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Activity Report 2018

Project-Team DISCO

Dynamical Interconnected Systems in COmplex Environments

IN COLLABORATION WITH: Laboratoire des signaux et systèmes (L2S)

RESEARCH CENTER
Saclay - Île-de-France

THEME
Optimization and control of dynamic systems

Table of contents

Project-Team DISCO

Creation of the Team: 2010 January 01, updated into Project-Team: 2012 January 01

Keywords:

Computer Science and Digital Science:

A3.4.4. - Optimization and learning
A3.4.5. - Bayesian methods
A6.1.1. - Continuous Modeling (PDE, ODE)
A6.1.3. - Discrete Modeling (multi-agent, people centered)
A6.4.1. - Deterministic control
A6.4.3. - Observability and Controlability
A6.4.4. - Stability and Stabilization

Other Research Topics and Application Domains:

B2.2.3. - Cancer
B2.3. - Epidemiology
B3.6. - Ecology
B4.3.3. - Wind energy
B4.4. - Energy delivery
B5.2.3. - Aviation
B7.2.1. - Smart vehicles

1. Team, Visitors, External Collaborators

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2. Overall Objectives

2.1. Objectives

The goal of the project is to better understand and well formalize the effects of complex environments on the dynamics of the interconnections, as well as to develop new methods and techniques for the analysis and control of such systems.

It is well-known that the interconnection of dynamic systems has as consequence an increased complexity of the behavior of the total system.

In a simplified way, as the concept of dynamics is well-understood, the interconnections can be seen as associations (by connections of materials or information flows) of distinct systems to ensure a pooling of the resources with the aim of obtaining a better operation with the constraint of continuity of the service in the event of a fault. In this context, the environment can be seen as a collection of elements, structures or systems, natural or artificial constituting the neighborhood of a given system. The development of interactive games through communication networks, control from distance (e.g. remote surgical operations) or in hostile environment (e.g. robots, drones), as well as the current trend of large scale integration of distribution (and/or transport and/or decision) and open information systems with systems of production, lead to new modeling schemes in problems where the dynamics of the environment have to be taken into account.

In order to tackle the control problems arising in the above examples, the team investigates new theoretical methods, develops new algorithms and implementations dedicated to these techniques.

3. Research Program

3.1. Analysis of interconnected systems

The major questions considered are those of the characterization of the stability (also including the problems of sensitivity compared to the variations of the parameters) and the determination of stabilizing controllers of interconnected dynamic systems. In many situations, the dynamics of the interconnections can be naturally modelled by systems with delays (constant, distributed or time-varying delays) possibly of fractional order. In other cases, partial differential equations (PDE) models can be better represented or approximated by using systems with delays. Our expertise on this subject, on both time and frequency domain methods, allows us to challenge difficult problems (e.g. systems with an infinite number of unstable poles).

- Robust stability of linear systems

  Within an interconnection context, lots of phenomena are modelled directly or after an approximation by delay systems. These systems may have constant delays, time-varying delays, distributed delays ...

For various infinite-dimensional systems, particularly delay and fractional systems, input-output and time-domain methods are jointly developed in the team to characterize stability. This research is developed at four levels: analytic approaches (H_∞-stability, BIBO-stablity, robust stability, robustness metrics) [1], [2], [5], [6], symbolic computation approaches (SOS methods are used for determining easy-to-check conditions which guarantee that the poles of a given linear system are not in the closed right half-plane, certified CAD techniques), numerical approaches (root-loci, continuation methods) and by means of softwares developed in the team [5], [6].

- Robustness/fragility of biological systems

  Deterministic biological models describing, for instance, species interactions, are frequently composed of equations with important disturbances and poorly known parameters. To evaluate the impact of the uncertainties, we use the techniques of designing of global strict Lyapunov functions or functional developed in the team.

  However, for other biological systems, the notion of robustness may be different and this question is still in its infancy (see, e.g. [65]). Unlike engineering problems where a major issue is to maintain stability in the presence of disturbances, a main issue here is to maintain the system response in the presence of disturbances. For instance, a biological network is required to keep its functioning in case of a failure of one of the nodes in the network. The team, which has a strong expertise in robustness for engineering problems, aims at contributing at the develpment of new robustness metrics in this biological context.

3.2. Stabilization of interconnected systems

- Linear systems: Analytic and algebraic approaches are considered for infinite-dimensional linear systems studied within the input-output framework.

  In the recent years, the Youla-Kučera parametrization (which gives the set of all stabilizing controllers of a system in terms of its coprime factorizations) has been the cornerstone of the success of the H_∞-control since this parametrization allows one to rewrite the problem of finding the optimal stabilizing controllers for a certain norm such as H_∞ or H_2 as affine, and thus, convex problem.

  A central issue studied in the team is the computation of such factorizations for a given infinite-dimensional linear system as well as establishing the links between stabilizability of a system for a certain norm and the existence of coprime factorizations for this system. These questions are fundamental for robust stabilization problems [1], [2].

  We also consider simultaneous stabilization since it plays an important role in the study of reliable stabilization, i.e. in the design of controllers which stabilize a finite family of plants describing a system during normal operating conditions and various failed modes (e.g. loss of sensors or actuators, changes in operating points). Moreover, we investigate strongly stabilizable systems, namely systems which can be stabilized by stable controllers, since they have a good ability to track reference inputs and, in practice, engineers are reluctant to use unstable controllers especially when the system is stable.
- Nonlinear systems

  The project aims at developing robust stabilization theory and methods for important classes of nonlinear systems that ensure good controllerperformance under uncertainty and time delays. The main techniques include techniques called backstepping and forwarding, contructions of strict Lyapunov functions through so-called "strictification" approaches [3] and construction of Lyapunov-Krasovskii functionals [4], [5], [6].
- Predictive control

  For highly complex systems described in the time-domain and which are submitted to constraints, predictive control seems to be well-adapted. This model based control method (MPC: Model Predictive Control) is founded on the determination of an optimal control sequence over a receding horizon. Due to its formulation in the time-domain, it is an effective tool for handling constraints and uncertainties which can be explicitly taken into account in the synthesis procedure [7]. The team considers how mutiparametric optimization can help to reduce the computational load of this method, allowing its effective use on real world constrained problems.

The team also investigates stochastic optimization methods such as genetic algorithm, particle swarm optimization or ant colony [8] as they can be used to optimize any criterion and constraint whatever their mathematical structure is. The developed methodologies can be used by non specialists.

3.3. Synthesis of reduced complexity controllers

- PID controllers

  Even though the synthesis of control laws of a given complexity is not a new problem, it is still open, even for finite-dimensional linear systems. Our purpose is to search for good families of “simple” (e.g. low order) controllers for infinite-dimensional dynamical systems. Within our approach, PID candidates are first considered in the team [2], [67].

- Predictive control

  The synthesis of predictive control laws is concerned with the solution of multiparametric optimization problems. Reduced order controller constraints can be viewed as non convex constraints in the synthesis procedure. Such constraints can be taken into account with stochastic algorithms.

