IN PARTNERSHIP WITH:
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Activity Report 2016

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

The team is located at L2S, CentraleSupelec.

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1. Members

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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. Modeling of complex environment

We want to model phenomena such as a temporary loss of connection (e.g. synchronisation of the movements through haptic interfaces), a nonhomogeneous environment (e.g. case of cryogenic systems) or the presence of the human factor in the control loop (e.g. grid systems) but also problems involved with technological constraints (e.g. range of the sensors). The mathematical models concerned include integro-differential, partial differential equations, algebraic inequalities with the presence of several time scales, whose variables and/or parameters must satisfy certain constraints (for instance, positivity).

3.2. Analysis of interconnected systems

- 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. [66]). 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.

3.3. 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.

3.4. 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 epidemia.

4.2. Energy Management

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

5. New Results

5.1. Characterizing the Codimension of Zero Singularities for Time-Delay Systems: A Link with Vandermonde and Birkhoff Incidence Matrices

Participants: Islam Boussaada, Silviu-Iulian Niculescu.

The analysis of time-delay systems mainly relies on detecting and understanding the spectral values bifurcations when crossing the imaginary axis. We have dealed with the zero singularity, essentially when the zero spectral value is multiple. The simplest case in such a configuration is characterized by an algebraic multiplicity two and a geometric multiplicity one, known as the Bogdanov-Takens singularity. Moreover, in some cases the codimension of the zero spectral value exceeds the number of the coupled scalar-differential equations. Nevertheless, to the best of the author's knowledge, the bounds of such a multiplicity have not been deeply investigated in the literature. It is worth mentioning that the knowledge of such an information is crucial for nonlinear analysis purposes since the dimension of the projected state on the center manifold is none other than the sum of the dimensions of the generalized eigenspaces associated with spectral values with zero real parts. Motivated by a control-oriented problems, we have provided an answer to this question for time-delay systems, taking into account the parameters' algebraic constraints that may occur in applications. We emphasize the link between such a problem and the incidence matrices associated with the Birkhoff interpolation problem. In this context, symbolic algorithms for LU-factorization for functional confluent Vandermonde as well as some classes of bivariate functional Birkhoff matrices are also proposed [11].

5.2. Tracking the Algebraic Multiplicity of Crossing Imaginary Roots for Generic Quasipolynomials: A Vandermonde-Based Approach

Participants: Islam Boussaada, Silviu-Iulian Niculescu.

A standard approach in analyzing dynamical systems consists in identifying and understanding the eigenvalues bifurcations when crossing the imaginary axis. Efficient methods for crossing imaginary roots identification exist. However, to the best of the author's knowledge, the multiplicity of such roots was not deeply investigated. We have emphasized [12] that the multiplicity of the zero spectral value can exceed the number of the coupled scalar delay-differential equations and a constructive approach Vandermonde-based allowing to an adaptive bound for such a multiplicity is provided. Namely, it is shown that the zero spectral value multiplicity depends on the system structure (number of delays and number of non zero coefficients of the associated quasipolynomial) rather than the degree of the associated quasipolynomial. We have extended the constructive approach in investigating the multiplicity of crossing imaginary roots $j\omega$ where $\omega \neq 0$ and establishes a link with a new class of functional confluent Vandermonde matrices. A symbolic algorithm for computing the LU-factorization for such matrices is provided. As a byproduct of the proposed approach, a bound sharper than the Polya-Szegö generic bound arising from the principle argument is established.

5.3. Coprimeness of fractional representations

Participants: Catherine Bonnet, Le Ha Vy Nguyen, Yutaka Yamamoto [Kyoto Univ].

Coprimeness of a fractional representation plays various crucial roles in many different contexts, for example, stabilization of a given plant, minimality of a state space representation, etc. It should be noted however that coprimeness depends crucially on the choice of a ring (or algebra) where such a representation is taken, which reflects the choice of a plant, and particular problems that one studies. Such relationships are particularly delicate and interesting when dealing with infinite-dimensional systems. We have disucssed various coprimeness issues for different rings, typically for H_∞ and pseudorational transfer functions. The former is related to H_∞-stabilizability, and the latter to controllability of behaviors. We have also given some intricate examples where a seemingly non-coprime factorization indeed turns out to be a coprime factorization over H_∞ [28], [29].

5.4. Output-feddback control design for time-delay systems

Participants: Catherine Bonnet, Caetano Cardeliquio, Matheus Souza [FEEC-UNICAMP], André Fioravanti [FEM-UNICAMP].

We presented new results on H_∞-control synthesis, via output-feedback, for time-delay linear systems. We extend the use of a finite order LTI system, called comparison system, to design a controller which depends not only on the output at the present time and maximum delay, but also on an arbitrary number of values between those. This approach allows us to increase the maximum stable delay without requiring any additional information.

5.5. Backstepping control design through the introduction of delays

Participants: Frederic Mazenc, Michael Malisoff [LSU], Jerome Weston [LSU].

We provided new backstepping results for time-varying systems with input delays. The results were obtained by the introduction of constant 'artificial' pointwise delays in the input. Thus they are significantly different from backstepping results for systems with delay in the input as presented in previous contributions.

I) The novelty of the contribution in [18] is in the bounds on the controls, and the facts that (i) one does not need to compute any Lie derivatives to apply the proposed controls, (ii) the controls have no distributed terms, and (iii) no differentiability conditions on the available controls for the subsystems are needed. The latter aspect is of paramount importance from an applied point of view.

II) In [43], we extended [18]. We provided new globally stabilizing backstepping controls for single input systems in a partially linear form. Instead of measuring the full state, the feedbacks use current and several time lagged values of a function of the state of the nonlinear subsystem (and have no distributed terms). We also allowed input delays. This improves on [18], since we allowed an arbitrary number of integrators whereas [18] is limited to one integrator.

5.6. Switched Nonlinear Systems

Participants: Frederic Mazenc, Yue-E Wang [Shaanxi Normal University], Xi-Ming Sun [Dalian University of Technology].

We considered in [26] a class of nonlinear time-varying switched control systems for which stabilizing feedbacks are available. We analyzed the effect of the presence of a delay in the input of switched nonlinear systems with an external disturbance. By contrast with most of the contributions available in the literature, we did not assume that all the subsystems of the switched system we consider are stable when the delay is present. Through a Lyapunov approach, we derived sufficient conditions in terms of size of the delay, ensuring the global exponential stability of the switched system. Moreover, under appropriate conditions, the input-to-state stability of the system with respect to an external disturbance was established.

5.7. Studies of systems with long delays

Participants: Frederic Mazenc, Michael Malisoff [LSU], Emilia Fridman [Tel-Aviv University].

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.

I) We considered in [17] the problem of stabilizing a linear continuous-time system with discrete-time measurements and a sampled input with a pointwise constant delay. In a first part, we designed a continuous-discrete observer which converges when the maximum time interval between two consecutive measurements is sufficiently small. In a second part, we constructed a dynamic output feedback by using a technique which is strongly reminiscent of the so called 'reduction model approach'. It stabilizes the system when the maximal time between two consecutive sampling instants is sufficiently small. No limitation on the size of the delay was imposed and an ISS property with respect to additive disturbances was established.

