IN PARTNERSHIP WITH:
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Activity Report 2017

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

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Project-Team DISCO

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

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1. Personnel

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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) eventually 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 might have fixed 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. [70]). 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], [71].
- 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. Highlights of the Year

5.1. Highlights of the Year

Silviu-Iulian Niculescu is a 2018 IEEE Control Systems Society Fellow for research on the effects of delays in system dynamics.

6. New Software and Platforms

6.1. YALTA

Yet Another LTI TDS Algorithm

FUNCTIONAL DESCRIPTION: The YALTA toolbox is a Matlab toolbox dedicated to the study of classical and fractional systems with delay in the frequency-domain. Its objective is to provide basic but important information such as, for instance, the position of the neutral chains of poles and unstable poles, as well as the root locus with respect to the delay of the system. The corresponding algorithms are based on recent theoretical results and on classical continuation methods exploiting the particularities of the problem.

- Participants: André Fioravanti, Catherine Bonnet, David Avanessoff, Hugo Cavalera, Jim Pioche and Le Ha Vy Nguyen
- Contact: Catherine Bonnet
- URL: http://yalta-toolbox.gforge.inria.fr/

7. New Results

7.1. Maximal-multiplicity-based rightmost-root assignment for retarded TDS

Participants: Islam Boussaada, Silviu-Iulian Niculescu, Sami Tliba [L2S], Hakki Unal [Anadolu University], Toma Vyhlidal [Czech Technical University].

The proposed approach is a stabilizing delayed state-feedback design guaranteeing an appropriate (admissible) convergence rate to the trivial solution of the controlled dynamical system. Unlike methods based on finite spectrum assignment, our method does not render the closed loop system finite dimensional but consists in controlling its rightmost spectral value. First, it consists in characterizing the root of the characteristic quasipolynomial function to be of maximal multiplicity by mean of an analytical necessary and sufficient condition. Then, conditions on such a root (of maximal multiplicity) to be stable and dominant are established. These results are obtained for reduced-orders time-delay system (scalar and quadratic cases), see [69].

7.2. Migration of multiple roots under parameters/delays perturbation

Participants: Islam Boussaada, Dina Irofti, Silviu-Iulian Niculescu, Wim Michiels [KU Leuven].

In the context of the perturbation theory of nonlinear eigenvalue problem, the sensitivity of multiple eigenvalues with respect to parameters' variations is studied. In the complete regular splitting case, explicit expressions for the leading coefficients of the Puiseux series of the eigenvalue are provided [22]. In contrast to existing analysis of multiple roots of delay equations the developed results are in a matrix framework, i.e., without reduction of the problem to the analysis of a scalar characteristic quasipolynomial.

7.3. A generalized $\tau-$decomposition for TDS with delay-dependent coefficients

Participants: Chi Jin [L2S], Keqin Gu [Illinois State University], Islam Boussaada, Silviu-Iulian Niculescu.

The standard frequency domain approaches for Time-delay systems analysis do not apply when the coefficients of the system are delay-dependent. Given a system with delay-dependent coefficients as well as a delay interval of interest, a method is proposed to find all the delay subintervals guaranteeing the asymptotic stability of the trivial solution. The crossing direction criteria is proposed which can be clearly interpreted from a geometrical two-parameter perspective [36], [52].

7.4. State and Output-feedback control design for (possibly fractional) time-delay systems

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

We obtained this year new results for H_∞-control synthesis via output-feedback through a finite order LTI system, called comparison system [42].

We also generalised those results for fractional systems.

The fractional comparison system was obtained and through LMIs we were able to calculate the H_∞-norm for the fractional system and design a state-feedback control through the comparison system approach.

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

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

We presented a new approach to develop an envelope that engulfs all poles of a time-delay system.

Through LMIs we determined envelopes for retarded and neutral time-delay systems.

The envelopes proposed were not only tighter than the ones in the literature but they can also be applied to verify the stability of the system.

The approach was also used to design state-feedback controllers which cope with design requirements regarding $\alpha - stability$.

7.6. Backstepping with artificial delays

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

We worked on the problem of improving a fundamental control design technique called backstepping.

We provided in [54] a new backstepping control design for time-varying systems with input delays. The result was obtained by the introduction of a constant 'artificial' pointwise delay in the input and a dynamic extension. Thus it is significantly different from backstepping results for systems with delay in the input as presented in previous contributions. The result in [54] ensures global asymptotic convergence for a broad class of partially linear systems with an arbitrarily large number of integrators. We used only one artificial delay, and we assumed that the nonlinear subsystems satisfy a converging-input-converging-state assumption. When the nonlinear subsystem is control affine with the state of the first integrator as the control, we provided sufficient conditions for our converging-input- converging-state assumption to hold.

7.7. Stability of time-varying systems with delay and Switched Nonlinear Systems

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

Switched systems is a family of systems which is frequently encountered in practice and can be used to approximate time-varying systems to ease their stability analysis or control. In the two works [20] and [17], we provided results that are useful when it comes to analyze the stability of time-varying or switched systems with delay. In [20] we provided several significant applications of the trajectory approach developed recently by Mazenc and Malisoff. In two results, we used a Lyapunov function for a corresponding undelayed system to provide a new method for proving stability of linear continuous-time time-varying systems with bounded time-varying delays. Our main results used upper bounds on an integral average involving the delay. We also provided a novel reduction model approach that ensures global exponential stabilization of linear systems with a time-varying pointwise delay in the input, which allows the delay to be discontinuous and uncertain.

