$. Further, under the assumption of exponential stability iISS is just admissibility of the input operator with respect to an Orlicz space.

Further, we prove that for parabolic diagonal systems ISS and iISS are equivalent notions.

This is joint work with Felix Schwenninger (University of Hamburg), Jonathan R. Partington (University of Leeds), Robert Nabiullin.

PDE Stabilization by Sampled-Data Control
Miroslav Krstic
University of California San Diego, United States

I present joint results with Iasson Karafyllis on the application of boundary feedback control with sampled measurements and zero-order-held inputs to 1-D linear parabolic and first-order hyperbolic PDEs with non-local terms. We show that the emulation approach based on backstepping guarantees closed-loop exponential stability, provided that the sampling period, while possibly time-varying, is sufficiently small. We also provide an emulation result for the 1980s reduced model design for parabolic systems and compare it with the result for backstepping. We also compare the backstepping emulation results for parabolic and hyperbolic PDEs and show that, for hyperbolic PDEs, a reduction in the sampling period leads to an unlimited convergence rate, which is not achievable for parabolic PDEs by changes in the sampling schedule alone. Our stability estimate for parabolic systems is in the 2-norm and for hyperbolic systems in the sup-norm.

Well-posedness of infinite-dimensional networks of hyperbolic partial differential equations
Julia Kleinhans
University of Wuppertal, Germany

We consider partial differential equations of the form
\begin{equation}
\dot{x}(t) = A\mathcal{H}x(t), \quad x(0) = x_0, \quad (3)
\end{equation}
where $A$ is a linear operator on the Hilbert space $X := L^2(0,1; H)$ given by
\begin{equation}
Ax := \left( \sum_{k=0}^{N} P_k \frac{\partial^k}{\partial \zeta^k} \right) x, \quad x \in \mathcal{D}(A) = \left\{ x \in W^{N,2}(0,1; H) \mid \hat{W}_B \Phi(x) = 0 \right\}, \quad (4)
\end{equation}
where $P_k, k = 0, \cdots, N$, linear bounded operators on a Hilbert space $H$ with $P_k^* = (-1)^{k+1}P_k$, $k = 1, \cdots, N$, $P_N$ invertible, and $\mathcal{H}(\zeta)$ is a positive operator on $H$ for a.e. $\zeta \in (0,1)$ satisfying...
$\mathcal{H}, \mathcal{H}^{-1} \in L^\infty(0,1; \mathcal{L}(H))$. This class of partial differential equations covers coupled wave and beam equations and in particular infinite networks of these equations. In order to guarantee unique solutions of equation (3), we have to impose boundary conditions:

$$\hat{W}_B(\Phi(Hx))(\cdot, t) = 0,$$

where $\hat{W}_B \in \mathcal{L}(H^N \times H^N, H^N)$ and $\Phi : W^{N,2}(0,1; H) \rightarrow H^{2N}$ is given by

$$\Phi(x) := [\Phi_1(x), \Phi_0(x)] := \left[ x(1), \ldots, \frac{d^{N-1}x}{d\zeta^{N-1}}(1), x(0), \ldots, \frac{d^{N-1}x}{d\zeta^{N-1}}(0) \right].$$

Clearly, whether or not equation (3) possesses unique and non-increasing solutions depends on the boundary condition, or equivalently on the operator $\hat{W}_B$.

In the following we will call $A$ a port-Hamiltonian operator. The main result of the paper is given in the following theorem. Let $Q \in \mathcal{L}(H^N)$ be defined by

$$Q := (Q_{ij})_{1 \leq i,j \leq N} = \begin{cases} (-1)^{i-j}P_{i+j-1} & \text{if } i+j \leq N+1 \\ 0 & \text{else,} \end{cases}$$

$$W_B := \left[ W_1 \quad W_2 \right] := \hat{W}_B \begin{bmatrix} Q & -Q \\ I & I \end{bmatrix}^{-1} \quad \text{and} \quad \Sigma := \begin{bmatrix} 0 & I \\ I & 0 \end{bmatrix} \in \mathcal{L}(H^N \times H^N).$$

**Theorem 1** Let $A$ be given by (4). Further assume $\text{ran} \ (W_1 - W_2) \subseteq \text{ran} \ (W_1 + W_2)$. TFAE:

1. The operator $A_H$ with domain $\mathcal{D}(A_H)$ generates a contraction semigroup on $(X, \langle \cdot, \cdot \rangle_H)$;
2. $\text{Re} \ \langle Ax, x \rangle \leq 0$ for every $x \in \mathcal{D}(A)$;
3. $\text{Re} \ P_0 \leq 0$, $W_1 + W_2$ is injective and $W_B \Sigma W_B^* \geq 0$;
4. $\text{Re} \ P_0 \leq 0$, $W_1 + W_2$ is injective and there exists $V \in \mathcal{L}(H)$ with $\|V\| \leq 1$ such that $W_B = \frac{1}{2}(W_1 + W_2) \left[ I + V \quad I - V \right]$;
5. $\text{Re} \ P_0 \leq 0$ and $u^*Qu - y^*Qy \leq 0$ for every $[u \ y] \in \ker \hat{W}_B$.