II) We solved stabilization problems for linear time-varying systems under input delays. We showed how changes of coordinates lead to systems with time invariant drifts, which are covered by the reduction model method and which lead to the problem of stabilizing a time-varying system without delay. For continuous-time periodic systems, we used Floquet's theory to find the changes of coordinates. We also proved an analogue for discrete time systems, through an original discrete-time extension of Floquet's theory [19].

III) In [21] and [42], we proposed a prediction based stabilization approach for a general class of nonlinear time-varying systems with pointwise delay in the input. It is based on a recent new prediction strategy, which makes it possible to circumvent the problem of constructing and estimating distributed terms in the expression for the stabilizing control laws. We observed that our result applies in cases where other recent results do not, including notably the case where a time-varying delay is present.

5.8. Extension of the Razumikhin's theorem

Participants: Frederic Mazenc, Michael Malisoff [LSU].

The Razumikhin's Theorem is a major extension of the Lypunov function theory, making possible to establish the global asymptotic stability of nonlinear systems with delays. It is especially efficient when the delays are time-varying. We provide in [41] an extension of this theorem for continuous-time time-varying systems with time-varying delays. Our result uses a novel 'strictification' technique for converting a nonstrict Lyapunov function into a strict one. Our examples show how our method can sometimes allow broader classes of allowable delays than the results in the literature.

5.9. Observer design for nonlinear systems

Participant: Ali Zemouche.

A new high-gain observer design method with lower gain compared to the standard high-gain observer was proposed. 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. The aim of this research is the application of this new observer design to estimate some vehicle variables in autonomous vehicle applications.

5.10. Set invariance for discrete-time delay systems

Participants: Sorin Olaru, Mohammed Laraba [L2S], Silviu Niculescu, Franco Blanchini [Univ. Udine, Italy], Stefano Miani [Univ. Udine, Italy].

The existence of positively invariant sets for linear delay-difference equations was pursued in [15]. We made a survey effort and presented in a unified framework all known necessary and/or sufficient conditions for the existence of invariant sets with respect to dynamical systems described by linear discrete time-delay difference equations (dDDEs). Secondly, we address the construction of invariant sets in the original state space (also called D-invariant sets) by exploiting the forward mappings. The notion of D-invariance is appealing since it provides a region of attraction, which is difficult to obtain for delay systems without taking into account the delayed states in some appropriate extended state space model. The paper contains a sufficient condition for the existence of ellipsoidal D-contractive sets for dDDEs, and a necessary and sufficient condition for the existence of D-invariant sets in relation to linear time-varying dDDE stability. Another contribution is the clarification of the relationship between convexity (convex hull operation) and D-invariance of linear dDDEs. In short, it is shown that the convex hull of the union of two or more D-invariant sets is not necessarily D-invariant, while the convex hull of a non-convex D-invariant set is D-invariant. Positive invariance is an essential concept in control theory, with applications to constrained dynam-ical systems analysis, uncertainty handling as well as related control design problems. It serves as a basic tool in many topics, such as model predictive control, fault tolerant control and reference governor design. Furthermore, there exists a close link between classical stability theory and positive invariant sets. It is worth mentioning that, in Lyapunov theory, invariance is implicitly described.

5.11. Interpolation-based design for constrained dynamical systems

Participants: Sorin Olaru, Nam Nguyen [IFP, France], Per Olof Gutman [Technion, Israel].

A technique is presented in [49] leading to an explicit state feedback solution to the regulation problem for uncertain and/or time-varying linear discrete-time systems with state and control constraints. A piecewise affine control law is provided which not only guarantees recursive feasibility and robust asymptotic stability, but is also optimal for a region of the state space containing the origin.

5.12. Inverse optimality results for constrained control

Participants: Sorin Olaru, Ngoc Anh Nguyen [L2S], Pedro Rodriguez [L2S], Morten Hovd [NTNU Trondheim, Norway], Ioan Necoara [Univ. Politehnica Bucharest, Romania].

Parametric convex programming has received a lot of attention, since it has many applications in chemical engineering, control engineering, signal processing , etc. Further, inverse optimality plays an important role in many contexts, e.g., image processing, motion planning. In this context we introduced [10] a constructive solution of the inverse optimality problem for the class of continuous piecewise affine functions. The main idea is based on the convex lifting concept. Accordingly, an algorithm to construct convex liftings of a given convexly liftable partition have been put forward. Continuous piecewise affine function defined over a polytopic partition of the state space are known to be obtained as the solution of a parametric linear/quadratic programming problem. Regarding linear model predictive control, is shown that any continuous piecewise affine control law can be obtained via a linear optimal control problem with the control horizon at most equal to 2 prediction steps.

5.13. Robustness and fragility of Piecewise affine control laws

Participants: Sorin Olaru, Ngoc Anh Nguyen [L2S], Pedro Rodriguez [L2S], Morten Hovd [NTNU Trondheim, Norway], Georges Bitsoris [Univ. Patras, Greece].

We focus in [9]on the robustness and fragility problem for piecewise affine (PWA) control laws for discrete-time linear system dynamics in the presence of parametric uncertainty of the state space model. A generic geometrical approach will be used to obtain robustness/fragility margins with respect to the positive invariance properties. For PWA control laws defined over a bounded region in the state space, it is shown that these margins can be described in terms of polyhedral sets in parameter space. The methodology is further extended to the fragility problem with respect to the partition defining the controller. Finally, several computational aspects are presented regarding the transformation from the theoretical formulations to explicit representations (vertex/halfspace representation of polytopes) of these sets.

5.14. Distributed robust model predictive control

Participants: Sorin Olaru, Alexandra Grancharova [Technical University of Sofia, Bulgaria].

We presented in a suboptimal approach to distributed closed-loop min-max MPC for uncertain systems consisting of polytopic subsystems with coupled dynamics subject to both state and input constraints. The approach applies the dynamic dual decomposition method and reformulates the original centralized min-max MPC problem into a distributed optimization problem. The suggested approach was illustrated on a simulation example of an uncertain system consisting of two interconnected polytopic subsystems.

5.15. Algebraic Analysis Approach to Linear Functional Systems

Participants: Guillaume Sandou, Mohamed Lotfi Derouiche [Ecole nationale d'Ingénieurs de Tunis], Soufiene Bouallegue [Ecole nationale d'Ingénieurs de Tunis], Joseph Haggège Derouiche [Ecole nationale d'Ingénieurs de Tunis].