Three of our other works are devoted to switched systems. In [55] and [21], a new technique is proposed to ensure global asymptotic stability for nonlinear switched time-varying systems with time-varying discontinuous delays. It uses an adaptation of Halanay's inequality to switched systems and the trajectory based technique mentioned above. The result is applied to a family of linear time-varying systems with time-varying delays. In [53], we presented an extension of the trajectory based approach mentioned above for state feedback stabilization of switched linear continuous-time systems with a time-varying input delay. In contrast with finding classical common Lyapunov function or multiple Lyapunov functions for establishing the stability of the closed-loop switched system, the new trajectory based approach relies on verifying certain inequalities along the solution of a supplementary system. This study does not make any assumption regarding the stabilizability of all of the constituent modes of the switched system. Moreover, no assumption is needed about the differentiability of the delay and no constraint is imposed on the upper bound of the delay derivative.

In [17], we proved extensions of the celebrate Razumikhin's theorem for a general family of time-varying continuous and discrete-time nonlinear systems. Our results include a novel "strictification" technique for converting a nonstrict Lyapunov function into a strict one. We also provided new constructions of Lyapunov-Krasovskii functionals that can be used to prove robustness to perturbations. Our examples include a key model from identification theory, and they show how our method can sometimes allow broader classes of delays than the results in the literature.

7.8. Systems with Long Delays

Participants: Frederic Mazenc, Silviu Niculescu, Michael Malisoff [LSU,USA], Jerome Weston [LSU,USA], Ali Zemouche, Bin Zhou [Harbin Institute of Technology], Qingsong Liu [Harbin Institute of Technology].

We solved several problems of observer and control designs pertaining to the fundamental (and difficult) case where a delay in the input is too long for being neglected.

In [35], we studied the stabilization of linear systems with both state and input delays where the input delay can be arbitrarily large but exactly known. Observer-predictor based controllers are designed to predict the future states so that the input delay can be properly compensated. Necessary and sufficient conditions guaranteeing the stability of the closed-loop system are provided in terms of the stability of some simple linear time-delay systems refereed to as observer-error systems. Moreover, linear matrix inequalities are used to design both the state feedback gains and observer gains. Finally, a numerical example illustrates that the proposed approaches are more effective and safe to implement than the existing methods.

In [57], for a particular family of systems, we constructed observers in the case where the measured variables are affected by the presence of a point-wise time-varying delay. The key feature of the proposed observers is that the size of their gains is proportional to the inverse of the largest value taken by the delay. The main result is first presented in the case of linear chain of integrators and next is extended to nonlinear systems with specific nonlinearities (systems of feedforward form).

Two of our works are devoted to the development of the prediction technique based on sequential predictors. Let us recall that one of the key advantages of this method is that it circumvents the problem of constructing and estimating distributed terms in the control laws: instead of using distributed terms, our approach to handling longer delays is to increase the number of predictors. In [61], we provided a significant generalization of our previous results to cases with arbitrarily large feedback delay bounds, and where, in addition, current values of the plant state are not available to use in the sequential predictors. We illustrate our work in a pendulum example. In [18], we provided a new sequential predictors approach for the exponential stabilization of linear time-varying systems. Our method allows arbitrarily large input delay bounds, pointwise time-varying input delays and uncertainties. We obtain explicit formulas to find lower bounds for the number of required predictors.

7.9. Nonlinear Observer Design via LMIs

Participants: Ali Zemouche, Rajesh Rajamani [University of Minneapolis, USA], Hieu Trinh [Deakin University, Australia], Yan Wang [University of Minneapolis, USA], Michel Zasadzinski [CRAN], Hugues Rafaralahy [CRAN], Boulaid Boulkroune [Flanders Make, Lommel, Belgium], Gridsada Phanomchoeng [Chulalongkorn University,Thailand], Khadidja Chaib-Draa [University of Luxembourg], Mohamed Darouach [CRAN], Marouane Alma [CRAN], Holger Voos [University of Luxembourg].

- Observer Design for Lipschitz and Monotonic nonlinear systems using LMIs:

  New LMI (Linear Matrix Inequality) design techniques have been developed to address the problem of designing performant observers for a class of nonlinear systems. The developed techniques apply to both locally Lipschitz as well as monotonic nonlinear systems, and allows for nonlinear functions in both the process dynamics and output equations [59], [34]. The LMI design conditions obtained are less conservative than all previous results proposed in literature for these classes of nonlinear systems. By judicious use of Young's relation, additional degrees of freedom are included in the observer design. These additional decision variables enable improvements in the feasibility of the obtained LMI. Several recent results in literature are shown to be particular cases of the more general observer design methodology developed in this paper. Illustrative examples are used to show the effectiveness of the proposed methodology. The application of the method to slip angle estimation in automotive applications is discussed and experimental results are presented. Although this application was the main motivation of this work, the proposed techniques have been applied to an anaerobic digestion model for different contexts [43], [44], [45].
- HG/LMI Observer:

A new high-gain observer design method with lower gain compared to the standard high-gain observer was proposed [62]. This new observer, called "HG/LMI" observer is obtained by combining the standard high-gain methodology with the LPVLMI-based technique. Through analytical developments, it is shown how the new observer provides a lower gain. A numerical example was used to illustrate the performance of the new "HG/LMI" observer that we can call "smart high-gain observer". The aim of this research is the application of this new observer design to estimate some variables in vehicle applications and other real-world applications.

- Dual Spatially Separated Sensors for Enhanced Estimation:

  Inspired by the function of spatially separated sensory organs found in nature, we explored the use of dual spatially separated sensors for enhanced estimation in modern engineering applications [26]. To illustrate the interest of dual spatially separated sensors, some real applications have been considered: 1) Adaptive parameter and state estimation in magnetic sensors; 2) Estimation of an unknown disturbance input in an automotive suspension; 3) Separation of inputs based on their direction of action in a digital stethoscope. Both analytical observer design developments and experimental evaluation of the results have been provided.