As a corollary we receive the well-known contraction semigroup characterization for the case of a finite-dimensional Hilbert space $H$. However, we remark that Condition 3. and 4. are even new in the finite-dimensional situation.

Furthermore, we are also able to characterize generation of the semigroups on the semi-axis for Port-Hamiltonian systems of order 1.

This is joint work with Birgit Jacob.
A reformulation of the internal model principle using factorization approach

Petteri Laakkonen
Laboratory of Mathematics, Tampere University of Technology, Finland

Frequency domain methods offer a simple way to characterize many of the fundamental results of robust regulation, e.g., the internal model principle and the parametrization of all robustly regulating controllers [5]. A number of different studies on this topic have been carried out with several stability types appearing in the related research articles, see [2, 5] and the references therein. Recently, the factorization approach has been used to study robust regulation. The strength of the results obtained is their generality since they cover the different stability types in a unifying framework. Here we present the main results of the related articles. For the sake of brevity we concentrate on the internal model principle. For single-input single-output (SISO) systems the results are presented in [3, 4] by the author and A. Quadrat, and the multi-input multi-output (MIMO) extension in [1] by the author.


Well-Posedness of Infinite-dimensional Stochastic Port-Hamiltonian Systems with Boundary Control and Observation

François Lamoline
Namur Institute for Complex Systems (naXys) and Department of Mathematics, University of Namur, Belgium

Various disturbances such as modeling inaccuracies, environment noises can occur when real plants are to be controlled. As depicted in [6], when not considered, disturbances can lead to performance degradations and non-stabilization of the controlled system. This motivates the study of stochastic dierential equations (SDEs) and stochastic control theory. Furthermore, in some practical situations, it is more convenient to have the actuators and the sensors acting on the boundary of the spatial domain, which leads to the mathematical diculty of handling unbounded control and observation operators. Due to the unboundedness it is not clear whether the state process and the observation process are well-posed. Linear boundary controlled port-Hamiltonian systems are known to be well-posed under the condition of generation of a $C_0$-semigroup in the homogeneous case, which is the simplest verication condition for PDEs. The main purpose of this work is the introduction of stochastic port-Hamiltonian systems (SPHSs) on infinite-dimensional spaces and the study of the well-posedness of this new class of systems. [3]. On nite-dimensional spaces, SPHSs were dened in [6]. To the best of the authors’ knowledge, no extension in infinite dimension with boundary control and observation is currently available in the literature.
This is joint work with J.J. Winkin (Namur Institute for Complex Systems (naXys) and Department of Mathematics, University of Namur, Belgium).


**Inverse boundary value problems for Laplace equation and holomorphic functions**

Juliette Leblond

INRIA, Nice, France

We will consider inverse Cauchy type problems for harmonic functions in dimension 2, like data transmission or geometrical issues. These are ill-posed problems that need to be regularized. The links between harmonic functions in domains of the plane and holomorphic functions of the complex variable, based on Cauchy-Riemann equations, will be used in order to recast these issues in normed Hardy spaces of holomorphic functions, as interpolation or best constrained approximation ones. In this framework, we will discuss uniqueness of the solution, smoothness and stability properties. Constructive issues will be considered as well, in order to provide robust resolution schemes, and we will show some numerical examples connected to physical applications. Generalizations to conductivity partial differential equation, yet in dimension 2, and to Laplace equation in dimension 3 will be briefly commented.

This is based on joint works with L. Baratchart, L. Bourgeois, S. Chaabane, I. Fellah, M. Jaoua, M. Mahjoub, J. R. Partington, D. Ponomarev, E. Pozzi.

**Transfer Functions of Infinite-Dimensional Systems: Positive Realness and Stabilization**

Hartmut Logemann

University of Bath, United Kingdom

We consider a general class of operator-valued irrational positive-real functions with an emphasis on their frequency-domain properties and the relation with stabilization by output feedback. Such functions arise naturally as the transfer functions of numerous infinite-dimensional control systems, including examples specified by PDEs. Our results include characterizations of positive realness in terms of imaginary axis conditions, as well as characterizations in terms of stabilizing output feedback, where both static and dynamic output feedback are considered. In particular, it is shown that stabilizability by all static output feedback operators belonging to a sector can be characterized in terms of a natural positive-real condition and, furthermore,
we derive a characterization of positive realness in terms of a mixture of imaginary axis and stabilization conditions. Finally, we introduce concepts of strict and strong positive realness, prove results which relate these notions and analyze the relationship between the strong positive realness property and stabilization by feedback. The theory is illustrated by examples, some arising from controlled and observed partial differential equations.