In this study, a new Model Predictive Controller (MPC) parameters tuning strategy is proposed using a LabVIEW-based perturbed Particle Swarm Optimization (pPSO). This original LabVIEW implementation of this metaheuristic algorithm is firstly validated on some test functions in order to show its efficiency and validity. The optimization results are compared with the standard PSO approach. The parameters tuning problem, i.e. the weighting factors on the output error and input increments of the MPC algorithm, is then formulated and systematically solved, using the proposed LabVIEW pPSA algorithm. The case of a Magnetic Levitation (MAGLEV) system is investigated to illustrate the robustness and superiority of the proposed pPSO-based tuning MPC approach. All obtained simulation results, as well as the statistical analysis tests for the formulated control problem with and without constraints, are discussed and compared with the Genetic Algorithm Optimization (GAO)-based technique in order to improve the effectiveness of the proposed pPSA-based MPC tuning methodology derouiche:hal-01347041.

5.16. Attitude dynamics, control and observation

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

In [27], we addressed the rigid-body attitude tracking problem in the absence of angular velocity measurements. To achieve proportional-derivative feedback control, an angular velocity observer with global exponential convergence was designed based on the Immersion and Invariance (I&I) method. A dynamic scaling factor was introduced to circumvent the integrability condition typically arising in I&I design. Unlike the existing I&I observer for this problem, the estimated angular velocity is defined using a rotation matrix of the current quaternion state to avoid use of an additional filter for the angular velocity estimate. As a result, stability analysis became less complex and the observer structure was further simplified by efficient handling of the Coriolis effect in the observer error dynamics. In the case where proportional-derivative control is combined with the observer, asymptotic convergence of tracking errors was proved while establishing a separation property. Numerical simulations were provided to demonstrate the performance of the proposed observer and the output feedback controller.

5.17. Estimation for vehicle application

Participants: Ali Zemouche, Rajesh Rajamani [University of Minneapolis, USA], Gridsada Phanomchoeng [Chulalongkorn University, Thailand].

A new LMI (Linear Matrix Inequality) design technique is developed to address the problem of circle criterion based $\mathcal{H}_\infty$ observer design for nonlinear systems. The developed technique applies to both locally Lipschitz as well as monotonic nonlinear systems, and allows for nonlinear functions in both the process dynamics and output equations. The LMI design condition obtained is less conservative than all previous results proposed in literature for these classes of nonlinear systems. By judicious use of a modified 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. This application was the main motivation of this work.

5.18. Observer-based stabilization for lateral vehicle control

Participants: Ali Zemouche, Rajesh Rajamani [University of Minneapolis, USA], Yan Wang [University of Minneapolis, USA].

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. 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. A vehicle lateral control problem was presented to demonstrate the applicability of the proposed algorithm to a real-world estimated state feedback control design.

5.19. Unified model for low-cost high-performance AC drives: the equivalent flux concept

Participants: Guillaume Sandou, Mohamad Koteich [Renault], Abdelmalek Maloum [Renault], Gilles Duc [CentraleSupélec].

This study presents a unified modeling approach of alternating current (AC) machines for low-cost high-performance drives. The Equivalent Flux concept is introduced. Using this concept, all AC machines can be seen as a non-salient synchronous machine with modified (equivalent) rotor flux. Therefore, complex salient-rotor machines models are simplified, and unified shaft-sensorless AC drives can be sought. For this purpose, a unified observer-based structure for rotor-flux position and speed estimation is proposed. The equivalent flux concept generalizes the existing concepts, such as the extended back-electromotive force, the fictitious flux and the active flux.

5.20. Supervision and rescheduling of a mixed CBTC traffic on a suburban railway line

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

Railway companies need to achieve higher capacities on existing infrastructures such as high density suburban mainlines. Communication based train control (CBTC) systems have been widely deployed on dedicated subway lines. However, deployment on shared rail infrastructure, where CBTC and non-CBTC trains run, leads to a mixed positioning and controlling system with different precision levels and restrictions. New performance and complexity issues are to arise. In this study, a method for rescheduling adapted to a CBTC system running in a mixed traffic, is introduced. The proposed method is based on a model predictive control (MPC) approach. In each step, an enhanced genetic algorithm with new mutation mechanisms solves the problem to optimize the cost function. It determines the dwell times and running times of CBTC trains, taking into account the non-CBTC trains planning and fixed-block localization. In addition, reordering can be allowed by modifying the problem constraints. The work is supported by a simulation tool developed by SNCF and adapted to mixed traffic study. The approach is illustrated with a case study based on a part of an East/West line in the Paris region network, proving the ability of the method to find good feasible solutions when delays occur in traffic [46].

5.21. Combined Feedback Linearization and MPC for Wind Turbine Power Tracking

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

The problem of controlling a variable-speedvariable-pitch wind turbine in non conventional operating points is addressed.We aim to provide a control architecture for a general active power tracking problem for the entire operating envelope. The presented control enables to cope with system non linearities while handling state and input constraints, and avoiding singular points. Simulations are carried out based on a 600 kW turbine parameters. Montecarlo simulation shows that the proposed controller presents a certain degree of robustness with respect to the system major uncertainties [36].

5.22. Hierarchical Control of a Wind Farm for Wake Interaction Minimization

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

The problem of controlling a wind farm for power optimization by minimizing the wake interaction among wind turbines is addressed. We aim to evaluate the real gain in farm power production when the dynamics of the controlled turbines are taken into account. The proposed local control enables the turbines to track the required power references in the whole operating envelope, and under the major uncertainties of the system. Simulations are carried out based on a wind farm of 600 kW turbines and they show the actual benefit of considering the wake effect in the optimization algorithm [54].

5.23. Control of a model of chemostat with delay

Participants: Frederic Mazenc, Michael Malisoff [LSU], Jerome Harmand [INRA].

We provided in [39] a new control design for models of chemostats, under constant substrate input concentrations, using piecewise constant delayed measurements of the substrate concentration. The growth functions can be uncertain and are not necessarily monotone. The dilution rate is the control. We used 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.

5.24. 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.

ALMA project focuses on analysis of healthy and unhealthy blood cell production. Dynamics of cell populations are modeled and mathematically analyzed in order to explain why some pathological disorders may occur. 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. This year, we have progressed on this line [35] and particular emphasis has been placed on a new generation of differential systems, coupled to algebraic equations, modeling abnormal proliferation as observed in acute myeloid leukemia [65]. We have developed, in [34], Lyapunov-like techniques in order to derive global or local exponential stability conditions for that class of differential-difference hematopoietic models. A new model describing the coexistence between ordinary and mutated hematopoietic stem cells was introduced and analyzed in [33]. Above all, this was about giving theoretical conditions to guarantee the survival of healthy cells while eradicating unhealthy ones. Interpretation of mathematical results leads us to provide possibly innovative therapies by combining drugs infusions. By continuing on the path of models coupling healthy and malignant cells, we proposed a framework to investigate the phenomena of tumour dormancy, which goes beyond leukemias, to cover all types of cancer. Finally, in a recent study, we highlighted the role played by growth factors -hormone-like molecules- on the regulation of various biological features involved in hematopoietic mechanisms; that we interpret in the framework of switching systems with distributed delays.