7.10. Observer-Based Stabilization of Uncertain Nonlinear Systems

Participants: Ali Zemouche, Rajesh Rajamani [University of Minneapolis, USA], Yan Wang [University of Minneapolis, USA], Fazia Bedouhne [University of Tizi-Ouzou, Algeria], Hamza Bibi [University of Tizi-Ouzou, Algeria], Abdel Aitouche [CRIStAL, Lille].

- Relaxed LMI conditions for switched systems and LPV systems:

  By exploiting the Finsler's lemma in a non-standard way, we derived new LMI conditions. This technique has been applied to linear switched systems with uncertain parameters [10], [40] and LPV (Linear Parameter Varying) systems with inexact parameters [39], respectively. In each case, the Finsler's inequality is exploited in a convenient way to get additional decision variables which render the LMIs less conservative than those existing in the literature. In addition to analytical comparisons, several numerical examples have been used to show the superiority of the proposed new LMI conditions.

- From LMI relaxations to sequential LMI algorithm:

  Recently, motivated by autonomous vehicle control problem, a robust observer based estimated state feedback control design method for an uncertain dynamical system that can be represented as a LTI system connected with an IQC-type nonlinear uncertainty was developed [28]. Different from existing design methodologies in which a convex semidefinite constraint is obtained at the cost of conservatism and unrealistic assumptions, the design of the robust observer state feedback controller is formulated in this paper as a feasibility problem of a bilinear matrix inequality (BMI) constraint. Unfortunately, the search for a feasible solution of a BMI constraint is a NP hard problem in general. The applicability of the linearization method, such as variable change method or congruence transformation, depends on the specific structure of the problem at hand and cannot be generalized. A new sequential LMI optimization method to search for a feasible solution was established. In the application part, a vehicle lateral control problem is presented to demonstrate the applicability of the proposed algorithm to a real-world estimated state feedback control design.

7.11. Analysis of PWA control of discrete-time linear dynamics in the presence of variable input delay

Participants: Sorin Olaru, Mohammed Laraba [CentraleSupélec], Silviu Niculescu.

We have addressed the robustness of a specific class of control laws, namely the piecewise affine (PWA) controllers, defined over a bounded region of the state-space. More precisely, we were interested in closed-loop systems emerging from linear dynamical systems controlled via feedback channels in the presence of varying transmission delays by a PWA controller defined over a polyhedral partition of the state-space. We exploit the fact that the variable delays are inducing some particular model uncertainty. Our objective was to characterize the delay invariance margins: the collection of all possible values of the time-varying delays for which the positive invariance of the corresponding region is guaranteed with respect to the closed-loop dynamics. These developments are proving to be useful for the analysis of different design methodologies and, in particular, for model predictive control (MPC) approaches. The proposed delay margin describes the admissible transmission delays for an MPC implementation. From a different perspective, the delay margin further characterizes the fragility of an embedded MPC implementation via the on-line optimization and subject to variable computational time.

7.12. On the precision in polyhedral partition representation and the fragility of PWA control

Participants: Sorin Olaru, Rajesh Koduri [CentraleSupélec], Pedro Rodriguez [CentraleSupélec].

Explicit model predictive control (EMPC) solves a multi-parametric Quadratic Programming (mp-QP) problem for a class of discrete-time linear system with linear inequality constraints. The solution of the EMPC problem in general is a piecewise affine control function defined over non-overlapping convex polyhedral regions composing a polyhedral partition of the feasible region. In this work, we considered the problem of perturbations on the representation of the vertices of the polyhedral partition. Such perturbations may affect some of the structural characteristics of the PWA controller such as *non-overlapping within the regions* or *the closed-loop invariance*. We first showed how a perturbation affects the polyhedral regions and evoked the overlapping within the modified polyhedral regions. The major contribution of this work is to analyze to what extend the non-overlapping and the invariance characteristics of the PWA controller can be preserved when the perturbation takes place on the vertex representation. We determined a set called sensitivity margin to characterize for admissible perturbation preserving the non-overlapping and the invariance property of the controller. Finally, we show how to perturb multiple vertices sequentially and reconfigure the entire polyhedral partition

7.13. Convex Lifting: Theory and Control Applications

Participants: Sorin Olaru, Martin Gulan [STU, Bratislava, Slovaquie], Ngoc Anh Nguyen [J. Kepler Univ., Linz, Austria], Pedro Rodriguez [CentraleSupélec].

We introduced the *convex lifting* concept which was proven to enable significant implementation benefits for the class of piecewise affine controllers. Accordingly, two different algorithms to construct a convex lifting for a given polyhedral/polytopic partition were presented. These two algorithms rely on either the vertex or the halfspace representation of the related polyhedra. Also, we introduced an algorithm to refine a polyhedral partition, which does not admit a convex lifting, into a convexly liftable one. Furthermore, two different schemes are put forward to considerably reduce both the memory footprint and the runtime complexity which play a key role in implementation of piecewise affine controllers. These results have been illustrated via a numerical example and a complexity analysis.

7.14. Attitude control

Participants: Frederic Mazenc, Maruthi Akella [Univ. of Texas,USA], Sungpil Yang [Univ. of Texas,USA].