This is joint work with Chris Guiver and Mark Opmeer.

**Feedback Stabilization of the Incompressible Navier–Stokes Equations Coupled with a Damped Elastic System in Two Dimensions**

Debayan Maity
Université de Bordeaux

In this talk, we consider a system coupling the incompressible Navier–Stokes equations with an elastic structure governed by a damped wave equation in a two dimensional channel. The elastic structure is located at the upper boundary of the domain occupied by the fluid. The domain occupied by the fluid depends on the displacement of the elastic structure, and therefore it depends on time. We prove that this coupled system may be stabilized around the steady state zero, at any exponential decay rate, by a Dirichlet control acting in the lower boundary of the fluid domain. This is a joint work with Jean-Pierre Raymond.

**Fractional Derivatives and Diffusive Representations: Semigroup formulation, Stability issues and Engineering Applications**

Denis Matignon
Université de Toulouse & ISAE-Supaéro, France

Viscoelastic materials are often characterized by a completely monotone kernel: this gives rise to dynamical systems involving a convolution term. These systems can be treated in a quite general framework, but still, an efficient way of tackling these convolution terms is to transform them into so-called diffusive representations. The idea is to add an extra memory variable to the original system, which helps suppress the convolution term: it amounts to a kind of a realization, in the sense of systems theory. In the linear case, the analysis of such an augmented system can be performed within the framework of evolution semigroups. Eventhough some Lyapunov functional is to be found for the augmented system, LaSalle’s invariance principle can not be applied to it, since a lack of compactness is to be found in the equivalent model: hence, for the proof of asymptotic stability property, we resort to Arendt-Batty theorem.

In the second part of the talk, we will focus on the following worked-out examples, stemming from diverse engineering applications:

- the Webster-Lokshin wave equation in musical acoustics, with a fractional derivative in time. Some numerical schemes will be presented to illustrate the behaviour of these viscous systems;
- a sandwich structure composed of elastic and viscoelastic materials, described by the Zener model, including the frequency-dependence of the mechanical properties of a viscoelastic material;
• the linearised Euler equations with impedance boundary conditions which arise in aeronautics, and makes use both of fractional derivatives and time delays: so-called parabolic-hyperbolic realization will be used to study this system theoretically, and to perform numerical simulations;

• the Burgers-Lokshin equation, a non-linear fractional PDE arising in the modelling of brass instruments, whence the famous brassy effect.

Part of the talk is joint work with Ghislain Haine, from ISAE-Supaéro, and with Florian Monteghetti, Ph.D. student co-advised with E. Piot (Onera, France).

Références:
Global Stabilization of a Korteweg-de-Vries Equation with Saturating Distributed Control

Swann Marx
Gipsa-Lab Department of Automatic Control, Grenoble, France

This presentation deals with the design of saturated controls in the context of partial differential equations. It focuses on a Korteweg-de Vries equation, which is a nonlinear mathematical model of waves on shallow water surfaces. Two different types of saturated controls are considered. The stability of the closed-loop nonlinear partial differential equation is presented.

This is joint work with Eduardo Cerpa, Christophe Prieur and Vincent Andrieu.

On the boundary control of the wave equation with a potential

Sorin Micu
University of Craiova, Romania

We study the $L^2$-norm of the boundary controls for the one dimensional linear wave equation with a space variable potential $a = a(x)$. It is known that these controls depend of $a$ and their norms may increase exponentially with $\|a\|_{L^\infty}$. Our aim is to make a deeper study of this dependence in correlation with the properties of the initial data. The main result of the paper shows that the minimal $L^2$-norm controls are uniformly bounded with respect to the potential $a$, if the initial data have only sufficiently high eigenmodes. In the second part of the talk we deal with the approximation of the boundary controls of this equation by using a finite difference space semi-discrete scheme. Due to the high frequency numerical spurious oscillations, the semi-discrete model is not uniformly controllable with respect to the mesh-size and the convergence of the approximate controls corresponding to initial data in the finite energy space cannot be guaranteed. We analyze how do the initial data to be controlled and their discretization affect the result of the approximation process. We prove that the convergence of the scheme is ensured if the continuous initial data are sufficiently regular or if the highest frequencies of their discretization have been filtered out. In both cases, the minimal $L^2$-norm discrete controls are shown to be convergent to the corresponding continuous one when the mesh size tends to zero.
Some sharp Lebeau-Robbiano inequalities without Carleman estimates (a retrospect)
Luc Miller
Université Paris Ouest Nanterre, France

This mostly expository talk connects Observability estimates in Control Theory to some Duration and bandwidth limiting results in Time-Signal Analysis, and to some Uncertainty principles in Mathematical Physics. Long before the overwhelming use of Carleman estimates, the early days of the Control Theory of Parabolic PDEs were mainly based on the analysis of series of exponentials. But other aspects of Harmonic Analysis may have been overlooked, although they provide deep insight into some of the most basic examples: the interior null-controllability for the heat equation on a circle or a line.