5.25. Ananlysis of Dengue Fever SIR Model with time-varying parameters

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

Dengue fever is an infectious viral disease occuring 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 worldwilde. We have considered here a SIR model of Dengue fever with a periodically time-dependent infection rate. Such a model has been considered by other authors before but we focused here on different aspects such as the existence of a periodic stable orbit and the importance of the phase of the infection rates.

6. Bilateral Contracts and Grants with Industry

6.1. Bilateral Contracts with Industry

A collaboration with SAGEM Défense Sécurité on the stabilization of the lines of sight for pointing systems from optronic criterion using Bayesian optimization ended in December 2016 (CIFRE).

A collaboration with Renault on the observability study of AC machines ended in May 2016 (CIFRE).

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 anc control of district heating networks is undergoing (financial support of a PhD student).

7. Partnerships and Cooperations

7.1. 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 is to provide a refined coupled model of healthy and cancer cell dynamics in AML whose (stability) analysis will enable evaluation of polychemiotherapies delivered in the case of AML which have a high level of Flt-3 duplication (Flt-3-ITD).

7.2. National Initiatives

7.2.1. 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 Supélec and gathers about 20 people (academic and industrial researchers, PhD students, post-doctoral researchers).

7.3. European Initiatives

7.3.1. 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.

Program: IEF

Project acronym: FUTURISM

Project title: Multiple sensor FaUlt ToleRant control for management of Interconnected nonlinear SysteMs

Duration: May 2014 - April 2016

Coordinator: Sorin Olaru

Abstract: The primary research objective of this project is the design and analysis of novel methods for diagnosing multiple sensor faults and compensating their effects on multi-sensory schemes used for controlling interconnected, nonlinear systems. The second main objective of this project is the application of these methods to complex systems.

7.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: PHC STEFANIK 2016 (Slovakia)

Project acronym: AIMPC

Project title: Advanced techniques for practical implementation of model predictive control strategies

Duration: January 2016 - December 2017

Coordinator:Cristina Stoica (France), Martin Gulan (Slovakia)

Abstract: The proposed project is dedicated to the model predictive control with a particular emphasis on its practical implementations. The main objective is to explore new techniques allowing for an efficient deployment of control algorithms on embedded, preferably low-cost microcontrollerbased computing platforms. The inherent hardware memory/speed issues that become particularly challenging for fast real-time applications are to be addressed by appropriate acceleration and complexity reduction techniques targeting either the implicit or the explicit control laws while preserving the optimality of associated solutions. The run-time performance of the proposed control policies will be experimentally verified and monitored in chosen existing applications.

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: 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 favour scientific advancement in above mentioned areas by coordinating activities of academic research groups towards an efficient deployment of fractal theory to industry applications.

7.4. International Initiatives

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

Guillaume Sandou is the co-supervisor of a PhD student in the Ecole nationale d'ingénieur de Tunis, on the optimal tuning of MPC controllers using stochastic optimization methods.

7.4.1. Inria International Labs

7.4.1.1. 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

7.4.2. Participation in Other International Programs

7.4.2.1. 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.

7.5. International Research Visitors

Gonzalo Robledo, Universidad de Chile, Chile, $14/11 - 28/11$.

Hitay Ozbay, Bilkent University, $26/10 - 02/11$.

Saed Ahmed, Bilkent University, $04/12 - 16/12$.

7.5.1. Visits of International Scientists

Stefanella Boatto, Federale University Rio de Janeiro, Brazil, 2 October-23 December

André Fioravanti, UNICAMP, Sao Paulo, Brazil, 24 November-31 December

Emilia Fridman, Tel-Aviv University, Israel, 23-30 September

Yutaka Yamamoto, Kyoto University, Japan, 6 September-19 November

7.5.2. Visits to International Teams

7.5.2.1. Research Stays Abroad

Matsumae International Foundation (MIF) fellowship - 3 months research visit of Sorin Olaru (June-September 2016) to Kyushu Institute of Technology (Hosted by Prof. Hiroshi Ito).

Mitacs Globalink Research Award – 3 months research visit of Dina Irofti (July – October 2016) to University of Lethbridge, Alberta, Canada (hosted by Marc R. Roussel).

8. Dissemination

8.1. Promoting Scientific Activities

8.1.1. Scientific Events Organisation

8.1.1.1. General Chair, Scientific Chair

- Catherine Bonnet is together with Alexandre Chapoutot (ENSTA ParisTech) and Paolo Mason (L2S) the co-organizer of the Working Group Shy of Digicosme on the Plateau de Saclay.

- Catherine Bonnet was together with Alexandre Chapoutot and Laurent Fribourg (ENS Cachan) the co-organizer of the DigiCosme Spring School 2016 on Hybrid Systems, May 9-13, ENSTA ParisTech.

- Sorin Olaru was the Scientific organizer of the Workshop "Interpolation-based techniques for constrained control: from improved vertex control to robust model predictive control alternatives" at ECC 201

8.1.2. Scientific Events Selection

Frédéric Mazenc was Associate Editor for the conferences 2017 American Control Conference, Seattle, USA and the 55th IEEE Conference on Decision and Control, Las Vegas, USA, (2016).

Ali Zemouche was Associate Editor for the conferences 2017 American Control Conference, Seattle, USA, and the 55th IEEE Conference on Decision and Control, Las Vegas, USA, (2016).

8.1.2.1. Member of the Conference Program Committees

Catherine Bonnet was a member of the International Program Committee of the IFAC Conference on Time-Delay Systems - IFAC TDS2016.

Sorin Olaru was a member of the conference program committee: International Conference on System Theory, Control and Computing - ICSTCC 2016.

Guillaume Sandou was a member of the program committee of the 2016 IEEE Symposium on Computational Intelligence in Production and Logistics Systems, Athens, Greece.

Ali Zemouche was a member of the International Program Committee of the IFAC ACD16 Conference, Lille, November 2016.

Ali Zemouche is a member of the Technical Program Committee of the 2017 IEEE - ACC Conference, Seattle, May 2017.

8.1.2.2. Reviewer

The team reviewed many papers for international Conferences eg IEEE CDC 2016; IEEE ACC 2016, IFAC TDS 2016

8.1.3. Journal

8.1.3.1. Member of the Editorial Boards

Frédéric Mazenc is Member of the Mathematical Control and Related Fields editorial board.

Frédéric Mazenc is Member of the European Journal of Control editorial board.

Frédéric Mazenc is Associate Editor for the Asian Journal of control.

Frédéric Mazenc is Associate Editor for the Journal of Control and Decision.

Frédéric Mazenc is Associate Editor for IEEE Transactions on Automatic Control.

Sorin Olaru is a Member of the editorial board of IMA Journal of Mathematical Control and Information

Ali Zemouche is Member of the European Journal of Control editorial board.

Ali Zemouche is Associate Editor for SIAM Journal on Control and Optimization.

8.1.3.2. Reviewer - Reviewing Activities

The team reviewed many papers for international journals of mathematics, e.g. European Journal of Control, Automatica, IEEE Trans. Aut. Contr., SICON, IEEE Trans. on Control Systems Technology, Journal of Process Control, Asian Journal of Control, transactions on control systems and technology journal as well as a book for Springer.