Finally, the development of algorithms based on both symbolic computation and numerical methods, and their implementations in dedicated Scilab/Matlab/Maple toolboxes are important issues in the project.

4. Application Domains

4.1. Analysis and Control of life sciences systems

The team is involved in life sciences applications. The two main lines are the analysis of bioreactors models and the modeling of cell dynamics in Acute Myeloblastic Leukemias (AML) in collaboration with St Antoine Hospital in Paris. A recent new subject is the modelling of Dengue epidemics.

4.2. Energy Management

The team is interested in Energy management and considers optimization and control problems in energy networks.

5. New Software and Platforms

5.1. FEMMES

KEYWORD: Linear system
FUNCTIONAL DESCRIPTION: The Software FEMMES makes it possible to perform simulations for observers which converge to the exact value of the solutions of a studied system in finite time. The considered systems are linear continuous-time time-invariant systems.

- Partner: Inria
- Contact: Frédéric Mazenc

6. New Results

6.1. Spectral abscissa characterization for Time-delay systems

Participants: Islam Boussaada, Silviu-Iulian Niculescu, Sami Tliba [Université Paris Sud], Thomas Vyhlidal [Czech technical university in Prague], Karim Trabelsi [IPSA].

It is well known that the spectral abscissa of a given dynamical is nothing but the corresponding solutions' exponential decay. The analytical characterization of the spectral abscissa for infinite dimensional dynamical systems is an old problem which is still nowadays a question of ongoing interest due to its links with stability problems. We produced several works in this topic dealing with reduced order retarded Time-delay systems and emphasized a property that we call *multiplicity induced-dominancy*. In the paper [13], the interest of using time-delay in the controller design as a control parameter is underlined and the way to assign a dominant spectral value is demonstrated. As a matter of fact, it is shown that the multiplicity of given spectral value may reach the degree of the corresponding quasipolynomial. Furthermore, when this holds, then using a particular factorization of the quasipolynomial, such a multiple spectral value is shown to be the corresponding spectral abscissa. A generalization of such a result to generic second order retarded equation with a single delay is established in [12]. More precisely, a parametric characterization of the spectral abscissa is established using the principle argument theorem. Furthermore, in the work [45], the potential applicability of such a parametric characterization in controller design in concrete application is demonstrated. As a matter of fact, a third order retarded system modeling the dynamics of Mach number in a wind tunnel is considered and a delayed controller design based on the spectral abscissa assignment is proposed.

6.2. Poles placement for reduced order Time-delay systems

Participants: Souad Amrane [University Mouloud Mammeri], Islam Boussaada, Fazia Bedouhen [University Mouloud Mammeri], Silviu-Iulian Niculescu, Matej Kure [Czech technical university in Prague], Wim Michiels [KU Leuven], Thomas Vyhlidal [Czech technical university in Prague].

It is well known in dynamical system theory that real spectral values correspond to non oscillating solutions. In the paper [11]we made a connexion between the degree of a given quasipolynomial and the admissible number of non oscillating modes for the corresponding Time-delay system. More precisely, we have shown that the assignment of at most n real spectral values is possible for generic quasipolynomial function of degree n. Namely, explicit formulas on the quasipolynomial's coefficients guaranteeing the coexistence of n negative spectral values are obtained. Furthermore, a new quasipolynomial factorization technique, analogous to the one we developed for multiple spectral values for the proof of the dominancy of n distinct negative spectral values is obtained.

In the paper [23] a robust alternative of the delayed resonator is proposed by spectral approach where a double root assignment at the excitation frequency is proposed. Such an excitation frequency is projected to widening the stop-band in the active absorber frequency response. It is shown that the performance sensitivity to the mismatch between the design and true excitation frequency is considerably decreased. Additionally, the overall scheme is supplemented by a control loop which improves the stability margin.

6.3. Asymptotic behavior of critical imaginary roots for retarded differential equations

Participants: Islam Boussaada, Jie Chen [City University of Hong Kong], Liana Felix [Universidad Autonoma de San Luis Potosi], Keqin Gu [Southern Illinois University], Fernando Mendez-Barrios [Universidad Autonoma de San Luis Potosi], Dina Irofti, Silviu-Iulian Niculescu, Alejandro Martinez.

The behavior of characteristic roots of time-delay systems, when the delay is subject to small variations is investigated in [26]. We performed an analysis by means of the Weierstrass polynomial which are employed to study the stability behavior of the characteristic roots with respect to small variations on parameters. Analytic description and splitting properties of the Puiseux series expansions of critical roots are characterized by allowing a full description covering all the cases that can be encountered.

In the paper [21] the migration of double imaginary roots of the systems characteristic equation when two parameters are subjected to small deviations is geometrically investigated. Under the least degeneracy assumptions, the local stability crossing curve is shown to have a cusp at the point that corresponds to the double root, which divides the neighborhood of this point into two sectors (called S-sector and a G-sector). We have shown that when the parameters move into the G-sector, one of the roots moves to the right half-plane, and the other moves to the left half-plane. However, when the parameters move into the S-sector, both roots move either to the left half-plane or the right half-plane depending on the sign of a quantity that depends on the characteristic function and its derivatives up to the third order.

6.4. Stability analysis of retarded differential equations with delay-dependent coefficients

Participants: Islam Boussaada, Silviu-Iulian Niculescu, Chi Jin [IPSA], Keqin Gu [Southern Illinois University].

Retarded dynamical systems with delay dependent coefficients is a class of systems which is frequently encountered in various scientific and engineering applications. The paper [36] provides an overview of the stability analysis of such systems which generalizes those on systems with delay-independent coefficients. Methods of analysis for systems with a single delay and commensurate delays are presented, their application to output feedback control and a geometric perspective that establishes a link between systems with and without delay-dependent coefficients.

The paper [22] presents a systematic method to analyse the stability of systems with single delay in which the coefficient polynomials of the characteristic equation depend on the delay. With respect to the literature on the topic, a less restrictive method to analyse stability is presented. It is found that a much richer behavior is possible when the restrictive assumptions are removed. The interval of interest for the delay is partitioned into subintervals so that the magnitude condition generates a fixed number of frequencies as functions of the delay within each subinterval. The crossing conditions are expressed in a general form, and a simplified derivation for the first-order derivative criterion is obtained.

6.5. Stability and Stabilisability Through Envelopes for Retarded and Neutral Time-Delay Systems

Participants: Catherine Bonnet, Caetano Cardeliquio, Silviu Niculescu, André Fioravanti [FEM-UNICAMP, Brazil].

Through an LMI approach it was possible to determine envelopes and use them not only to study stability but to design robust controllers for retarded and neutral time-delay systems. The controller designed is robust to parametric uncertainties and can guarantee delay independant stability or delay-dependant $\alpha - stability$ [46].

6.6. Some remarks on the Walton and Marshall method for neutral delay systems

Participants: Catherine Bonnet, Islam Boussaada, Le Ha Vy Nguyen, Marianne Souaiby.