In [31], we addressed adaptive control of specific Euler-Lagrange systems: rigid-body attitude control, and the n-link robot manipulator. For each problem, the model parameters are unknown but the lower bound of the smallest eigenvalue of the inertia matrix is assumed to be known. The dynamic scaling Immersion and Invariance (I&I) adaptive controller is proposed to stabilize the system without employing a filter for the regressor matrix. A scalar scaling factor is instead implemented to overcome the integrability obstacle that arises in I&I adaptive control design. First, a filter-free controller is proposed for the attitude problem such that the rate feedback gain is proportional to the square of the scaling factor in the tracking error dynamics. The gain is then shown to be bounded through state feedback while achieving stabilization of the tracking error. The dynamic scaling factor increases monotonically by design and may end up at a finite but arbitrarily large value. However, by introducing three more dynamic equations, the non-decreasing scaling factor can be removed from the closed-loop system. Moreover, the behavior of dynamic gain is dictated by design parameters so that its upper bound is limited by a known quantity and its final value approaches the initial value. A similar approach for the dynamic gain design is also applied to a filter-dependent controller where a filter for the angular rate is utilized to build a parameter estimator. Unlike the filter-free design, the filter-dependent controller admits a constant gain for the rate feedback while the dynamic scaling factor rather appears in the filter. Finally, the proposed design is applied to robot manipulator systems. Spacecraft attitude and 2-link planar robot tracking problems are considered to demonstrate the performance of the controllers through simulations.

The work [32] builds on the preliminary results by generalizing to the tracking case and some further analysis of the filter-free case. Extending the strictification technique, a partially strict Lyapunov function is constructed toward establishment of stability and ultimate boundedness properties for the closed-loop system. With known upper bounds of the magnitude of measurement errors, disturbance torques, and parameter uncertainties, a feasible range for the feedback gains is derived in terms of bounds on the initial conditions in such a way to ensure asymptotic convergence of all closed-loop signals to within a residual set. In spite of the nonlinear structure of the kinematics and dynamics of the problem, however, the closed-loop system is rigorously analyzed through the standard Lyapunov analysis methods. This is achieved owing to the fact that the strictified Lyapunov function allows us to deal with this nontrivial problem in a standard way. As the passivity-based controller is not new for the attitude control problem, the key contribution of this paper is a theoretical analysis of the ideal case design in the presence of uncertainties through Lyapunov stability analysis.

7.15. Active Vibration Control of thin structures

Participants: Islam Boussaada, Silviu-Iulian Niculescu, Sami Tliba [L2S], Hakki Unal [Anadolu University], Toma Vyhlidal [Czech Technical University].

The problem of active vibrations damping of thin mechanical structures is a topic that has received great attention by the control community for several years, especially, when actuators and sensors are based on piezoelectric materials. For mechanical structures that are deformable, piezoelectric materials are used as strain sensors or strain actuators. With an appropriate controller, they allow to achieve shape control or the active damping of multi-modal vibrations thanks to their very large bandwidth. In this area, the major challenge is the design of controllers able to damp the most vibrating modes in a specified low-frequency bandwidth while ensuring robustness against high-frequency modes, outside the bandwidth of interest, often unmodelled or weakly modelled. The inherent feature of this kind of systems is that they arise robustness issues when they are tackled with finite dimensional control tools. A delayed state-feedback control strategies based on rightmost spectral values assignment allowing a fast vibration damping are proposed in [69], [41], [11].

7.16. Automatic Train Supervision for a CBTC Suburban Railway Line Using Multiobjective Optimization

Participants: Guillaume Sandou, Juliette Pochet [SNCF], Sylvain Baro [SNCF].

Communication-based train control (CBTC) systems have been deployed on subway lines to increase capacities on existing infrastructures. For the same purpose, CBTC systems are to be deployed on suburban railway lines where operating principles and constraints are significantly different. A regulation method for CBTC trains on a suburban line has been developed. This method is designed to combine CBTC functionalities with suburban operating principles. It includes a traffic management method in station, and a rescheduling method in case of disturbances. The proposed regulation method is integrated into the railway system simulation tool SIMONE developed by SNCF. This simulation tool includes models of the whole CBTC system, as well as the classic signaling system, train dynamics and railway infrastructures. Models of these different agents are described. The integration of the proposed regulation method into the tool SIMONE allows evaluating performances while taking into account the functional complexity of a CBTC railway system. The approach is illustrated with a realistic case: simulations of a CBTC traffic on the urban part of a railway line in the Paris region network are described. The proposed regulation method shows interesting results in disturbed situations according to the railway operating principles [60].

7.17. A Distributed Consensus Control Under Disturbances for Wind Farm Power Maximization

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

We have addressed the problem of power sharing among the wind turbines (WTs) belonging to a wind farm. The objective is to maximize the power extraction under the wake effect, and in the presence of wind disturbances. Because of the latter, WTs may fail in respecting the optimal power sharing gains. These are restored by employing a consensus control among the WTs. In particular, under the assumption of discrete-time communication among the WTs, we propose a distributed PID-like consensus approach that enhances the rejection of the wind disturbances by providing the power references to the local WT controllers. The latter are designed by employing a novel feedback linearization control that, acting simultaneously on the WT rotor speed and the pitch angle, guarantees the tracking of general deloaded power references. The obtained results are validated on a 6-WT wind farm example. [50].

7.18. Distributed Particle Swarm Optimization Algorithm for the Optimal Power Flow Problem

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

The distributed optimal power flow problem has been addressed. No assumptions on the problem cost function, and network topology are needed to solve the optimization problem. A particle swarm optimization algorithm is proposed, based on Deb's rule to handle hard constraints. Moreover, the approach enables to treat a class of distributed optimization problems, via a population based algorithm, in which the agents share a common optimization variable. A simulation example is provided, based on a 5-bus electric grid. [51].

7.19. Chemostat

Participants: Frederic Mazenc, Michael Malisoff [LSU,USA], Gonzalo Robledo [Univ. de Chile,Chile].