The Lebeau-Robbiano strategy is an evermore popular tool for the control of parabolic PDEs. It starts from some stationnary inequality, which is usually a statement about sums of eigenfunctions of some elliptic operator. We write this crucial observability inequality in this (equivalent) new form: for all $\lambda > 0$, there exists $\gamma_\lambda > 0$ such that, for all "state" vector $v$ in the Hilbert space $\mathcal{E}$,

$$\gamma_\lambda \|v\|^2 \leq \| Cv\|^2 + \| R_\lambda v\|^2,$$

where $C \in \mathcal{L}(\mathcal{E})$ is an "observation" operator, and $R_\lambda \in \mathcal{L}(\mathcal{E})$ are a family of "remainder" operators (e.g. $R_\lambda$ is usually the projection on the sum of the eigenspaces, associated to eigenvalues greater than $\lambda$, of the generator of the dynamics). For the heat equation in $\mathbb{R}^d$ with a control acting outside the unit ball, this observability inequality is: for all square-summable function $f$ on $\mathbb{R}^d$,

$$\gamma_\lambda \int_{\mathbb{R}^d} | f(x) |^2 dx \leq \int_{|x|>1} | f(x) |^2 dx + \int_{|\xi|^2>\lambda} | \hat{f}(\xi) |^2 \left( \frac{d\xi}{2\pi} \right)^d,$$

where $\hat{f}(\xi) := \int f(x) e^{-ix\xi} dx$ denotes the Fourier transform.

This talk is a retrospect of some classical harmonic analysis results (by Lax, Fuchs, Landau-Pollak-Slepian, Paneah, Katsnelson, Logvinenko-Sereda, Gorin, Havin-Jöricke, Kovrijine and others) with the above inequality in sight, in particular the exponential decrease rate of $\gamma_\lambda$ as $\lambda$ tends to infinity.

Characterizations of Input-to-State Stability for Wide Classes of Control Systems
Andrii Mirchonenko
University of Passau, Germany

For ordinary differential equations (ODEs), the concept of input-to-state stability (ISS) was introduced in [7]. Since then it has become indispensable for various branches of nonlinear control theory such as robust stabilization of nonlinear systems, design of nonlinear observers, analysis of large-scale networks etc. [10]. The success of ISS theory of ODEs and the need of proper tools for robust stability analysis of partial differential equations motivated the development of ISS theory in an infinite-dimensional setting, see e.g. [6, 3, 2, 5, 1]. A fundamental role for the development of the theory of ISS for ODEs was played by characterizations of ISS in terms of Lyapunov functions [8] and in terms of asymptotic gain and local stability [9]. Such characterizations are equally important and desirable for infinite-dimensional systems. On the way of proving such general ISS criteria we face substantial difficulties: closed bounded
balls are never compact in the norm topology of infinite-dimensional normed linear spaces, nonuniformly globally asymptotically stable nonlinear systems do not need to have bounded finite-time reachability sets and even if they do, this still does not guarantee uniform global stability [4] (all these unpleasant things cannot occur for ODE systems). Because of these obstructions, the generalization of the characterizations developed by Sontag and Wang in [9] for ODE systems is a challenging task, which has been solved in [5] for local ISS and in [4] for global ISS properties. In this contribution we would like to give a brief introduction to the new concepts and results related to these generalizations. Due to the space limits we concentrate only on the main theorems and leave aside other important results.

This is joint work with Fabian R. Wirth.


The role of sensors and actuators in control of infinite-dimensional systems

Kirsten Morris
University of Waterloo, Canada

For systems modeled by partial differential equations there is generally choice in the type of actuator and sensors used and also their locations. Several examples are given to illustrate how choice and modeling of the actuators and sensors affects control system performance. Once the control hardware, that is, the actuators and sensors, are selected, performance depends not only on the controller, but also on the location of the hardware. Physical intuition does not always lead to the best choice of locations. Since it is often difficult to move hardware, and trial-and-error may not be effective when there are multiple sensors and actuators, analysis is crucial. Integrating controller design with actuator location can lead to better performance without increased controller cost. Similarly, better estimation can be obtained with carefully placed sensors. Proper placement when there are disturbances present is in general different from that appropriate for reducing the response to an initial condition, and both are different from
locations based on optimizing controllability or observability. Approximations to the governing equations, often of very high order, are required and this complicates both controller design and optimization of the hardware locations.