The Walton and Marshall method allows to determine stability windows of delay systems of the retarded and neutral type. We noticed that some delay systems of the neutral type do not behave as claimed in [66] and analyzed carefully the position of the poles of such systems in the right half-plane.

6.7. Local Analysis of Lurie Systems

Participants: Elena Panteley [L2S,CNRS], Stephen Duncan [University of Oxford], Thomas Lathuiliere [University of Oxford], Giorgio Valmorbida.

An important aspect of nonlinear systems is the fact that stability might only be a local property. This means that associated to a stable equilibrium point or periodic trajectory, there is a region of attraction. Such a region is formed by points of trajectories converging to the stable sets. An important task of practical interest is then to estimate these regions via numerical methods that rely on the model of the system. As an illustration, it might be of interest to know the region of safe operation of an electric motor in order to preserve its integrity or, in the case of an autonomous vehicle, limit the operating condition for safety purposes.

For the particular class of Lurie systems, namely systems defined by the interconnection of a linear system and a static nonlinearity, it is possible to compute estimates based on sector inequalities characterizing the nonlinearities in the system. If further information, such as the slope of the nonlinearity is available, one can better characterize local properties such as regions of stability, and input-output relations such as reachable sets and local nonlinear gains.

To obtain these characterizations we rely on numerical methods based on convex optimization. These methods are based on the solution of Lyapunov inequalities yielding Lyapunov functions that are quadratic on both the states and the nonlinearity and has an integral term on the nonlinearity [39].

Moreover, whenever a more precise characterization of the nonlinearity is at hand as for instance nonlinearities having rational Jacobian, one can generalize the local analysis methods using polynomial optimization. This includes the case of standard Lurie systems by considering the interconnection of a polynomial system with static sector nonlinearities that have rational Jacobian. In this setting we have proposed conditions that relax the requirement on the candidate Lyapunov function [17], which serve as stability certificates, from being sum-of-squares of polynomial with respect to the nonlinearities and the Lurie-Postnikov terms from being non-negative.

Further to the stability analysis we were interested in another important phenomenon and its analysis through numerical methods : the existence of limit cycles on nonlinear systems. Such a phenomenon is relevant since it can be used as a method to design stable oscillators with known amplitude and frequency but also to evaluate and suppress undesirable oscillations in engineered systems. In order to proceed with this analysis we have limited our attention to a particular class of systems defined by a Liénard systems and formulate sufficient conditions for existence and uniqueness of limit cycles for systems with a non-differentiable vector field. As an application we consider the example of a linear system with saturation [24]. Moreover, for planar saturating systems we present sufficient conditions for the existence of periodic orbits and we characterize inner and outer sets bounding the periodic orbits. A method to build these bounds, based on the solution to a convex optimization problem is proposed and numerical examples optimizing the region bounding the limit cycle illustrate the technique [25].

6.8. New advances on backstepping

Participants: Frederic Mazenc, Michael Malisoff [LSU], Laurent Burlion [ONERA Toulouse], Jerome Weston [LSU].

We worked on the problem of improving a fundamental control design technique for nonlinear systems called backstepping by using a fundamentally new approach which consists in introducing in the control artificial delays or using dynamic extensions.

In [28], we provided backstepping results for a large class of partially linear systems with an arbitrarily large number of integrators. We proposed control laws whose size respects some constaints given a priori. The key tool is a dynamic extension that contains only one artificial delay, which is in sharp contrast with our prior contributions. We also showed that the closed-loop system is robust, in the input-to-state stability sense, with respect to a large class of model uncertainties, and robust with respect to delays in the measurements. We illustrated the result using an example that is beyond the scope of classical backstepping.

The paper [57] also provides a crucial backstepping result. We explained how globally asymptotically stabilizing output feedbacks can be constructed for a family of nonlinear systems using only a dynamic extension and a "Converging Input-Converging State" assumption and no additional delays. The technique presents several advantages. It provides control laws whose expressions are simple. It makes it possible to stabilize systems in the presence of uncertain terms, which are not necessarily of class C^1 and which prevent the use of the classical backstepping technique. It applies in cases where only part of the state variables can be measured.

6.9. Time-varying systems with delay and Switched Systems

Participants: Frederic Mazenc, Michael Malisoff [LSU], Saeed Ahmed [Inria], Hitay Ozbay [Blikent University, Turkey].

The family of the switched systems is frequently encountered in practice. It can be used to approximate time-varying systems to ease their stability analysis or control.

In [29] we provided theoretical results for the stability and robustness analysis of nonlinear switched time-varying systems with uncertainties and time-varying delays. The delays are allowed to be discontinuous and arbitrarily long with known upper bounds. We established the results via an adaptation of Halanay's inequality and a trajectory based technique. Also, we used the results for designing switched controllers that stabilize linear time-varying systems with time-varying delays.

The contribution [10] proposed a new technique of construction of observers making possible to stabilize by output feedback a class of continuous-time switched linear systems with a time-varying delay in the output. The motivation of this paper is strong: frequently measurements are affected by pointwise time-varying delays. For stability analysis, we developped an extension of the trajectory based approach. A stability condition is given in terms of the upper bound on the time-varying delay to ensure global exponential stability of the switched feedback systems. It is worth observing that the main result applies in cases where some of the subsystems of the switched system are not stabilizable and not detectable.

The paper [27] is also devoted to classes of nonlinear time-varying continuous-time systems with outputs. For a first family of systems, we builded an observer in the case where a state dependent disturbance affects the linear approximation. A fundamental feature of our observer is the fact that it converges after a predetermined finite time. When the disturbances are the zero functions, it provides exact values of the state and it provides an approximate estimate when there are nonzero disturbances. We used this construction to design a globally exponentially stabilizing dynamic output feedback for a second family of nonlinear systems whose outputs are only available on some finite time intervals. Our technique consists in switching between control laws. We applied the control design to the controlled Mathieu equation, which arises in the study of vibrations of an elliptic membrane.

The paper [38] is devoted to a stability analysis for a class of nonlinear systems with a time-varying delay taking both large and small values in an alternating manner, precluding the application of most of the classical control design techniques. The type of assumption we imposed is the following: we imposed on the delay to be "small" on "long" time intervals and possibly "large" on "small" time-intervals. Bearing in mind this key property, we first introduced the concept of delay-hybrid-dependent stability, which grasps the features of the delays described above and represented the studied system as a system with a switched delay. Then by using switching techniques and Lyapunov-Krasovskii functionals (LKFs), we provided a new stability criterion.

6.10. Observers

Participants: Frederic Mazenc, Michael Malisoff [LSU], Saeed Ahmed [Inria], Ali Zemouche [CRAN], Rajesh Rajamani [University of Minneapolis, USA], Maruthi Akella [University of Texas, USA].

We produced several works which pertain to the case where only a part of the state variables can be measured.