A chemostat is a fundamental bioreactor used to study the behavior of microorganisms. Many different types of chemostats exist, and many different types of models represent them.

We studied in [56] a 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. Under delays and uncertainties, we provided bounds on the delays and on the uncertainties that ensure a robustness property of input-to-state stability with respect to uncertainties.

In [16], we provided a new control design for chemostats, under constant substrate input concentrations, using piecewise constant delayed measurements of the substrate concentration. Our growth functions can be uncertain and are not necessarily monotone. The dilution rate is the control. We use a new Lyapunov approach to derive conditions on the largest sampling interval and on the delay length to ensure asymptotic stabilization properties of a componentwise positive equilibrium point.

7.20. Qualitative/quantitative analysis of a delayed chemical model

Participants: Islam Boussaada, Silviu-Iulian Niculescu, Hakki Unal [Anadolu University].

The Belousov-Zhabotinsky reaction is a complex chemical reaction exhibiting sustained oscillations observed in some real biological oscillators. However, its oscillatory behavior is represented by a simple mechanism, called the Oregonator. A qualitative/quantitative analysis of a two-delay Oregonator based chemical oscillator is considered where the delay effect in dynamics is investigated; the existence of positive equilibrium point, the stability and boundedness of solutions for positive initial conditions are explored [27].

7.21. 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].

The ALMA3-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.

In 2017, we have discussed some of the issues that are related to the modeling of the cell cycle, with particular insight into hematopoietic systems. For instance, i) we introduced and studied for the first time the effect of cell plasticity (dedifferentiation and transdifferentiation mechanisms) in the class of models that we focus on, and ii) we considered the effect of cell-arrest (i.e. some cells can be arrested during their cell-cycle) in models with several maturity stages. Stability features of the resulting biological models are highlighted, since systems trajectories reflect the most prominent healthy or unhealthy behaviors of the biological process under study. We indeed perform stability analysis of systems describing healthy and unhealthy situations, particularly in the case of acute myeloblastic leukemia (AML). More precisely, these are nonlinear time-delay systems that involve finite or infinite distributed delay terms, with possibly time-varying parameters. We pursue the objectives of earlier works in order to understand the interactions between the various parameters and functions involved in the mechanisms we study. Sometimes, we extend the stability analysis and the application of some already existing models, whereas news models and variants are other times introduced to cover novel biological evidences, such as: mutations accumulation and cohabitation between ordinary and mutated cells in niches, control and eradication of cancer stem cells, cancer dormancy and cell plasticity. In fact, the challenging problem that we are facing is to steadily extend both modelling and analysis aspects to constantly better represent this complex physiological mechanism, which is not yet fully understood. So, this year, we have progressed on our project and we have extended our works in order to develop the modeling and analysis aspects in cancer dormancy by including the effects of immuno-therapies in AML [48]. Lyapunov-like techniques have been used in this work in order to derive global or local exponential stability conditions for that class of differential-difference systems. Finally, in [49], we have modeled the role played by growth factors -these are hormone-like molecules- or drugs on the regulation of various biological features that are involved in hematopoiesis.

7.22. 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.

Dengue fever is an infectious viral disease occurring in humans that is prevalent in parts of Central and South America, Africa, India and South-east Asia and which causes 390 millions of infections worldwide. We continued this year our study on modeling of dengue epidemics.

We have first considered a SIR model with birth and death terms and time-varying infectivity parameter $\beta(t)$. In the particular case of a sinusoidal parameter, we showed that the average Basic Reproduction Number R_o, introduced in [Bacaër $\&$ Guernaoui, 2006], is not the only relevant parameter and we emphasized the rôle played by the initial phase, the amplitude and the period. For a (general) periodic infectivity parameter $\beta(t)$ a periodic orbit exists, as already proved in [Katriel, 2014]. In the case of a slowly varying $\beta(t)$ an approximation of such a solution is given, which is shown to be asymptotically stable under an extra assumption on the slowness of $\beta(t)$. For a non necessarily periodic $\beta(t)$, all the trajectories of the system are proved to be attracted into a tubular region around a suitable curve, which is then an approximation of the underlying attractor. Numerical simulations are given [68].

In other to study the effects of urban human mobility on Dengue epidemics, we have considered a SIR-network model (still with birth and death rates). The same model without these rates was introduced in [72].

In the case of constant infection rates, we first examine networks of two nodes. For arbitrary network topologies, some general properties of the equilibrium points are obtained. Then for several specific topologies, we derive explicit expressions of multiple equilibrium points and characterize their stability properties. We extend the study to networks with an arbitrary number of nodes and obtain sufficient conditions for global asymptotic stability of the disease-free equilibrium point.

In the case of time-varying infection rates and networks of arbitrary number of nodes, we introduce a specific topology which leads to a simplification of the network: the dynamics of the total population is described by the classical SIR model. This fact, together with the results of the team on the SIR model, allows a complete characterization of the stability properties of the system, especially the approximation of the epidemic attractor.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

A collaboration with SNCF on the supervision and rescheduling of a mixed CBTC traffic on a suburban railway line is currently undergoing (CIFRE).

A collaboration with EDF on the control of renewable energy parks is undergoing (financial support of a PhD student).

A collaboration with CEA and ADEME on the modelling and control of district heating networks is undergoing (financial support of a PhD student).