**Spectral inequalities and some applications**

Iván Moyano

Laboratoire Jacques-Louis Lions, Université-Pierre-et-Marie-Curie, Paris, France

The purpose of this talk is to give a brief survey on a class of functional inequalities, called spectral inequalities, originated from the seminal works of Lebeau, Robbiano, Jerison and Zuazua [4, 5]. These inequalities have a strong and deep influence in Control Theory. In the first part of the talk, we give some examples of spectral inequalities. More precisely, let \( \Omega \subset \mathbb{R}^d \) be a bounded smooth domain and consider the spectral family associated with the Dirichlet-Laplacian operator on \( \Omega \), i.e, the family \( \{\varphi_k\}_{k \in \mathbb{N}} \) satisfying

\[
-\Delta \varphi_k = \lambda_k \varphi_k \in \Omega, \quad \varphi_k = 0 \text{ on } \partial \Omega.
\]

The spectral inequality associated to this family guarantees that if \( \omega \subset \Omega \) is an open set, there exists a constant \( C = C(\omega) > 0 \) such that for any \( N > 0 \), one has

\[
\left\| \sum_{k: \lambda_k \leq N} \langle f, \varphi_k \rangle_{L^2(\Omega)} \varphi_k \right\|_{L^2(\omega)}^2 \leq e^{C(\omega)N} \left\| \sum_{k: \lambda_k \leq N} \langle f, \varphi_k \rangle_{L^2(\Omega)} \varphi_k \right\|_{L^2(\omega)}^2, \quad \forall f \in L^2(\Omega).
\]

The meaning of this inequality is that the observability of low frequencies can be achieved from the open set \( \omega \), as long as the observability constant is allowed to depend on the number of frequencies involved [4, 5]. Recently, a spectral inequality for the Laplacian operator in the whole space \( \mathbb{R}^d \) has been obtained in [3]. In the second part of the talk, we give some applications of such inequalities in different contexts, such as the controllability of parabolic equations [4], controllability of kinetic equations [3, 2, 7], singular limits of the damped wave equation [6] or observability properties from measurable sets [1].

References:


Infinite-dimensional input-to-state stability and Orlicz spaces
Robert Nabiullin
University of Wuppertal, Germany

In this talk, the relation between input-to-state stability and integral input-to-state stability is studied for linear infinite-dimensional systems with an unbounded control operator. Although a special focus is laid on the case $L^\infty$, general function spaces are considered for the inputs. We show that integral input-to-state stability can be characterized in terms of input-to-state stability with respect to Orlicz spaces. Since we consider linear systems, the results can also be formulated in terms of admissibility. For parabolic diagonal systems with scalar inputs, both stability notions with respect to $L^\infty$ are equivalent.

This is joint work with Birgit Jacob, Jonathan R. Partington and Felix L. Schwenninger.

Robust output regulation of regular linear systems
Lassi Paunonen
Tampere University of Technology, Finland

We study the control of infinite-dimensional linear systems of the form
\begin{align}
\dot{x}(t) &= Ax(t) + Bu(t) + B_d w_{\text{dist}}(t) \quad x(0) = x_0 \in X \\
y(t) &= C_\Lambda x(t) + Du(t)
\end{align}

on a Banach space $X$. The main goal in output regulation is to choose the input $u(t)$ of the system in such a way that the output $y(t)$ converges asymptotically (as $t \to \infty$) to a given reference signal $y_{\text{ref}}(t)$ despite the external disturbance signals $w_{\text{dist}}(t)$. In robust output regulation the same control law must achieve the convergence of the output even if the operators $(A, B, B_d, C, D)$ of the system experience perturbations or contain uncertainties.

In this presentation we introduce new results in the theory of robust output regulation for regular linear systems. In particular, we present robust error feedback controllers for different classes of systems \[5\] and signals $y_{\text{ref}}(t)$ and $w_{\text{dist}}(t)$ \[3\]. The constructions are based on the internal model principle \[2\] that characterises the controllers solving the robust output regulation problem.

We also discuss the challenges and limitations of achieving asymptotically accurate output tracking of nonsmooth periodic reference signals. One of the consequences of nonsmooth signals $y_{\text{ref}}(t)$ and $w_{\text{dist}}(t)$ is that exponential stability of the closed-loop system consisting of the system \[5\] and the error feedback controller becomes unachievable outside special situations. In this presentation we analyse non-uniform and polynomial stability \[1\] of the closed-loop system, and derive rational convergence rates for the output to the reference signal.