In the paper [58], we adopted a technique based on the indroduction of several observers in cascade (such a cascade is called 'sequential observer') for a class of time-varying linear systems in which the inputs and outputs containing sampling and arbitrarily long delays. The observers are of a continuous-discrete type. We used the observers to design controllers that ensure a strong robustness property with respect to uncertainties in the system and the output, under delays and sampling. A fundamental aspect of the approach is that it produces the observers and controllers without distributed terms. We have assessed the performance of the control laws through two examples, which inlcude a DC motor model that illustrates the utility of the work in engineering applications.

In two papers, we developped the theory of the finite time observers. In [53], we study a class of linear continuous-time time-varying systems with piecewise continuous disturbances and piecewise constant outputs. Under a classical assumption of observability, we designed a new type of observers to estimate the solutions of the system in a predetermined finite time. In contrast to the well-established finite time observer design techniques which estimate the system state using a continuous output, our proposed observer applies when only piecewise constant measurements are available. In [54], we construct finite-time reduced order observers for a broad family of nonlinear time-varying continuous-time systems. The motivation for this is the fact that in practice the time-varying aspect of a system may be an obstacle to the design of full-order finite-time observers, but not for the design of reduced order ones. We illustrated our results using a tracking problem for nonholonomic systems in chained form.

Two of our works present construction of asymptotic observers without delay. The paper [61] solves an H_∞ observer design problem for a class of descriptor nonlinear systems. The method we established is theoretical and can be applied to many automatic control design problems such as unknown input estimation problem, which plays an important role in control systems, namely for diagnosis and fault tolerant control. The design relies on the Linear Matrix Inequality condition (LMI) technique. We applied our resut to a model of a flexible joint robot system.

The work [16] is dedicated to the design of a smooth six-degree-of-freedom observer to estimate the incorporating linear and angular velocity, called dual angular velocity, for a rigid body. The approach is based on the dual-quaternion description and we proved that the estimation errors exhibit asymptotic convergence. Furthermore, to achieve tracking control objective, we combined the proposed observer with an independently designed proportional-derivative-like feedback control law (using full-state feedback), and a special Lyapunov "strictification" process is employed to ensure a separation property between the observer and the controller. We performed numerical simulations for a prototypical spacecraft hovering mission application.

6.11. Stabilization of various systems with pointwise delays

Participants: Frederic Mazenc, Michael Malisoff [LSU], Delphine Bresch-Pietri [Mines Paris Tech.], Nicolas Petit [Mines Paris Tech.], Robledo Gonzalo [Univ. de Chile, Chile], Maruthi Akella [University of Texas, USA], Xi-Ming Sun [Dalian University of Technology, China], Xue-Fan Wang [Dalian University of Technology, China].

The presence of delays to big for being neglected is an obstacle to the design of stabilizing controllers in many cases. We have made efforts to overcome this challenge by developping several techniques.

In the paper [14], we investigated the design of a prediction-based controller for a linear system subject to a problematic time-varying input delay: the delay we considered is not necessarily "First-In/First-Out". The feedback law we proposed uses the current delay value in the prediction. It does not exactly compensate the delay in the closed-loop dynamics but does not require to predict future delay values, contrary to classical prediction techniques. Modeling the input delay as a transport Partial Differential Equation, we proved asymptotic stabilization of the system state, provided that the average L_2-norm of the first derivative of the delay over some time-window is sufficiently small and that the average time between two discontinuities (average dwell time) is sufficiently large.

In the paper [51], we adopted another type of strategy: we used a new sequential predictors approach to build uniformly globally exponentially stabilizing feedback controls for a large class of linear time-varying systems that contain an arbitrary number of different delays. This allows different delays in different components of the input. We illustrated our work in an example from identification theory, and in an Euler-Lagrange system arising from two-link manipulator systems.

The paper [31] continues our works on the chemostat model with an arbitrary number of competing species, one substrate, and constant dilution rates. We allowed delays in the growth rates and additive uncertainties. Using constant inputs of certain species, we derived bounds on the sizes of the delays that ensure asymptotic stability of an equilibrium when the uncertainties are zero, which can allow persistence of multiple species. In the presence of delays and uncertainties, we provided bounds on the delays and on the uncertainties that ensure, with respect to uncertainties, the robustness property called "input-to-state stability".

6.12. Low complexity constrained control using higher degree Lyapunov functions

Participants: Sarmad Munir [NTNU, Trondheim], Sorin Olaru, Morten Hovd [NTNU, Trondheim].

Explicit Model Predictive Control often has a complex solution in terms of the number of regions required to define the solution and the corresponding memory requirement to represent the solution in the online implementation. An alternative approach to constrained control is based on the use of controlled contractive sets. However, polytopic controlled contractive sets may themselves be relatively complex, leading to a complex explicit solution, and the polytopic structure can limit the size of the controlled contractive set. Our recent results [33] develop a method to obtain a larger controlled contractive set by allowing higher order functions in the definition of the contractive set, and explores the use of such higer-order contractive sets in controller design leading to a low complexity explicit control formulation.

6.13. Characterization of ultimate bounds for systems with state-dependent disturbances

Participants: Sorin Olaru, Hiroshi Ito [Kyushu Institute of Technology, Japan].

The work [37] pursues a framework of set characterization of dynamical systems with state-dependent disturbances. It aims to propose a new approach to analysis and design of nonlinear systems involving non-differentiability and asymmetric components which hamper application and effectiveness of local linearization methods. Several characterizations of ultimate bounds are developed. The utility of shifting the fix point is formulated as a parametrization of the ultimate bounds.

6.14. Combinatorial Approach towards Multi-Parametric Quadratic Programming based on Characterizing Adjacent Critical Regions

Participants: Parisa Ahmadi-Moshkenani [NTNU, Trondheim], Sorin Olaru, Tor Johansen [NTNU, Trondheim].

Several optimization-based control design techniques can be cast in the form of parametric optimization problems. The multi-parametric quadratic programming (mpQP) represents a popular class often related to the control of constrained linear systems. The complete solution to mpQP takes the form of explicit feedback functions with a piecewise affine structure, valid in polyhedral partitions of the feasible parameter space known as critical regions. The recently proposed combinatorial approach for solving mpQP has shown better efficiency than geometric approaches in finding the complete solution to problems with high dimensions of the parameter vectors. The drawback of this method, on the other hand, is that it tends to become very slow as the number of constraints increases in the problem. This work [9] presents an alternative method for enumerating all optimal active sets in a mpQP based on theoretical properties of adjacent critical regions and their corresponding optimal active sets. Consequently, it results in excluding a noticeable number of feasible but not optimal candidate active sets from investigation. Therefore, the number of linear programs that should be solved decreases noticeably and the algorithm becomes faster. Simulation results confirm the reliability of the suggested method in finding the complete solution to the mpQPs while decreasing the computational time compared favourably with the best alternative approaches.

6.15. Active vibration damping in a mechanical structures

Participants: Islam Boussaada, Silviu-Iulian Niculescu, Sami Tliba [Université Paris Sud], Thomas Vyhlidal [Czech technical university in Prague], Daniela Danciu [University of Craiova].