9. Partnerships and Cooperations

9.1. Regional Initiatives

DIGITEO Project (DIM LSC) ALMA3

Project title: Mathematical Analysis of Acute Myeloid Leukemia (AML) and its treatments

September 2014 - August 2017

Coordinator: Catherine Bonnet

Other partners: Inria Paris-Rocquencourt, France, L2S, France, UPMC, St Antoine Hospital Paris

Abstract: this project follows the regional projects ALMA (2010-2014) and ALMA2 (2011-2013). Starting from the work of J. L. Avila Alonso's PhD thesis in ALMA the aim of this project was to provide a refined coupled model of healthy and cancer cell dynamics in AML whose (stability) analysis may enable evaluation of polychemiotherapies delivered in the case of AML which have a high level of Flt-3 duplication (Flt-3-ITD).

9.2. National Initiatives

9.2.1. 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).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: **ITN**

Project acronym: TEMPO

Project title: Training in Embedded Predictive Control and Optimization

Duration: January 2014 - January 2018

Coordinator: Tor Arne Johanson; with Sorin Olaru (as French PI)

Other partners: U. Frieburg, Oxford, Imperial College; NTNU Trondheim; STUBA Bratislava; EPFL Lausanne; KU Leuven, Renault, ABB, Ampyx Power

Abstract: TEMPO is an international PhD program for highly motivated young scientists, where state-of-the-art research is combined with a comprehensive training program. The network is funded by the European Communityâs Seventh Framework program. The European Commission wants to make research careers more attractive to young people and therefore offers early-stage researchers (ESRs) a PhD program the opportunity to improve their research skills, join established research teams and enhance their career prospects via the Marie Curie Initial Training Networks (ITN) in the area of Embedded Predictive Control and Optimization.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: **PHC BOSPHORE 2016 (Turkey)**

Project title: Robust Control of Time Delayed Linear Parameter Varying Systems via Switched Controllers.

Duration: January 2016 - December 2017

Coordinator: Frédéric Mazenc (France), Hitay Özbay (Turkey).

Abstract: The main goal of this project is to develop computational algorithms for robust controller design for different classes of time delay systems appearing in various engineering applications such as chemical processes, transportation systems and communications networks. The participants will consider control problems of significant practical implications in this area: (i) developing new computational techniques for simple (low order) reliable and scalable decentralized controllers for control of (and control over) networks; and (ii) reducing conservatism in recently developed dwell-time based stability results for the analysis of switched time delay systems. Moreover, design of scalable low order controllers for reducing the effect of time delays is an important problem investigated in this project. One of the objectives of this collaboration is to generalize the design techniques already developed by the French and Turkish teams to larger classes of time delay systems, in particular multi-input-multi-output (MIMO) systems with time varying delays.

Program: **PHC BRANCUSI 2017 (Romania)**

Project acronym: ProCo

Project title: Systems with propagation: New approaches in control design for oscillation quenching

Duration: January 2016 - December 2018

Coordinator: Islam Boussaada (France) et Daniela Danciu (Romania)

Abstract: The project aims to building a unitary framework for the modeling, the analysis and the control of distributed-parameters systems (DPS) described by hyperbolic partial differential equations in one space variable and non-standard boundary conditions. This main objectives are modeling of DPS and the corresponding functional differential equations, the construction of reduced-order models approximating DPS by both numerical and computational modeling, the design of new control methods for oscillations quenching in DPS.

Program: **PHC CARLSO FINLEY 2017 (Cuba)**

Project title: MODELISATION ET COMMANDE POUR LE PROCESSUS DE CRYOCONSERVATION.

Duration: June 2017 - December 2017

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.

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.

9.4. International Initiatives

Catherine Bonnet is the co-supervisor together with André Fioravanti of a PhD student of Unicamp (Brazil).

Frédéric Mazenc is the co-supervisor together with Hitay Ozbay of a PhD Student of Bilkent University (Turkey).

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- College of Mathematics and Information Science, Shaanxi Normal University, China
- School of Control Science and Engineering, Dalian University of Technology, Dalian, China
- 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

9.4.2. Participation in Other International Programs

9.4.2.1. International Initiatives

STADE

Title: Stability and Dichotomies in Differential Equations (Ordinary & Delay).

International Partners (Institution - Laboratory - Researcher):

Universidad de Chile (Chile) - Mathematics Department - Gonzalo Robledo

Universidad de la Republica Uruguay (Uruguay) - Faculty of Engineering - Pablo Monzon

Duration: 2016 - 2017

Start year: 2016

See also: http://www.stade.cl/pages/list.html

The ship-flags of this project are the concepts of dichotomy and stability in an ODE & DDE framework. We intend to study some theoretical and applied problems involving these concepts and its relations. In particular, converse stability results (expressed in the existence of density functions), feedback stabilization, stability in delay differential equations and some applications to bioprocesses.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Stefanella Boatto, Federale University Rio de Janeiro, Brazil, 1 January-31 December.

André Fioravanti, UNICAMP, Sao Paulo, Brazil, 7 January-28 February.

Yutaka Yamamoto, Kyoto University, Japan, 17 May -2 August.

Hitay Ozbay, Bilkent University, Turkey, 15 November 2017 - 18 November 2017.

9.5.2. Visits to International Teams

Stefanella Boatto visited the Department of Mathematics, Universidade de Lisboa, Portugal, 19-23 June 2017.

Frédéric Mazenc visited the Department of Mathematics of the Louisiana State University, Baton Rouge USA, 2 April - 14 April 2017, the Departamento de Ingeniaria de Control y Robotico of the Universidad Nacional Autonoma de Mexico, Mexico-city 14 August 2017 - 16 August and 18 August - 27 August 2017, the Laboratoire Franco-Mexicain d'Informatique et d'Automatique (LAFMIA), Mexico-City, 17 August 2017, Universidad de Chile, Santiago de Chile, 15 October 2017 to 28 October 2017.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. Member of the Organizing Committees

- Frederic Mazenc has organized with Pablo Monzon, Alvaro Castaneda and Gonzalo Robledo the "Workshop and Spring School on Stability and Dichotomies on Differential and Delay Equations" of the Universidad de Chile, Facultad de Ciencias, October 17-26, 2017.