Some parameter identifiability problems linked to structured models in population dynamics
Antoine Perrasso
University Bourgogne Franche-Comté, France

Given a parametric dynamical system, the question of parameter identifiability consists in studying if the parameter to output map is into. If there are several theoretical approaches to deal with this problem in the case of ODE systems (system equivalence, Taylor series expansions, algebro-differential elimination method...), few effective methods relate to transport PDE systems in structured population dynamics. In this talk, we address two examples of parameter identifiability study linked to structured PDE models: the von Foerster-McKendrick equation and an age and infection load-structured epidemic model.

Optimal control of resources for species survival
Yannick Privat
Laboratoire Jacques-Louis Lions, Université Pierre et Marie Curie, Paris, France

In this work, we are interested in the analysis of optimal resources configurations (typically foodstuff) necessary for a species to survive. For that purpose, we use a logistic equation to model the evolution of population density involving a term standing for the heterogeneous spreading (in space) of resources.

The principal issue investigated in this talk writes:
How to spread in an optimal way resources in a closed habitat?

This problem can be recast as the one of minimizing the principal eigenvalue of an operator with respect to the domain occupied by resources, under a volume constraint. By using symmetrization techniques, as well as necessary optimality conditions, we prove new qualitative results on the solutions. In particular, we investigate the optimality of balls.

This is a joint work with Jimmy Lamboley (univ. Paris Dauphine), Antoine Laurain (univ. Sao Paulo) and Grégoire Nadin (univ. Paris 6).

A survey on analysis for Dirichlet series
Kristian Seip
NTNU, Norway

We have in recent years seen a notable growth of interest in certain functional analytic aspects of the theory of ordinary Dirichlet series

\[
\sum_{n=1}^{\infty} a_n n^{-s}.
\]

Inspired by the classical theory of Hardy spaces and the operators acting on such spaces, this topic is also intertwined with analytic number theory and function theory on the infinite dimensional torus. Of particular interest are problems that involve an interplay between the additive and multiplicative structure of the integers, in this context embodied respectively by function theory in half-planes and the so-called Bohr lift that transforms Dirichlet series into functions of infinitely many complex variables.
In this survey talk, I will present some highlights from the function theory of Hardy spaces of Dirichlet series and outline some aspects of the operator theory that has been developed for these spaces, with special attention paid to topics of possible interest to control theorists, such as for example completeness and basis properties of systems of dilated functions and multiplicative Hankel operators.

**On the relation of $L^\infty$-admissibility and $H^\infty$-calculus**

Felix Schwenninger
University of Hamburg, Germany

We present a result linking a version of the Weiss conjecture for $L^\infty$ to the boundedness of the $H^\infty$-calculus for analytic semigroup generators $A$. This is motivated by questions in the recent developments in the study of input-to-state stability for linear, infinite-dimensional systems. We show that if $A$ has a bounded calculus, then the notions of input-to-state stability and integral-input-to-state stability coincide.

This is joint work with Birgit Jacob and Hans Zwart.

**Local controllability to trajectories of a one dimensional model of turbulence**

Takéo Takahashi
INRIA, Nancy, France

We study the local controllability to trajectories of a one dimensional model for turbulence. By linearization we are led to an equation with a non local term whose controllability properties are analyzed by using Fourier decomposition and biorthogonal techniques. Once the existence of controls is proved and the dependence of their norms with respect to the time is established for the linearized model, a fixed point method allows us to deduce the result for the nonlinear initial problem.

**$L^p$-tauberian theorems and energy decay**

Yuri Tomilov
IM PAN, Warsaw, Poland

We present several tauberian theorems for $L^p$-functions equipped with (optimal) convergence rates in an $L^p$-sense. We then show how the developed tauberian theory leads to genuinely properties of energy decay in the setting of damped wave equations. We finish with a discussion of several very recent extensions of the results above.

This is joint work with C. Batty (Oxford) and A. Borichev (Marseille).
In this talk, we study the compensation of an unstable (ODE or PDE) system interconnected with a dynamically stable PDE system. The output of the unstable system is fed into the stable PDE system, and, in turn, the output of the dynamically stable PDE system is fed into the unstable system. The remarkable feature of the whole coupled system is that the derivative in time of the whole energy function is only related the stable PDE. The goal of our study is to compensate the unstable system by using the output of the stable PDE system directly. It is shown that, with suitable interconnections between two subsystems, some unstable ODE/PDEs can be stabilized by the dynamically stable PDE. Some examples of ODE-PDE, hyperbolic-parabolic, and hyperbolic-hyperbolic systems are presented.

Deterministic models are developed for the spatial spread of epidemic diseases in geographical settings. The models are focused on outbreaks that arise from a small number of infected hosts imported into subregions of the geographical settings. The goal is to understand how spatial heterogeneity influences the dynamics of the susceptible and infected populations. The models consist of systems of partial differential equations with diffusion terms describing the spatial spread of the underlying microbial infectious agents. Applications are given to recent influenza, zika, and dengue epidemics in Puerto Rico.