In the work [13], an aluminium-based flexible structure embedded in a mobile support subjected to an acceleration is considered. Such a flexible beam is equipped with two piezoelectric patches. One of them is used as an actuator and the second acts as a sensor. These patches are supposed to be rigidly bounded on the beam, one on each side, located at the clamped edge. The whole device is called a piezo-actuated beam which is generally modeled by Euler-Bernoulli equations. Finite element modeling is then applied to reduce the PDE system to a linear finite-dimensional system. Then, the peak of resonance of the first bending mode is damped by using a delayed output-feedback controller, without affecting the neglected vibrating modes in the reduced order model. The proposed controller design is based on the spectral abscissa characterization using the multiplicity property.

6.16. Landing of a civil aircraft

Participants: Frederic Mazenc, Michael Malisoff [LSU], Laurent Burlion [ONERA Toulouse], Victor Gibert [Airbus Toulouse].

In this work and the following, we applied the technique of [28] to problems arising from applications. The paper [56] is devoted to the problem of stabilizing a nonlinear system approximated in a neighborhood of the origin by a saturated chain of integrators when the variables are not accurately measured. We used our control design to solve a control problem that arises in the context of vision based landing of a civil aircraft. In [55], we solved the problem of stabilizing a nonlinear system when the variables are not accurately measured and cannot be differentiated. The proposed method was first motivated and thus finally applied to the vision based control problem of a landing airliner.

6.17. Power electronics devices

Participants: Frederic Mazenc, Alessio Iovine [Efficacity, France].

The contribution [50] is distinct from the papers mentioned above because it uses more traditional backstepping tools. It is devoted to power electronics devices. We proposed a nonlinear control law for a DC/DC boost converter dedicated to extract the maximum power from a photovoltaic (PV) array, taking into account the constraints of the control action. We performed simulations on SimPowerSystems to validate how the developed control strategy is able to properly control the converter.

6.18. Wind Farm Distributed PSO-based Control for Constrained Power Generation Maximization

Participants: Nicolo Gionfra [L2S], Guillaume Sandou, Houria Siguerdidjane [L2S], Damien Faille [EDF], Philippe Loevenbruck [EDF].

A novel distributed approach to treat the wind farm (WF) power maximization problem accounting for the wake interaction among the wind turbines (WTs) is presented. Power constraints are also considered within the optimization problem. These are either the WTs nominal power or a maximum allowed power injection, typically imposed by the grid operator. The approach is model-based. Coupled with a distributed architecture it allows fast convergence to a solution, which makes it exploitable for real-time operations. The WF optimization problem is solved in a cooperative way among the WTs by introducing a new distributed particle swarm optimization algorithm, based on cooperative co-evolution techniques. The algorithm is first analyzed for the unconstrained case, where we show how the WF problem can be distributed by exploiting the knowledge of the aerodynamic couplings among the WTs. The algorithm is extended to the constrained case employing Deb's rule. Simulations are carried out on different WFs and wind conditions, showing good power gains and fast convergence of the algorithm. To appear in Rnewable Energy, 2019.

6.19. Wind Farm Distributed PSO-based Control for Constrained Power Generation Maximization

Participants: Sophie Frasnedo [Safran Electronics and Defense], Guillaume Sandou, Gilles Duc [L2S], Philippe Feyel [Safran Electronics and Defense], Cedric Chapuis [Safran Electronics and Defense].

The inertial stabilisation of the line of sight of an imager fixed on a mobile carrier is considered in order to acquire good quality images despite the disturbances generated by the carrier.

A double stage mechanical stabilisation architecture is proposed, where a second stabilisation stage, based on a piezoelectric actuator, is added to the usual structure. The piezoelectric actuator transfer function and hysteresis are characterized through experiments.

In order to design the controllers of both stages, a high-level image quality criterion (the Modulation Transfer Function MTF) is considered, together with design constraints on the main variables of interest. The criterion and the constraints are evaluated by realistic simulations based on some input and noise profiles measured on a real-life system. The MTF evaluation being time-consuming, a Bayesian optimisation method specially dedicated to expensive-to-evaluate functions is used to obtain the parameters of the controllers. The obtain experimental results are displayed and their performances discussed. To appear in the International Journal of Systems and Sciences in 2019.

6.20. Model Identification for Demand-Side Management of District Heating Substations

Participants: Nadine Aoun [L2S, CEA-LITEN, ADEME], Roland Baviere [CEA-LITEN], Mathieu Vallee [CEA-LITEN], Guillaume Sandou.

Demand-Side Management (DSM) strategies, such as load shifting and nighttime set-back, exploit the thermal inertia of buildings to make the operation of District Heating Systems (DHSs) more efficient. The control strategy requires a building model to assess the flexibility of buildings in handling demand modulation, without jeopardizing the thermal comfort. Reduced Order Models (ROMs) with few parameters are often used for this end; in many previous works their parameters have been identified using time-series data including indoor temperature measurements. However, at a city scale and due to privacy rights, such internal signals are usually unavailable. Thereby, identifying the ROM shall rely solely on measurements available at the substation level.

In our work, we develop and demonstrate a method respecting this practical constraint to identify a first and a second order building model. In literature, a rather simplified approach had been proposed to derive a first order building model from substation measurements. We compare the performance of our methodology with respect to the latter, using the same model structure. As for the second order model, its structure is more relevant to account for different dynamics in buildings equipped with hydronic heating systems or featuring important internal thermal inertia. Data used for the identification is restricted to the heat flux delivered from the DHS, both supply and return water temperatures, mass flowrate across the substation's heat-exchangers and the outdoor temperature. Validation of the proposed approach is carried out using a representative white-box model of a building and its substation written in the Modelica language. Implementation of advanced control strategies for DHSs based on this model identification is in prospect.

6.21. Mathematical Modelling of Acute Myeloid Leukemia

Participants: Catherine Bonnet, Jean Clairambault [MAMBA project-team], François Delhommeau [INSERM Paris (Team18 of UMR 872) Cordeliers Research Centre and St. Antoine Hospital, Paris], Walid Djema, Emilia Fridman [Tel-Aviv University], Pierre Hirsch [INSERM Paris (Team18 of UMR 872) Cordeliers Research Centre and St. Antoine Hospital, Paris], Frédéric Mazenc, Hitay Özbay [Bilkent University].

Our project is about the modeling and analysis of healthy and unhealthy cell population dynamics, with a particular focus on hematopoiesis, which is the process of blood cell production and continuous replenishment. We point out that medical research is now looking for new combined targeted therapies able to overcome the challenge of cancer cells (e.g. to stop overproliferation, to restore normal apoptosis rates and differentiation of immature cells, and to avoid the high toxicity effects that characterize heavy non-selective chemotherapy). In that quest, the ultimate goal behind mathematical studies is to provide some inputs that should help biologists to suggest and test new treatment, and to contribute within multi-disciplinary groups in the opening of new perspectives against cancer. Thus, our research project is imbued within a similar spirit and fits the expectations of a better understanding of the behavior of healthy and unhealthy blood cell dynamics. It involve intensive collaboration with hematologists from Saint Antoine hospital in Paris, and aims to analyze the cell fate evolution in treated or untreated leukemia, allowing for the suggestion of new anti-leukemic combined chemotherapy.