10.1.2. Scientific Events Selection

- Frederic Mazenc and Ali Zemouche were Associate Editor for the conferences 2018 American Control Conference, Milwaukee, USA, and the 56th IEEE Conference on Decision and Control, Melbourne, USA, (2017).
- Frederic Mazenc was Associate Editor for the European Control Conference, Limassol, Cyprus (2018).
- Ali Zemouche has co-organized three invited sessions in international conferences (*IEEE−ACC 2018*, *Workshop on Advanced Control and Diagnosis, ACD 2017*, *International Conference on Systems and Control, ICSC 2017*).

10.1.2.1. Chair of Conference Program Committees

- Ali Zemouche was an invited session chair of the "14th International Workshop on Advanced Control and Diagnosis, ACD 2017", which was held at Politehnica University of Bucharest, Romania, from 16 to 17 November 2017.
- International Society of Difference Equations (ISDE) Board of Directors has favorably voted for the proposal submitted by Sorin Olaru to organize the International Conference on Difference Equations and Applications (ICDEA) in 2021 in Paris Saclay.
- Guillaume Sandou is a member of the Program Committee of the IEEE Symposium on Computational Intelligence in Production and Logistics Systems, 2017, Hawai, USA

10.1.2.2. Member of the Conference Program Committees

- Catherine Bonnet was a member of the *Comité International Scientifique* de MADEV17, Rabat, Marocco.
- Frederic Mazenc is member (Associate Editor) of the *Control Editorial Board - IEEE - CSS*.
- Ali Zemouche is member (Associate Editor) of the *Control Editorial Board - IEEE - CSS*.
- Ali Zemouche was involved in the Technical Program Committee and International Program Committee of the following international conferences:
  - IEEE American Control Conference, ACC 2017;
  - Workshop on Advanced Control and Diagnosis, ACD 2017;
  - International Conference on Systems and Control, ICSC 2017;
  - Australian and New Zealand Control Conference, ANZCC 2017;
  - International Conference on Electrical Engineering and Control Applications, ICEECA 2017.

10.1.2.3. 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.

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

Frederic 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 member of the editorial boards (Associate Editor) of the following journals:

- IMA Journal of Mathematical Control and Information;
- IEEE CSS-Letters.

Ali Zemouche is member of the editorial boards (Associate Editor) of the following journals:

- SIAM Journal on Control and Optimization;
- European Journal of Control;
- Cogent Engineering.
- Managing Guest Editor for a **Special Issue** in European Journal of Control
  - *Title:* Advanced Control and Observers for Complex Systems via LMIs
  - *Organizers:* *Ali Zemouche et al.*
  - *url:* *https://www.journals.elsevier.com/european-journal-of-control/call-for-papers/special-issue-on-advanced-control-and-observer-design-for-no*

10.1.3.2. 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.

10.1.4. Invited Talks

Stefanella Boatto gave a talk entitled *'Modeling epidemics dynamics due to Aedes mosquitoes : the example of Rio de Janeiro and how to approximate an epidemic attractor*, Université de Bordeaux, 22 Dec 2017, a talk entitled *'The N-body pronlem on surfaces, Maxwell laws and the axioms of Mechanics'*, Fluid mechanics seminar, Dept. Mechanical Engineering , Universitat Rovira i Virgili, Tarragona, Spain, 30 June 2017, a talk entitled *'SIR-Network model : epidemics dynamics in a city & climate variations'*, Seminar of Analysis and Differential Equations, Dept. of Mathematics, University of Lisbon, Portugal, 20 June 2018, a talk entitled *' The N-body pronlem on surfaces, Maxwell laws and the axioms of Mechanics'*, IA Seminar, Physics Dept., Universirsity of Lisbon, Portugal 22 June 2017, Vortex Dynamics Group, a talk entitled *"N-body on surfaces of revolution: the rôle played by curvature and topology '*, School of Mathematics and Statistics, University of St. Andrews, UK, February 2017.

Catherine Bonnet and Frédéric Mazenc gave a talk entitled *'Modeling and Analysis of Cell Dynamics in Acute Myeloid Leukemia*, Institute of Disease Modeling, Seattle, USA, 30 May 2017.

Ali Zemouche gave a talk entitled *'Nonlinear observer design for Lipschitz systems'*, University of Toulon (IUT de Toulon, France).

Ali Zemouche gave a talk entitled *'Observer-based stabilization of uncertain nonlinear systems via LMIs'*, Deakin University (Geelong, Australia).

Frédéric Mazenc gave a talk entitled *Model reduction and predictor control*, the Departamento de Ingeniaria de Control y Robotico of the Universidad Nacional Autonoma de Mexico, Mexico-city, August 2017.

Frédéric Mazenc gave several talks and lectures to the "Workshop and Spring School on Stability and Dichotomies on Differential and Delay Equations" of the Universidad de Chile, Facultad de Ciencias, Santiago de Chile, October 17-26, 2017.

Frédéric Mazenc was one of the speakers of the tutorial session entitled "Tutorial on time-delay and sampled-data systems" organized by Alexandre Seuret and Emilia Fridman in the IFAC World Congress of Toulouse, 9-14 July 2017. The title of his talk was *Model reduction and predictor control*.

10.1.5. Leadership within the Scientific Community

Catherine Bonnet is a member of the IFAC Technical Committees *Distributed Parameter Systems* and *Biological and Medical Systems*. She is a member of the SIAG/CST (SIAM Activity group Control System Theory) steering committee (2015-2017) and a member of the management committee of the COST Action FRACTAL (2016-2020).