In this research we are concerned with a switched system that switches very fast between two infinite-dimensional LTI subsystems, when the overall system spends on average an equal amount of time in both possible subsystems. We ask if it is possible to approximate the switched system with an average system that is the limit of our switched system when the time between switchings tends to zero. We are mainly concerned with the situation when both systems are described by a contraction semigroup on a Hilbert space. We are in particular interested in the situation when both subsystems are obtained from a basic subsystem via different output feedback operators.

This is joint work with Hua-Cheng Zhou and Jian-Hua Chen.
The stochastic NLS and Littlewood-Paley Theory
Lutz Weis
Karlsruhe Institute of Technology, Germany

We consider a stochastic nonlinear Schrödinger equation with multiplicative noise in an abstract framework that covers subcritical focusing and defocusing SNLS in $H^1$ on compact manifolds and bounded domains. We construct a martingale solution using a modified Faedo-Galerkin-method based on the Littlewood-Paley-decomposition. In the case of 2d and 3d manifolds with bounded geometry, we use Strichartz estimates to show pathwise uniqueness.

This is joint work with Z. Brzezniak and F. Hornung.

Boundary Feedback Control of Linear Hyperbolic Systems
Joseph J. Winkin
University of Namur, Belgium

We consider distributed parameter systems that are modeled by hyperbolic partial differential equations which include a source term and hetero-directional velocities. It is reported that a specific boundary control problem for such systems is well-posed (in the sense of Tucsnak and Weiss), under appropriate assumptions coupling the boundary conditions and the source term. By means of operator theory, a sufficient condition of exponential stability is established, which is connected to classical Lyapunov function based sufficient conditions for stability analysis and boundary stabilization. The obtained sufficient exponential stability condition is used to design output feedback boundary controllers for hyperbolic systems of balance laws. More specifically, it is applied to the Saint-Venant-Exner equation describing the dynamics of the water level, the water flow and the sediment inside a channel. The effect of the friction and of the slope are taken into account in the application model. The results reported in this talk have been obtained jointly with Christophe Prieur (Univ. Grenoble Alpes, CNRS, Gipsa-lab, F-38000 Grenoble, France).


Admissibility results for retarded delay systems
Radoslaw Zawiski
University of Leeds, United Kingdom

We investigate admissibility conditions for a Hilbert space dynamical system of the form $z'(t) = Az(t) + A_1 z(t-\tau) + Bu(t)$, where $A$ generates a semigroup of contractions and $A_1$ is a bounded operator. Our approach is perturbation-based.

This is joint work with J.R. Partington.
Controllability under constraints
Enrique Zuazua
DeustoTech-Bilbao, UAM-Madrid, Spain and LJLL-Paris, France

The free heat equation is well known to preserve the non-negativity of solutions. On the other hand, due to the infinite velocity of propagation, the heat equation is null-controllable in an arbitrary small time interval. The following question then arises naturally: Can the heat dynamics be controlled under a positivity constraint on the state, requiring that the state remains non-negative all along the time dependent trajectory? We will show that, if the control time is large enough, constrained controllability holds. We will also show that it fails to be true if the control time is too short. In other words, despite of the infinite velocity of propagation, under the natural positivity constraint on the state, controllability fails when the time horizon is too short. Links with other related topics such as finite-dimensional systems, sparse control and the turnpike property will also be discussed.

This presentation is based on joint work with Jérôme Lohéac and Emmanuel Trélat.

Port-Hamiltonian Differential-Algebraic Equations
Hans Zwart
University of Twente, Netherlands

Differential-algebraic equations occur naturally during modelling. Also port-Hamiltonian systems occur naturally when deriving models. Hence a combined port-Hamiltian differential algebraic is also seen quite often in modelling. However, for systems described by partial differential equations, this class has hardly been studied. In this presentation we concentrate on homogeneous systems, but extension to systems with input and outputs are easily made. We begin by showing how these models may appear. Furthermore, we study the existence of solution for the following abstract differential equation

\[ E \dot{x}(t) = AQx(t), \quad x(0) = x_0, \]

where \( E \) and \( Q \) are block diagonal operators, and \( A \) generates a contraction semigroup on \( X = X_1 \oplus X_2 \oplus X_3 \). The kernel of \( E \) is \( X_3 \) and \( X_2 \) is the kernel of \( Q \). Furthermore, we assume that there exists a \( s \) such that \( sE - AQ \) is boundedly invertible. Under the above assumptions we show that the resulting differential equation for \( x_1 \) gives a contraction semigroup on \( X_1 \). We close the presentation with many examples, of which some are not generally written as Differential-algebraic equations.