Cells have amazing features that allow them to guide their development paths and determine their individual and collective fates. Dedifferentiation and transdifferentiation (cell plasticity) are little understood phenomena that allow cells to regress from an advanced differentiated state to a less differentiated one, including the case where cells lose their specific function and become stem cells.

We have introduced cell plasticity into a class of mathematical models we are interested in. We explored a new model involving a dedifferentiation function in the case of two cell maturity stages (stem cells and progeny). We have highlighted the role that dedifferentiation may have in the survival of cancer cells during therapy. The latter hypothesis appears to be in line with some medical observations [48].

We have also developed and analyzed a model taking into the account the fact that few cells of the proliferating compartment may be arrested during an unlimited time [49].

6.22. Analysis of Dengue Fever SIR Model with time-varying parameters

Participants: Stefanella Boatto [Univ Feder Rio de Janeiro], Catherine Bonnet, Frédéric Mazenc, Le Ha Vy Nguyen.

Migratory fluxes of humains and of insects of various species have favoured the spreading of diseases world-wide. In particular the Ae Aegypti and Ae Albopictus mosquitoes of the Aedes family are vectors able to transmit and spead among humans a variety of diseases: Dengue, Zika, Chikungunya, Yellow fever and the newly discovered Mayaro.

We have continued to analyze SIR models with time-varying parameters to predict dengue epidemics and compared numerical simulations with real data from Dengue epidemics in Rio de Janeiro in order to estimate the infectivity rate and predict what are the periods more at risk of infection [63], [41].

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Industrial-Academic Institute

Guillaume Sandou is the head of the RISEGrid Institute. The Institute is dedicated to the study, modelling and simulation of smart electric distribution grids and their interactions with the whole electric power system. It is located in CentraleSupélec and gathers about 20 people (academic and industrial researchers, PhD students, post-doctoral researchers). The Institute has been renewed in 2018 for 5 new years.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: **COST Action**

Project acronym: FRACTAL

Project title: Fractional-order systems; analysis, synthesis and their importance for future design

Duration: November 2016 - October 2020

Coordinator: Jaroslav Koton Czech Republic

Abstract: Fractional-order systems have lately been attracting significant attention and gaining more acceptance as generalization to classical integer-order systems. Mathematical basics of fractional-order calculus were laid nearly 300 years ago and since that it has gained deeply rooted mathematical concepts. Today, it is known that many real dynamic systems cannot be described by a system of simple differential equation or of integer-order system. In practice we can encounter such systems in electronics, signal processing, thermodynamics, biology, medicine, control theory, etc. The Action will favor scientific advancement in above mentioned areas by coordinating activities of academic research groups towards an efficient deployment of fractal theory to industry applications.

Program: **PHC BALATON**

Project acronym: SadHuB

Project title: Analysis of stabilizability of delayed dynamical system as function of the systems parameters and the time delays with applications to human balancing

Duration: 01/2018-12/2019

Coordinator: Islam Boussaada

Other partners: Budapest University of Technology and Economics, Hungary

Abstract: Motivated by a class of Time-delay systems occurring in modeling of many mechanical engineering applications, this project aims to associate researchers from control theory, applied mathematics and mechanical engineering to build together a general methodology for the analysis and control of mechanical/bio-mechanical structures. In particular, the human balance is often considered as a control system which operates in the presence of delays, primarily due to the time it takes to acquire the information needed for decision-making, to create control decisions, and to execute these decisions. A particular interest will be devoted to the delayed human balance, where a depthful study of the delay effect on the stability is expected.

Program: **PHC BRANCUSI**

Project acronym: Proco

Project title: systems with propagation: new approaches in control design for oscillations quenching

Duration: 01/2017-12/2018

Coordinator: Islam Boussaada

Other partners: Craiova University, Romania

Abstract: Propagation systems are met and analyzed in various fields, in natural sciences (Physics, Chemistry, Biology etc.) as well as in engineering sciences (energy, mechanics, electricity, optics etc.). According to projects research objectives, the general object of analysis is represented by the controlled systems with distributed parameters which are usually met in technology dynamical systems with parameter space variation along a single space variable. The standard physical phenomena that are modeled are: diffusion, transport and propagation, thus leading to partial differential equations of parabolic (diffusion), hyperbolic (propagation) and advection first order (transportation), respectively. According to the project main subject, the main application of the studies aimed at the automatically controlled processes in the field of energy in a domain where propagation phenomena are dominant. The scientific novelty of the studies arises from the consideration of the systems described by conservation laws in the following fields: oil drilling and extraction, co-generation (combined heat-electricity generation), energy production in hydroelectric plants.

Program: **PHC CARLOS J FINLEY (Cuba)**

Project title: Modélisation et commande pour les processus de cryoconservation.

Duration: June 2017 - December 2018

Coordinator: Sorin Olaru (France), Marcos Martinez Montero (Turkey).

Abstract: The aim of this project is to initiat a collaboration on subjects related to the mathematical modelling of the dynamics involved in the cryopreservations process. In particular, the viability analysis of the vegetal material subject to cryogeny is one of the main objectives. The approach will realy on the evaluation electric leakage properties.

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Informal International Partners

- Louisiana State University, Baton Rouge, USA
- School of Electrical Engineering at the Tel-Aviv University, Israel
- The University of Texas at Austin, Dept. of Aerospace Engineering & Engineering Mechanics, USA
- Blikent University, Turkey
- Universidad de Chile, Chile
- School of Mathematics, University of Leeds, U.K.
- University Federale Rio de Janeiro, Brazil
- UNICAMP, Brazil
- Kyoto University, Japan

7.3.2. Participation in Other International Programs

Giorgio Valmorbida is leading the CNRS funded IRN - SPaDisCo (International Research Network - Systèmes à Paramètres Distribués et Contraintes) composed by more than 50 researchers from Belgium, Czech Republic, France, Italy, Sweden, Turkey and the United Kingdom.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Stefanella Boatto, Federale University Rio de Janeiro, Brazil, 1 January- 2 March.

Pedro Luis Dias Peres, UNICAMP, Brazil, December 2018.

Valter Leite Junior, CEFET-MG, Brazil, May 2018.

Antonis Papachristodoulou, University of Oxford, UK, September 2018.

Yutaka Yamamoto, Kyoto University, Japan, 6 Sept - 6 Nov.

7.4.2. Visits to International Teams

7.4.2.1. Research Stays Abroad

Islam Boussaada spent one month during July 2018 as a Research Associate at the Department of Electronic Engineering at City University of Hong Kong. He started a research collaboration with Professor Jie Chen Team.