Sorin Olaru is a member of the IFAC Technical Committees *Robust Control* and the IFAC CSS TC on *hybrid systems*.

Ali Zemouche is member of the IFAC Technical Committee *Non-Linear Control Systems*.

10.1.6. 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 a, 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 a, expert for the Romanian National Council for Development and Innovation (Romania). His mission consists in evaluating research projects funded by the this institution.

10.1.7. 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).

In 2017, Frédéric Mazenc was president of the commission scientifique du CRI Saclay-Ile-de-France. In 2017, Frédéric Mazenc was member of the Bureau du Comité des Projets 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/

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

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

Licence : Walid Djema, Computer Architecture and Assembly Programming, 40h, L1, University Paris-Saclay

Licence : Walid Djema, Computer Sciences project, 24h, L1, University Paris-Saclay

Master : Dina Irofti, Industrial IT services, Java, Networks, 64h, M1 and M2 University Paris-Sud

Master : Dina Irofti, Control Theory, Mathematics and Numericam Analysis, M1, 54h, ESIEE

Doctorat : Frederic Mazenc, introduction to the ordinary differential equations, Lypunov design, control and observation of nonlinear dynamical systems, 21h, PhD, International Graduate School on Control of the EECI, CentraleSupelec

Doctorat : Frederic Mazenc, Stability and Dichotomies on Differential and Delay Equations, 3 h, PhD, Universidad de Chile, Facultad de Ciencias

Licence : Sorin Olaru, Automatic Control, 8h , M1, SUPELEC, France

Licence : Sorin Olaru, Signals and systems, 8h , L3, SUPELEC, France

Licence : Sorin Olaru, Embedded systems, 8h , M1, Centrale Paris, France

Licence : Sorin Olaru, Numerical methods and Optimization, 24h, niveau M1, SUPELEC, France

Licence : Sorin Olaru, Hybrid systems, 16h, M2, SUPELEC, France

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

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

DUT : Ali Zemouche, Java Programing, 24 HTD, 2$^{\text{éme}}$ année DUT (Bac + 2), University of Lorraine, France

10.2.2. Supervision

PhD in progress : Saeed Ahmed, Bilkent University, Stability analysis and control of switched systems with time-delay. Supervisor : Hitay Ozbay. Co-supervisor : 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 : Caetano Cardeliquio, Stability and stabilization of (possibly fractional) systems with delays. French Supervisor : Catherine Bonnet, Brazilian Supervisor : André Fioravanti.

PhD : Walid Djema, Understanding Cell Dynamics in Cancer from Control and Mathematical biology Standpoints - Particular Insights in the Modeling and Analysis Aspects in Hematopoietic Systems and Leukemia, Université Paris-Saclay, 21 November 2017. Supervisor : Catherine Bonnet. Co-supervisors : Jean Clairambault and Frédéric Mazenc.

PhD : Dina Irofti, Delay effects: a journey from multi-agent systems to genetic networks, Université Paris-Saclay, 18 July 2017. Supervisor : Silviu Niculescu. Co-supervisor : Islam Boussaada.

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. Supervisor: Soufienne Bouallegue, Joseph Haggége et Guillaume Sandou.

PhD in progress : 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.

PhD in progress : Juliette Pochet, Analyse de performance et de résilience d'une ligne de type RER équipée d'un automatisme CBTC. Analysis of the performance of a RER line with CBTC trains. Supervisor: Guillaume Sandou.

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.

10.2.3. Juries

Catherine Bonnet was a member of several recruiting committees: Junior Researcher competition in Inria Grenoble - Rhône-Alpes and Bordeaux - Sud-Ouest and Professor competition at Université de Nancy.

Catherine Bonnet was the President of the PhD Defense juries of Yacine Boukal *'Observation et commande des systèmes dynamiques d'ordre non entier'*, 16 October 2017, Université de Nancy and of Jin Chi *'Stability analysis of systems with delay-dependant coefficients'*, L2S, CentraleSupelec, 21 November 2017.

Sorin Olaru was a reviewer for the PhD thesis of JULIAN BARREIRO GOMEZ at Universiy of Catalunya in Barcelona.

Sorin Olaru was a reviewer of the HDR thesis of Christophe Louembet.

Guillaume Sandou was a reviewer of Khaleb Laib PhD, Analyse hierarchisee de a robustesse des systemes incertains de grade dimension.

Guillaume Sandou was a reviewer of Damien Casetta PhD, Modele d'aide à la conduite de réseaux de froid.

Frederic Mazenc was a reviewer of the PhD thesis of Mohamed Maghenem, *'Commande en formation de véhicules autonomes'* 05 July 2017, L2S, Centralesupelec.

Frederic Mazenc was a reviewer of the PhD thesis of Luis Borja Rosales, *'Stabilization of a class of nonlinear systems with passivity properties'*, 06 July 2017, L2S, Centralesupelec.

Frederic Mazenc was a reviewer of the PhD thesis of first half of the Phd ("suivi mi-parcours") of Mohamed Kahelras, *'Observation Problem for Different Classes of Nonlinear Delayed Systems'*, 9 October 2017, L2S, Centralesupelec.

10.3. Popularization

Catherine Bonnet gave a talk in the *Promenades Mathématiques* series of the event *Femmes en maths : une équation lumineuse* for female high school students, IHP, Paris, 19 december 2017. She met several groups of female high school students at the event *Femmes en maths : une équation lumineuse* IHP, Paris, january 2017. She met several groups of high school students at the event *Forum des métiers* in Lycée Hoche, Versailles, February 2017.

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