8.1.4. Invited Talks

Frédéric Mazenc was a speaker of 'The 5th International Symposium on Positive Systems'. September 14th-16th 2016, Universita Campus Bio-Medico di Roma, Italy. Title of his talk: *Stability analysis of a differential-difference system through a linear Lyapunov functional design.*

Frédéric Mazenc was a plenary speaker of the workshop 'Stability and Control of Infinite-Dimensional Systems', 12-14 October 2016, Passau, Germany. Title of his talk: *New trajectory based approach for systems with delay: application to the reduction model technique.*

8.1.5. Leadership within the Scientific Community

Catherine Bonnet and Sorin Olaru are members of the IFAC Technical Committees Robust Control.

Catherine Bonnet is a member of the IFAC Technical Committees Distributed Parameter Systems and Non linear Control Systems. She is a member of the SIAG/CST (SIAM Activity group Control System Theory) steering committee.

For 'The 5th International Symposium on Positive Systems', September 14th-16th 2016, Universita Campus Bio-Medico di Roma, Frédéric Mazenc organized an invited session entitled *Positive systems with delay*.

8.1.6. Scientific Expertise

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

Catherine Bonnet has been an expert for ANR.

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.

8.1.7. Research Administration

Catherine Bonnet is a Management Committee member of the COST action *Fractional-order systems; analysis, synthesis and their importance for future design*, member of the board of Directors of the consortium Cap'Maths, of the administration council of the association *Femmes et Mathématiques*, of the Inria Parity Committee (created in 2015) and of the *Cellule veille et prospective* of Inria.

Frédéric Mazenc and Sorin Olaru are members of the Conseil du Laboratoire of Laboratoire des Signaux et Systèmes (L2S).

Frédéric Mazenc is president of the commission scientifique du CRI Saclay-Ile-de-France.

Frédéric Mazenc is member of the Bureau du Comité des Projets du CRI Saclay-Ile-de-France.

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

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

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

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

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

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

Master : Dina Irofti, Java programming, 40h, M2, Paris-Sud

Master : Dina Irofti, Industrial computing, 16h, M1, Paris-Sud

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

F. Mazenc: March 2016. Teaching (in English) for the *International Graduate School on Control* of the EECI (Master level). 21 hours). Subject : introduction to the ordinary differential equations, Lypunov design, control and observation of nonlinear dynamical systems.

8.2.2. 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. 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 in progress : Walid Djema, Analysis of an AML model enabling evaluation of polychemiotherapies delivered in the case of AML which have a high level of Flt-3 duplication (Flt-3-ITD). Supervisor : Catherine Bonnet. Co-supervisors : Jean Clairambault and Frédéric Mazenc.

PhD : Sophie Frasnedo, Optimisation globale des lois de commande des autodirecteurs sur critére optronique : application à un autodirecteur à double phase de stabilisation. Supervisors : Gilles Duc et Guillaume Sandou, soutenue le 6 décembre 2016

PhD in progress : Nicolo Gionfra, Optimisation du pilotage d'un parc d'énergies renouvelables avec stockage et du réseau de distribution sous-jacent. Supervisors: Houria Siguerdidjane et Guillaume Sandou.

PhD : Mohamad Koteich, Modélisation et Observabilité des Machines Electriques en vue de la commande sans capteur mécanique. Supervisors: Gilles Duc et Guillaume Sandou, soutenue le 18 mai 2016.

PhD in progress : Mohamed Lotfi Derouiche, Sur l'optimisation par métaheuristiques avancées de lois de commande prédictive non linéaire. Supervisor: Soufienne Bouallegue, Joseph Haggége 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. Supervisor: Guillaume Sandou.

8.2.3. Juries

Catherine Bonnet was a reviewer of the PhD thesis of Marine Jacquier entitled "*Mathematical modeling of the hormonal regulation of food intake and body weight - Application to caloric restriction and leptin resistance*", University of Lyon 1, February 5th 2016.

Catherine Bonnet was a member of several recruiting committees: Junior Researcher competition in Inria Grenoble - Rhône-Alpes, Senior Researcher competition at Inria, Professor competition at University of Perpignan, Preofessor competition at CentraleSupelec.

Frédéric Mazenc was a reviewer of the PhD thesis of Youssef Bourfia, entitled "*Modélisation et Analyse de Modèles en Dynamique Cellulaire avec Applications à des Problèmes Liés aux Cancers*", (University of Cadi Ayyad de Marrakech and University of Pierre et Marie Curie, December 28, 2016).

Frédéric Mazenc was an examiner of the HDR of Ali Zemouche, entitled "*State Observer Design and Stabilization of Nonlinear Systems via LMIs*". Centre de Recherche en Automatique de Nancy, UMR 7039 CNRS - Université de Lorraine, December 01, 2016.

Sorin Olaru has been appointed as evaluator for V. Grelet's PhD thesis at University of Lyon. The thesis was defended on February 18th 2016.

Guillaume Sandou was a reviewer of the PhD thesis Modélisation dynamique et gestion avancée de réseaux de chaleur, Loic Giraud, Université Grenoble Alpes

Guillaume Sandou was a member of the following PhD theses committees:

- Roman Le Goff Latimier, " *Gestion et dimensionnement d'une flotte de véhicules électriques associée Ã une centrale photovoltaique : co-optimisation stochastique et distribuée*", 26 septembre 2016.
- Sinziana Carloganu, "*Evaluation des produits d'effacements réalisés sur un ensemble de consommateurs d'électricité par identification d'un modéle global*", 8 décembre 2016.

Ali Zemouche was an examiner of two PhD theses under the supervision of Professor Hieu TRINH from Deakin University, Geelong, Australia:

- The PhD thesis of Minh Cuong Nguyen, entitled "*State Observer Design Methods for Lipschitz Time-Delay Systems*", Deakin University, Geelong, Australia, September 15, 2016.
- The PhD thesis of Ngoc Thanh Pham, entitled "*Robust Load Frequency Control of Interconnected Grids with Electric Vehicles*", Deakin University, Geelong, Australia, December 9, 2016.