8. Dissemination

8.1. Promoting Scientific Activities

8.1.1. Scientific Events Organisation

8.1.1.1. Member of the Organizing Committees

Catherine Bonnet is member of the organizing committee of SIAM CT19, Chendu China, July 2019. Islam Boussaada is co-animator of the national working group GT OSYDI of the GDR MACS funded by CNRS. Giorgio Valmorbida was member of the Organizing committee of the 2nd Workshop on DElays and COnstraints on Distributed parameter systems (DECOD-2018).

8.1.2. Scientific Events Selection

- Catherine Bonnet was Associate Editor for the conferences 2019 American Control Conference, Philadelphia, USA.
- Islam Boussaada was Associate Editor for 14th IFAC Workshop on Time Delay Systems, Budapest, Hungary.
- Frédéric Mazenc was Associate Editor for the conferences 2019 American Control Conference, Philadelphie, USA, and the 57th IEEE Conference on Decision and Control, Miami, USA, (2018).

8.1.2.1. Member of the Conference Program Committees

- Catherine Bonnet is a member of the scientific committee of the GDRI (International Research Group funded by CNRS) SpaDisco since 2017.
- Catherine Bonnet, Islam Boussaada and Sorin Olaru are members of the International Program Committee of the Joint IFAC Conference 7th Symposium on System Structure and Control (SSSC 2019) and 15th IFAC Workshop on Delay Systems, Sinaia, Roumania, Sept 2019.
- Islam Boussaada was a member of the International Program Committee for 14th IFAC Workshop on Time Delay Systems (TDS 2018), Budapest, Hungary.
- Frédéric Mazenc and Giorgio Valmorbida are members (Associate Editors) of the *Control Editorial Board - IEEE - CSS*. Sorin Olaru was member of the International Program Committee of the 9th IFAC Symposium on Robust Control Design - ROCOND and of the IEEE Mediterranean Control Conference.

8.1.2.2. Reviewer

The team reviewed papers for several international conferences including IEEE Conference on Decision and Control, IEEE American Control Conference, European Control Conference, IFAC World Congress.

8.1.3. Journal

8.1.3.1. Member of the Editorial Boards

Frédéric Mazenc is member of the editorial boards (Associate Editor) of the following journals:

- IEEE Transactions on Automatic Control;
- European Journal of Control;
- Journal of Control and Decision.

Sorin Olaru is is member of the editorial boards (Associate Editor) of the following journals:

- IEEE Control Systems Letters;
- IMA Journal of Mathematical Control and Information, Oxford Press.

8.1.3.2. Reviewer - Reviewing Activities

The team reviewed papers for several journals including SIAM Journal on Control and Optimization, Automatica, IEEE Transactions on Automatic Control, IEEE Control Systems Magazine, Systems and Control Letters.

8.1.4. Invited Talks

Stefanella Boatto gave a talk at the biomathematics Seminar of Institut de Mathématiques de Marseille, Aix-Marseille univerité, February 2018, Marseilles, France. Title of her talk: '*Modelling epidemics dynamics due to Aedes mosquitoes : the example of Rio de Janeiro. How to approximate an epidemic attractor and to estimate the infectivity rate*'.

Frédéric Mazenc was a plenary speaker of the conference POSTA2018, August 2018, Hangzhou, China. Title of his talk: '*Stability of Positive Systems With Delay: Changes of Coordinates, Comparison Systems, Lyapunov Functionals*'.

Giorgio Valmorbida gave an invited talk at the International Workshop on Robust LPV Control Techniques and Anti-Windup Design, April 2018, Toulouse, France. Title of his talk: '*Anti-Windup Design for Synchronous Machines*'.

Giorgio Valmorbida gave an invited talk at the Meeting of the GT CSE (groupe de travail Commande de Systèmes Éléctriques) , May 2018, Paris, France. Title of his talk: '*Anti-Windup Design for Synchronous Machines*'.

Giorgio Valmorbida gave an invited talk at the 2nd Workshop on Stability and Control of Infinite-Dimensional Systems (SCINDIS-2018), May 2018, Wurzburg, Germany. Title of his talk: '*Convex Optimization Methods to Solve Integral Inequalities*'.

Giorgio Valmorbida gave an invited talk at the 2nd Workshop on DElays and COnstraints on Distributed parameter systems (DECOD-2018), November 2018, Toulouse, France. Title of his talk: '*Stability Analysis of Piece-wise Affine Discrete-Time systems*'.

8.1.5. Leadership within the Scientific Community

Catherine Bonnet is a member of the IFAC Technical Committees on *Distributed Parameter Systems* and on *Biological and Medical Systems*. She is a member of the management committee of the COST Action FRACTAL (2016-2020). Sorin Olaru is a member of the IFAC Technical Committees on *Robust Control* and on *Optimal control*. He is a member of the IEEE Technical Committee on *Hybrid Systems*. He is a Senior Member IEEE since 2012.

8.1.6. Scientific Expertise

Catherine Bonnet is a member of the Evaluation Committee of Inria since September 2015.

Since 2014, Frédéric Mazenc is an expert for the FNRS (Belgium). His mission consists in evaluating research projects funded by this institution.

Since 2012, Frédéric Mazenc is an expert for the ANVUR (National Agency for the Evaluation of Universities and Research Institutes, Italy). His mission consists in evaluating the contribution of Italian scientists.

Since 2011, Frédéric Mazenc is an expert for the Romanian National Council for Development and Innovation (Romania). His mission consists in evaluating research projects funded by the this institution.

8.1.7. Research Administration

Catherine Bonnet is a member of the administration council of the association *Femmes et Mathématiques*, of the *Parity Committee* of Inria and of the *Cellule veille et prospective* of Inria (both created in 2015). She is a member of the Bureau du Comité des Projets du CRI Saclay-Ile-de-France.

In 2018, Frédéric Mazenc is a member of the commission scientifique du CRI Saclay-Ile-de-France. Since October 2017, he is Correspondant Inria Saclay A.M.I.E.S., http://www.agence-maths-entreprises.fr/

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Master : Stefanella Boatto, Challenges in Biomathematical Modelling, 3h, M1, CentraleSupélec, France.

Master : Catherine Bonnet, Stability of Delay Systems, 1.5h, M1, CentraleSupélec.

Licence : Islam Boussaada, Complex analysis, 60, L3, IPSA, France.

Licence : Islam Boussaada, Harmonic analysis, 60, L3, IPSA.

Licence : Sorin Olaru, Automatic Control, 8h , M1, CentraleSupélec.

Licence : Sorin Olaru, Signals and systems, 8h , L3, CentraleSupélec.

Licence : Sorin Olaru, Embedded systems, 8h , M1, CentraleSupélec.

Licence : Sorin Olaru, Numerical methods and Optimization, 24h, M1, CentraleSupélec.

Licence : Sorin Olaru, Hybrid systems, 16h, M2, CentraleSupélec.