This work is joint work with Volker Mehrmann.
Phone numbers

Medical - Emergency

SOS Médecin: 05-56-44-74-74
Pharmacie des Capucins (open 24h/24): 05-56-91-62-66
Police: 17
Ambulance / SAMU: 15

Taxi stand

Talence: 06-17-82-34-34
Bordeaux: 06-09-34-02-48
Victoire: 05-56-91-47-05
Gare: 05 56 91 48 11

Other

Airport: 05 56 34 50 50
Train station: 36 35
Directions and Maps

Bordeaux and its surrounding communities have a fairly good system of public transportation (TBM). Please see the transportation network website (http://www.infotbm.com/); the site is also available in English, though the English version seems somewhat truncated. Google Maps’ website: (https://www.google.fr) If you need to purchase tickets yourself, be informed that you can buy them either from the bus driver (but not the tram one!) or at automatic distributor machines at tram stops. The tickets are valid for one hour since the first obliteration and they should be validated every time you take a bus or a tram. The conference takes place at the city campus of University of Bordeaux, situated at Place de la Victoire:
Coffee breaks, lunch and registration take place in the main entrance hall. The poster session is scheduled in the same place in the hall. The lectures will take place on the 3rd floor of the Building E (amphi E), as well as 3rd floor of building A for the parallel sessions (amphi Durkheim).
Hotel to University ("Place de la Victoire")

- Hôtel Teneo Talence
  Take Tram line B (Direction “Berges de la Garonne” or ”La Cité du Vin”) from “Forum” to ”Victoire”.

- Hotel “Victoria Garden”
  The way from the hotel to the University takes approximately 10 min.; please walk to Victoire square by “Cours de la Somme”.

- Appart City
  Take Tram line A (Direction “Floriac”), from stop “Gaviniès” to stop “Hotel de Ville”. Then take tram line B (Direction “Pessac Centre” or ”France Alouette”) from “Hotel de Ville” to “Victoire”.
• **Hôtel Clemenceau, Coeur de city**

The way from the hotel to the University takes approximately 10 min.; please walk to Gambetta square and take the Tram Line B (Direction “Pessac Centre” or ”France Alouette”) and stop at “Victoire”.
Gala: Social Events

- **Tuesday, July 4th**: Bordeaux Wine City - Visit and tasting (optional: 10 Euros/person) at 19h15 (7:15 PM).
  Take the Tram B (direction “Berges de la Garonne” or “La Cité du Vin”). Stop at “Cité du Vin”.

- **Wednesday, July 5th**: Excursion - Dune de Pyla & Oyster tasting (Free). 13h15 (1:15 PM): appointment in the hall of the university.
- **Tuesday, July 6th**: Conference Dinner: Cité Mondiale (Hotel Mercure) at 19h30 (7:30 PM).
  Take Tram B direction "Berges de la Garonne" or "La Cité du Vin" and stop at "CAPC Musée d’Art Contemporain".
Participants

- Achache Mahdi
- Achouri Zineb
- Ainseba Bedreddine
- Anita Sebastian
- Arendt Wolfgang
- Avdonin Sergei
- Banks H. Thomas
- Belkhatir Zehor
- Ben Aissa Akram
- Berbiche Mohamed
- Biccari Umberto
- De Teresa Luz
- Demetriou Michael
- Dochain Denis
- Ervedoza Sylvain
- Geshkovski Borjan
- Glass Olivier
- Guo Bao-Zhu
- Guo Wei
- Haak Bernhard
- Hartmann Andreas
- Hegoburu Nicolas
- Hernandez Esteban
- Hoang Duc Trung
- Hu Weiwei
- Humaloja Jukka-Pekka
- Ibanez Aitziber
- Jacob Birgit
- Kadai Ali Shegher
- Kellay Karim
- Kleinhaus Julia
- Kolumban Jozsef
- Krstic Miroslav
- Laakkonen Petteri
- Laasri Hafida
- Laleg Meriem
- Lamoline François
- Le Gorrec Yann
- Leblond Juliette
- Lissy Pierre
- Logemann Hartmut
- Magal Pierre
- Maity Debayan
- Marx Swann
- Matignon Denis
- Micu Sorin
- Miller Luc
- Mironchenko Andrii
- Nabiullin Robert
- Ouhabaz El Maati
- Paunonen Lassi
- Perasso Antoine
- Phan Duc Duy
- Pighin Dario
- Privat Yannick
- Rodriguez Charlotte
- Schmid Jochen
- Schwenninger Felix
- Seip Kristian
- Sueur Franck
- Takahashi Takeo
- Tomilov Yuri
- Tucsnak Marius
- Wang Junmin
- Webb Glenn
- Weis Lutz
- Weiss George
- Winkin Joseph
- Zawiski Radoslaw
- Zuazua Enrique
- Zwart Hans
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