9. Bibliography

Major publications by the team in recent years

[1] C. BONNET, J. PARTINGTON. *Analysis of fractional delay systems of retarded and neutral type*, in "Automatica", 2002, vol. 38, pp. 1133–1138

[2] C. BONNET, J. PARTINGTON. *Stabilization of some fractional delay systems of neutral type*, in "Automatica", 2007, vol. 43, pp. 2047–2053

[3] M. MALISOFF, F. MAZENC. *Constructions of Strict Lyapunov Functions*, Communications and Control Engineering Series, Springer-Verlag London Ltd., 2009

[4] F. MAZENC, P. BLIMAN. *Backstepping design for time-delay nonlinear systems*, in "IEEE Transactions on Automatic Control", January 2006, vol. 51, n^{o} 1, pp. 149–154

[5] W. MICHIELS, S.-I. NICULESCU. *Stability and Stabilization of Time-Delay Systems. An Eigenvalue-Based Approach*, Advances in Design and Control, SIAM: Philadelphia, 2007, vol. 12

[6] S.-I. NICULESCU. *Delay Effects on Stability: a Robust Control Approach*, Lecture Notes in Control and Information Sciences, Springer, 2001, vol. 269

[7] S. OLARU, D. DUMUR. *Avoiding constraints redundancy in predictive control optimization routines*, in "IEEE Trans. Automat. Control", 2005, vol. 50, n^{o} 9, pp. 1459–1465

[8] G. SANDOU. *Particle swarm optimization: an efficient tool for the design of automatic control law*, in "European Control Conference", Budapest, Hungary, August 23rd-26th 2009

Publications of the year

Articles in International Peer-Reviewed Journals

[9] N. ANH NGUYEN, S. OLARU, P. RODRIGUEZ-AYERBE, G. BITSORIS, M. HOVD. *Explicit robustness and fragility margins for linear discrete systems with piecewise affine control law*, in "Automatica", 2016, vol. 68, pp. 334-343 [*DOI :* 10.1016/J.AUTOMATICA.2015.10.048], https://hal-centralesupelec.archives-ouvertes.fr/hal-01408554

[10] N. ANH NGUYEN, S. S. OLARU, P. RODRIGUEZ-AYERBE, M. M. HOVD, I. I. NECOARA. *Constructive Solution of Inverse Parametric Linear/Quadratic Programming Problems*, in "Journal of Optimization Theory and Applications", 2016 [*DOI :* 10.1007/S10957-016-0968-0], https://hal-centralesupelec.archives-ouvertes.fr/hal-01408472

[11] I. BOUSSAADA, S.-I. NICULESCU. *Characterizing the Codimension of Zero Singularities for Time-Delay Systems : A Link with Vandermonde and Birkhoff Incidence Matrices*, in "Acta Applicandae Mathematicae", October 2016, vol. 145, n^{o} 1, pp. 47-88 [*DOI :* 10.1007/S10440-016-0050-9], https://hal-centralesupelec.archives-ouvertes.fr/hal-01429961

[12] I. BOUSSAADA, S.-I. NICULESCU. *Tracking the Algebraic Multiplicity of Crossing Imaginary Roots for Generic Quasipolynomials: A Vandermonde-Based Approach*, in "IEEE Transactions on Automatic Control", June 2016, vol. 61, n^{o} 6, pp. 1601-1606 [*DOI :* 10.1109/TAC.2015.2480175], https://hal-centralesupelec.archives-ouvertes.fr/hal-01425757

[13] J. CHEN, P. FU, C. F. MÉNDEZ BARRIOS, S.-I. NICULESCU, H. ZHANG. *Stability Analysis of Polynomially Dependent Systems by Eigenvalue Perturbation*, in "IEEE Transactions on Automatic Control", 2017, vol. 62, accepté le 23 décembre 2016 [*DOI :* 10.1109/TAC.2016.2645758], https://hal-centralesupelec.archives-ouvertes.fr/hal-01431810

[14] E. FRIDMAN, C. BONNET, F. MAZENC, W. DJEMA. *Stability of the cell dynamics in acute myeloid leukemia*, in "Systems and Control Letters", 2016 [*DOI :* 10.1016/J.SYSCONLE.2015.09.006], https://hal.inria.fr/hal-01257577

[15] M.-T. LARABA, S. OLARU, S.-I. NICULESCU, F. BLANCHINI, G. GIORDANO, D. CASAGRANDE, S. MIANI. *Guide on set invariance for delay difference equations*, in "Annual Reviews in Control", 2016, vol. 41, pp. 13 - 23 [*DOI :* 10.1016/J.ARCONTROL.2016.04.020], https://hal-centralesupelec.archives-ouvertes.fr/hal-01408474

[16] X.-G. LI, S.-I. NICULESCU, A. CELA, L. ZHANG, X. LI. *A frequency-sweeping framework for stability analysis of time-delay systems*, in "IEEE Transactions on Automatic Control", 2017, vol. 64, accepté le 21 octobre 2016 [*DOI :* 10.11.09/TAC.2016.2633533], https://hal-centralesupelec.archives-ouvertes.fr/hal-01431725

[17] F. MAZENC, E. FRIDMAN. *Predictor-based sampled-data exponential stabilization through continuous–discrete observers*, in "Automatica", 2016, vol. 63, 7 p. [*DOI :* 10.1016/J.AUTOMATICA.2015.10.016], https://hal.inria.fr/hal-01248072

[18] F. MAZENC, M. MALISOFF. *New Control Design for Bounded Backstepping under Input Delays*, in "Automatica", April 2016, vol. 66, 8 p. , https://hal.inria.fr/hal-01257338

[19] F. MAZENC, M. MALISOFF. *Reduction model approach for linear time-varying systems with input delays based on extensions of Floquet theory*, in "Systems & Control Letters", 2016, vol. 94 [*DOI :* 10.1016/J.SYSCONLE.2016.05.013], https://hal.inria.fr/hal-01389860

[20] F. MAZENC, M. MALISOFF. *Stability Analysis for Time-Varying Systems with Delay using Linear Lyapunov Functionals and a Positive Systems Approach*, in "IEEE Transactions on Automatic Control", 2016 [*DOI :* 10.1109/TAC.2015.2446111], https://hal.inria.fr/hal-01257336

[21] F. MAZENC, M. MALISOFF. *Stabilization of Nonlinear Time-Varying Systems through a New Prediction Based Approach*, in "IEEE Transactions on Automatic Control", August 2016, 1 p. [*DOI :* 10.1109/TAC.2016.2600500], https://hal.inria.fr/hal-01389859

[22] C. F. MÉNDEZ BARRIOS, S.-I. NICULESCU, F. LORENZ. *Sampling decomposition and asymptotic zeros behavior of sampled-data SISO systems. An eigenvalue-based approach*, in "IMA Journal on Mathematical Control and Information", December 2016, vol. 33, pp. 1177-1197 [*DOI :* 10.1093/IMAMCI/DNV029], https://hal-centralesupelec.archives-ouvertes.fr/hal-01284740

[23] L. H. V. NGUYEN, C. BONNET, A. FIORAVANTI. *Hinfty-stability analysis of fractional delay systems of neutral type*, in "SIAM Journal on Control and Optimization", 2016, vol. 54, n^{o} 2, pp. 740-759, https://hal.inria.fr/hal-01271889

[24] H.-N. NGUYEN, P.-O. GUTMAN, S. OLARU, M. HOVD. *Explicit improved vertex control for uncertain, time-varying lineardiscrete-time systems with state and control constraints*, in "International Journal of Robust and Nonlinear Control", 2016, vol. 26, n^{o} 12, pp. 2652-2667 [*DOI :* 10.1002/RNC.3466], https://hal.archives-ouvertes.fr/hal-01397717

[25] M. B. SALDIVAR, M. SABINE, S.-I. NICULESCU, H. MOUNIER, I. BOUSSAADA. *A control oriented guided tour in oilwell drilling vibration modeling*, in "Annual Reviews in Control", September 2016, vol. 42, pp.