Licence : Guillaume Sandou, Signals and Systems, 87h, L3, CentraleSupélec.

Licence : Guillaume Sandou, Model representation and analysis, 70h, L3, CentraleSupélec.

Licence : Guillaume Sandou, Mathematics and programming, 18h, L3, CentraleSupélec.

Licence : Giorgio Valmorbida, Embedded systems, 7.5h, M1, Cursus Ingénieur CentraleSupélec.

Master : Guillaume Sandou, Automatic Control, 8h, M1, CentraleSupélec.

Master : Guillaume Sandou, Numerical methods and optimization, 28h, M1 and M2, CentraleSupélec.

Master : Guillaume Sandou, Modelling and system stability analysis, 21h, M2, CentraleSupélec.

Master : Guillaume Sandou, Control of energy systems, 22h, M2, CentraleSupélec.

Master : Guillaume Sandou, Robust control and mu-analysis, 9h, M2, CentraleSupélec.

Master : Guillaume Sandou, Systems identification, 32h, M2, ENSTA.

Master : Guillaume Sandou, System Analysis, 22h, M2, Ecole des Mines de Nantes.

Master : Giorgio Valmorbida, Numerical methods and optimisation, 6 h, 6hETD, niveau M1, Cursus Ingénieur CentraleSupélec.

Master : Giorgio Valmorbida, Commande d'Entraînements de Vitesse Variable 12 h, M1, Cursus Ingénieur CentraleSupélec.

Master : Giorgio Valmorbida, Control Theory, 7.5 h, M1, Cursus Ingénieur CentraleSupélec.

Master : Giorgio Valmorbida, Dynamical Systems, 9 h, M2, Master Automatique Taitement du Signal et de I'image - Université Paris-Saclay, France.

Master : Giorgio Valmorbida, Control 30h, niveau M1, Master Nuclear Energy - Université Paris-Saclay.

Doctorat : Islam Boussaada, Introduction to the qualitative theory of functional differential equations, 12h, University Mouloud Mammeri, Algeria

8.2.2. Supervision

PhD : Saeed Ahmed, title: *Observer Design and Output Feedback Stabilization of Time Varying Systems*, Bilkent University. Thesis defense: 03 July 2018, supervisors: Hitay Ozbay, Frédéric Mazenc.

PhD in progress : Nadine Aoun, Modélisation de réseaux de chaleur et gestion avancée multi-échelles de la production, de la distribution et de la demande. Modeling and multi-scale advanced management of production, distribution and demand in district heating networks. Supervisor: Guillaume Sandou.

PhD in progress : Leonardo Broering Groff, Periodic Event-Triggered Control, mars 2016. Supervisors: Giorgio Valmorbida and Joao Manoel Gomes da Silva Jr.

PhD in progress : Caetano Cardeliquio, Stability and stabilization of (possibly fractional) systems with delays. French Supervisor : Catherine Bonnet, Brazilian Supervisor : André Fioravanti.

PhD in progress : Mohamed Lotfi Derouiche, Sur l'optimisation par métaheuristiques avancées de lois de commande prédictive non linéaire. On the optimization of nonlinear predictive control laws using advanced metaheuristics algorithms. Supervisors: Soufienne Bouallegue, Joseph Haggége et Guillaume Sandou.

PhD : Nicolo Gionfra, Optimisation du pilotage d'un parc d'énergies renouvelables avec stockage et du réseau de distribution sous-jacent. Optimization of the control of a park of renewable sources considering strorage means and distribution network. Supervisors: Houria Siguerdidjane et Guillaume Sandou. Defended in March 2018.

PhD in progress : Jean Mercat, Modele predictif des objets d'une scene routiere ; application à la sélection robuste des cibles pour les ADAS. Supervisor: Guillaume Sandou.

PhD in progress : Maxime Pouilly-Cathelain, Commande adaptative temps réel vis-a-vis de critères multiples de haut niveau. Supervisor : Guillaume Sandou.

8.2.3. Juries

- Catherine Bonnet was President of the Saclay-Ile-de-France Junior Researcher recruiting committee and a member of the National Inria Junior Researcher recruiting committee.
- Catherine Bonnet was reviewer of the PhD thesis of Mohamad Taki Asghar *'New advanced control strategies for steel making process'*, 3 May 2018, Université de Nancy. She was President of the PhD Defense juries of Noussaiba Gasmi *'Observation et commande des systèmes dynamiques d'ordre non entier'*, 14 November 2018, Université de Nancy, of Pierre-Marie Gibert *'Use of sinusoidal predictors for time-domain simulation of AC power systems'*, 30 November 2018, Université de Lyon, of Abdelkrim Bahloul *'Sur la commande des robots manipulateurs industriels en co-manipulation robotique'*, 7 December 2018, L2S, CentraleSupelec, and member of the PhD Defense jury of Bainan Liu *'Boundary obeserver-based output feedback control of coupled parabolic PDEs'*, 17 December 2018, INSA centre Val de Loire.
- Frédéric Mazenc was a reviewer of the Phd thesis of Ricardo Sanz Diaz, '*Robust control strategies for unstable systems with input/output delays*', September 27, 2018, Universitat Politecnica de Valencia, Spain and of the Phd thesis of Mohammed Safi, '*Stabilité de Lyapunov de systèmes couplés impliquant une équation de transport*', October 31, 2018, LAAS, Université de Toulouse, France.
- Sorin Olaru was President of the PhD Defense jury of Dominique Monnet, '*Global Minmax optimization for robust Hinf control*', université de Brest, France, reviewer of the PhD Defense jury of Nadia Paola Rosero Ibarra,*'Modeling and Observation applied to physiology-aware control for cycling'*, 12 November 2018, université Grenoble Alpes, France and member of the PhD Defense jury of Nassim Loukkas, *'State-membership state observer design based on explicit characterizations of the estimation-error bounds'*, 6 June 2018, université Grenoble Alpes.
- Giorgio Valmorbida was a member of the jury of the Phd thesis of Fabien Niel, *'Modeling and control of a wing at low Reynolds number with high amplitude aeroelastic oscillations'*, 26 January 2018, LAAS, université de Toulouse, France.

8.3. Popularization

8.3.1. Interventions

Catherine Bonnet awarded the price of Mathematics and Italian et Italien at the *Concours Général des lycées et des métiers du Ministère de l'Éducation nationale*, Grand Amphitéatre de La Sorbonne, July 2018. She welcomed a group of middle school students, 17 December 2018.

9. Bibliography

Major publications by the team in recent years

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Publications of the year

Articles in International Peer-Reviewed Journals

[9] P. AHMADI-MOSHKENANI, T. A. JOHANSEN, S. OLARU. *Combinatorial Approach towards Multi-Parametric Quadratic Programming based on Characterizing Adjacent Critical Regions*, in "IEEE Transactions on Automatic Control", 2018, 1 p. [*DOI :* 10.1109/TAC.2018.2791479], https://hal-centralesupelec.archives-ouvertes.fr/hal-01720260

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