100-113 [*DOI :* 10.1016/J.ARCONTROL.2016.09.002], https://hal-centralesupelec.archives-ouvertes.fr/hal-01425845

[26] Y.-E. WANG, X.-M. SUN, F. MAZENC. *Stability of switched nonlinear systems with delay and disturbance*, in "Automatica", 2016, vol. 69, pp. 78 - 86 [*DOI :* 10.1016/J.AUTOMATICA.2016.02.015], https://hal.inria.fr/hal-01391683

[27] S. R. YANG, M. R. AKELLA, F. R. MAZENC. *Immersion and Invariance Observers for Gyro-Free Attitude Control Systems*, in "Journal of Guidance, Control, and Dynamics", November 2016, vol. 39, pp. 2570 - 2577 [*DOI :* 10.2514/1.G002095], https://hal.inria.fr/hal-01389858

Invited Conferences

[28] C. BONNET, Y. YAMAMOTO. *Coprimeness of Fractional Representations*, in "55th IEEE Conference on Decision and Control", Las Vegas, United States, December 2016, https://hal.inria.fr/hal-01413310

[29] C. BONNET, Y. YAMAMOTO. *Stabilizability of Some Neutral Delay Systems with Chains of Poles Clustering on the Imaginary Axis*, in "Mathematical Theory of Networks and Systems", Minneapolis, United States, July 2016, https://hal.inria.fr/hal-01413303

International Conferences with Proceedings

[30] A. ALESSANDRI, A. ZEMOUCHE. *On the enhancement of high-gain observers for state estimation of nonlinear systems*, in "55th IEEE Conference on Decision and Control, CDC 2016", Las Vegas, NV, United States, December 2016, https://hal.archives-ouvertes.fr/hal-01418758

[31] H. BIBI, F. BEDOUHENE, H. KHELOUFI, A. ZEMOUCHE, H. TRINH. *Observer-based control design via LMIs for a class of switched discrete-time linear systems with parameter uncertainties*, in "55th IEEE Conference on Decision and Control, CDC 2016", Las Vegas, NV, United States, December 2016, https://hal.archives-ouvertes.fr/hal-01418759

[32] M. L. DEROUICHE, S. BOUALLÈGUE, J. HAGGÈGE, G. SANDOU. *LabVIEW Perturbed Particle Swarm Optimization Based Approach for Model Predictive Control Tuning*, in "4th IFAC International Conference on Intelligent Control and Automation Sciences (ICONS 2016)", Reims, France, June 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01347041

[33] W. DJEMA, F. MAZENC, C. BONNET, J. CLAIRAMBAULT, P. HIRSCH, F. DELHOMMEAU. *Stability of a Delay System Coupled to a Differential-Difference System Describing the Coexistence of Ordinary and Mutated Hematopoietic Stem Cells*, in "Conference on Decision and Control", Las Vegas, United States, December 2016, https://hal.inria.fr/hal-01389870

[34] W. DJEMA, F. MAZENC, C. BONNET. *Analysis of a Nonlinear Delay Differential-Difference Biological Model*, in "IFAC Time Delay Systems", Istanbul, Turkey, July 2016, https://hal.inria.fr/hal-01389867

[35] W. DJEMA, F. MAZENC, C. BONNET. *Stability of immature cell dynamics in healthy and unhealthy hematopoiesis*, in "2016 American Control Conference", Boston, United States, July 2016, pp. 6121 - 6126 [*DOI :* 10.1109/ACC.2016.7526631], https://hal.inria.fr/hal-01389865

[36] N. GIONFRA, H. SIGUERDIDJANE, G. SANDOU, D. FAILLE, P. LOEVENBRUCK. *Combined Feedback Linearization and MPC for Wind Turbine Power Tracking*, in "IEEE Multi-Conference on Systems and Control

(MSC 2016)", Buenos Aires, Argentina, September 2016 [*DOI :* 10.1109/CCA.2016.7587821], https://hal-centralesupelec.archives-ouvertes.fr/hal-01381416

[37] U. HAKKI, I. BOUSSAADA, S.-I. NICULESCU. *Further remarks on delay dynamics in Oregonator models*, in "IEEE International Conference on Control and Automation", Kathmandu, Nepal, June 2016 [*DOI :* 10.1109/ICCA.2016.7505261], https://hal-centralesupelec.archives-ouvertes.fr/hal-01445899

[38] H. KHELOUFI, B. CHERIFA, A. ZEMOUCHE, F. BEDOUHENE, H. TRINH. *New decentralized control design for interconnected nonlinear discrete-time systems with nonlinear interconnections*, in "55th IEEE Conference on Decision and Control, CDC 2016", Las Vegas, NV, United States, December 2016, https://hal.archives-ouvertes.fr/hal-01418757

[39] F. MAZENC, J. HARMAND, M. MALISOFF. *Stabilization in a chemostat with sampled and delayed measurements*, in "2016 American Control Conference", Boston , United States, July 2016, pp. 1857 - 1862 [*DOI :* 10.1109/ACC.2016.7525189], https://hal.inria.fr/hal-01389864

[40] F. MAZENC, M. MALISOFF. *Constructions of Strict Lyapunov Functions: Stability, Robustness, Delays, and State Constraints*, in "MTNS", Minneapolis, United States, July 2016, https://hal.inria.fr/hal-01389866

[41] F. MAZENC, M. MALISOFF. *Extension of Razumikhin's theorem for time-varying systems with delay*, in "2016 American Control Conference", Boston , United States, July 2016, 6 p. [*DOI :* 10.1109/ACC.2016.7524896], https://hal.inria.fr/hal-01389863

[42] F. MAZENC, M. MALISOFF. *New Prediction Approach for Stabilizing Time-Varying Systems under Time-Varying Input Delay*, in "CDC 2016 - 55th IEEE Conference on Decision and Control", Las Vegas, United States, December 2016, https://hal.inria.fr/hal-01389869

[43] F. MAZENC, M. MALISOFF, J. WESTON. *New Bounded Backstepping Control Designs for Time-Varying Systems under Converging Input Converging State Conditions*, in "Conference on Decision and Control", Las Vegas, United States, December 2016, https://hal.inria.fr/hal-01389868

[44] M. T. NGUYEN, L. RODRIGUES, C. STOICA MANIU, S. OLARU. *Discretized optimal control approach for dynamic Multi-Agent decentralized coverage*, in "IEEE Multi-Conference on Systems and Control", Buenos Aires, Argentina, September 2016, pp. 335-340 [*DOI :* 10.1109/ISIC.2016.7579984], https://hal.archives-ouvertes.fr/hal-01390082

[45] M. T. NGUYEN, C. STOICA MANIU, S. OLARU. *Decentralized constructive collision avoidance for Multi-Agent dynamical systems*, in "European Control Conference", Aalborg, Denmark, June 2016, pp. 1526-1531, https://hal.archives-ouvertes.fr/hal-01390087

[46] J. POCHET, S. BARO, G. SANDOU. *Supervision and rescheduling of a mixed CBTC traffic on a suburban railway line*, in "IEEE International Conference on Intelligent Rail Transportation (ICIRT 2016)", Birmingham, United Kingdom, August 2016 [*DOI :* 10.1109/ICIRT.2016.7588547], https://hal-centralesupelec.archives-ouvertes.fr/hal-01381366

[47] A. QUADRAT. *A constructive algebraic analysis approach to Artstein's reduction of linear time-delay systems*, in "12th IFAC Workshop on Time Delay Systems", Ann Arbor, United States, Proceedings of 12th IFAC Workshop on Time Delay Systems, University of Michigan, May 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01259862

[48] N. STROE, G. COLIN, K. BEN-CHERIF, S. OLARU, Y. CHAMAILLARD. *Towards a generic control-oriented model for HEV predictive energy management*, in "8th IFAC International Symposium on Advances in Automotive Control (AAC2016)", Kolmarden, Sweden, IFAC-PapersOnLine, June 2016, pp. 266-271, https://hal-univ-orleans.archives-ouvertes.fr/hal-01338065

Conferences without Proceedings

[49] P. AHMADI-MOSHKENANI, T. A. JOHANSEN, S. OLARU. *On degeneracy in exploration of combinatorial tree in multi-parametric quadratic programming*, in "Decision and Control (CDC), 2016 IEEE 55th Conference on", Las Vegas, United States, December 2016, vol. 26, pp. 2320 - 2326 [*DOI :* 10.1109/CDC.2016.7798609], https://hal-centralesupelec.archives-ouvertes.fr/hal-01408493

[50] P. AHMADI-MOSHKENANI, S. OLARU, T. A. JOHANSEN. *Further Results on the Exploration of Combinatorial Tree in Multi-Parametric Quadratic Programming*, in "European Control Confrence 2016", Aalborg, Denmark, June 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01429237

[51] I. BALLESTEROS-TOLOSANA, S. OLARU, P. RODRIGUEZ-AYERBE, G. PITA-GIL, R. DEBORNE. *Comparison of optimization-based strategies for constrained control of Auto-Steering systems*, in "European Control Confrence 2016", Aalborg, Denmark, June 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01429244

[52] M. L. DEROUICHE, S. BOUALLÈGUE, J. HAGGÈGE, G. SANDOU. *Rapid Model Predictive Control Prototyping with LabVIEW/CDSim and CompactRIO Target*, in "4th International Conference on Control Engineering & Information Technology (CEIT-2016)", Hammamet, Tunisia, December 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01415057

[53] N. O. GIONFRA, G. SANDOU, H. SIGUERDIDJANE, D. FAILLE, P. LOEVENBRUCK. *Optimisation du pilotage d'un parc d'énergies renouvelables*, in "3ième Journée Scientifique de l'Institut RISEGrid", Palaiseau, France, September 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01381714

[54] N. O. GIONFRA, H. SIGUERDIDJANE, G. SANDOU, D. FAILLE. *Hierarchical Control of a Wind Farm for Wake Interaction Minimization*, in "IFAC Workshop on Control of Transmission and Distribution Smart Grids (CTDSG 2016)", Prague, Czech Republic, October 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01381404

[55] N. GIONFRA, H. SIGUERDIDJANE, G. SANDOU, D. FAILLE, P. LOEVENBRUCK. *Advanced Control for Wind Turbine Grid Connection Requirements*, in "World Congress and Exhibition on Wind & Renewable Energy", Berlin, Germany, July 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01381643

[56] S. MUNIR, M. HOVD, G. SANDOU, S. OLARU. *Controlled contractive sets for low-complexity constrained control*, in "IEEE Multi-Conference on Systems and Control", Buenos Aires, Argentina, September 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01381706

Scientific Books (or Scientific Book chapters)

[57] I. PRODAN, F. STOICAN, S. OLARU, S.-I. NICULESCU. *Mixed-Integer Representations in Control Design: Mathematical Foundations and Applications*, Springer, 2016 [*DOI :* 10.1007/978-3-319-26995-5], https://hal-supelec.archives-ouvertes.fr/hal-01257452

[58] R. SIPAHI, S.-I. NICULESCU, F. ATAY. *Deterministic car-following traffic models. Delay effects and linear stability*, SpringerBriefs in Electrical and Computer Engineering (Control, Automation and Robotics), Springer : Heidelberg, 2017, accepté : novembre 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01431320

Research Reports

[59] N. A. NGUYEN, M. GULAN, S. OLARU, P. RODRIGUEZ-AYERBE. *Convex Liftings: Theory and Control Applications*, CentraleSupelec, June 2016, https://hal-centralesupelec.archives-ouvertes.fr/hal-01326804

Other Publications

[60] N. ANH NGUYEN, P. RODRIGUEZ-AYERBE, S. OLARU. *Any Discontinuous PWA Function Is Optimal Solution to a Parametric Linear Programming Problem*, June 2016, working paper or preprint, https://hal-centralesupelec.archives-ouvertes.fr/hal-01259879

[61] N. ANH NGUYEN, P. RODRIGUEZ-AYERBE, S. OLARU. *Inverse Parametric Linear/quadratic Programming Problem for Continuous PWA Functions Defined on Polyhedral Partitions of Polyhedra*, June 2016, working paper or preprint, https://hal-centralesupelec.archives-ouvertes.fr/hal-01259895

[62] C. CARDELIQUIO, M. SOUZA, A. FIORAVANTI. *Stability Analysis and Output-Feedback Control Design for Time-Delay Systems* , December 2016, working paper or preprint, https://hal.inria.fr/hal-01409265

[63] N. GIONFRA, H. SIGUERDIDJANE, G. SANDOU, D. FAILLE, P. LOEVENBRUCK. *Optimisation du contrôle d'un parc éolien*, October 2016, Vers la Transition Energétique, WTE 2016, Poster, https://hal-centralesupelec.archives-ouvertes.fr/hal-01381012

[64] L. HETEL, C. FITER, H. OMRAN, A. SEURET, E. FRIDMAN, J.-P. RICHARD, S.-I. NICULESCU. *Recent developments on the stability of systems with aperiodic sampling: an overview* ⋆, September 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01363448

References in notes

[65] M. ADIMY, A. CHEKROUN, T.-M. TOUAOULA. *Global asymptotic stability for an age-structured model of hematopoietic stem cell dynamics*, in "Applicable Analysis", February 2016, pp. 1 - 12 [*DOI :* 10.1080/00036811.2016.1139698], https://hal.inria.fr/hal-01396691

[66] H. KITANO. *Biological robustness*, in "Nature", 2004, vol. 5, pp. 826–837

[67] H. OZBAY, C. BONNET, A. FIORAVANTI. *PID Controller Design for Fractional-Order Systems with Time Delays*, in "Systems and Control Letters", January 2012, vol. 61, n^{o} 1, pp. 18-23, http://hal.inria.fr/hal-00766062