Evaluation of Inria theme
Optimization and control of dynamic systems

Project-team Non-A

Non-Asymptotic estimation for online systems

14/03/2017

Project-team title: Optimization and control of dynamic systems

Scientific leader: Jean-Pierre Richard

Research center: Lille - North Europe

Common project-team with: CNRS (CRIStAL - UMR9189), Centrale Lille, and University of Lille.

1 Personnel

1.1 Current composition of the project-team:

Research scientists and faculty members:
- Lotfi Belkoura [Univ. Lille I, Professor, HDR]
- Denis Efimov [Inria, Researcher, HDR]
- Thierry Floquet [CNRS, Senior Researcher, HDR]
- Wilfrid Perruquetti [Centrale Lille, Professor, HDR]
- Andrey Polyakov [Inria, Researcher]
- Alban Quadrat [Inria, Senior Researcher, HDR]
- Jean-Pierre Richard [Team leader, Centrale Lille, Professor, HDR]
- Rosane Ushirobira [Inria, Researcher, HDR]
- Gang Zheng [Inria, Researcher, HDR]

Engineers:
- Roudy Dagher [Inria, Research Engineer, PhD]

Post-docs:
- Mohamed Yacine Bouzidi [Centrale Lille, started 12/2015]
- Lucien Etienne [Inria, started 02/2016]

Ph.D. students:
- Deesh Dileep [KULeuven - H2020, started 02/2017]
- Maxime Feingesicht [Centrale Lille - Region, started 01/2015]
- Zohra Kader [Univ. Lille, started 10/2014]
- Tatiana Kharkovskaia [ITMO St Petersburg - Centrale Lille, started 12/2015]
- Désiré Kokou Langueh [Centrale Lille, started 10/2015]
- Francisco Lopez Ramirez [Inria, started 10/2015]
- Alexis Martin [CIFRE Renault & Univ. Lille, started 02/2017]
- Nadhynee Martinez-Fonseca [IPN Mexico, started 03/2015]
- Gabriele Perozzi [ONERA, started 11/2015]

- Guillaume Rance [CIFRE Sagem & UPHC, started 04/2015]
- Haïk Silm [Centrale Lille - H2020, started 12/2016]
- Jijju Thomas [Centrale Lille - H2020, started 12/2016]
- Quentin Voortman [TU/Eindhoven - H2020, started 02/2017]
- Yue Wang [CRC - Centrale Lille, started 02/2016]

Administrative assistant:
- Corinne Jamroz [Inria]

External collaborators:
- Jean-Pierre Barbot [ENSEA Cergy, Professor, HDR]
- Olivier Gibaru [ENSAM Lille, Professor, HDR]
- Laurentiu Hetel [CNRS, Researcher]
- Cédric Join [Univ. Nancy I, HDR]
- Mamadou Mboup [Univ. Reims, Professor, HDR]
- Samer Riachy [ENSEA Cergy, Associate Professor]
- Stephane Thiery [ENSAM Lille, Associate Professor]

1.2 Personnel at the start of the evaluation period (26/03/2013)

	INRIA	CNRS	University	Other	**Total**
DR (1) / Professors	0	0	3	(3 ext)	3
CR (2) / Assistant professors	2	1	0	(3 ext)	3
ARP and SRP (3)					
Permanent engineers (4)					
Temporary engineers (5)	1		2		3
Post-docs	2		2		4
PhD Students	1		5		6
Total	6	1	12		19

(1) “Senior Research Scientist (Directeur de Recherche)”
(2) “Junior Research Scientist (Chargé de Recherche)”
(3) “Inria Advanced Research Position” and “Inria Starting Research Position”
(4) “Civil servant (CNRS, INRIA, ...)”
(5) “Associated with a contract (Ingénieur Expert, Ingénieur ADT, . . .)”

1.3 Personnel at the time of the evaluation (14/03/2017)

	INRIA	CNRS	University	Other	**Total**
DR / Professors	1	1	3	(3 ext)	5
CR / Assistant professors	4	0	0	(3 ext)	4
ARP and SRP					
Permanent engineers	1				1
Temporary engineers					
Post-docs			1		1
PhD Students	1		6	7	14
Total	7	1	10	4	22

1.4 Changes in the scientific staff

DR / Professors / ARP CR / Assistant Professors / SRP	INRIA	CNRS	University	Other	**Total**
Arrivals	3	0	0	0	3
Departures	0	0	0	0	0

Comments: Alban Quadrat came from DISCO (Saclay), promoted from CR to DR.

1.5 Current position of former project-team members

- Hafiz Ahmed, **PhD** 2013-2016, currently Post-Doc at Clemson University, USA
- Zilong Shao, **PhD** 2013-2016, currently Eng. Ensam ParisTech Metz, France
- Youssef El Afou, **PhD**, 2011-2015, currently Teacher Ensam Meknes, Morocco
- Matteo Guerra, **PhD** 2012-2015, currently Post-Doc Onera Toulouse, France
- Qi Guo, **PhD** 2012-2015, currently Eng. A.I.Mergence, Paris
- Hassan Omran, **PhD** 2011-2014, currently Ass.Prof. Univ. Strasbourg, France
- Sonia Maalej, **PhD** 2011-2014, currently Ass. Prof. Univ. Sfax-ENI, Tunisia
- Diego Mincarelli, **PhD** 2010-2013, currently Eng. General Motors, Torino, Italy
- Marouene Oueslati, **PhD** 2009-2013, cur. Eng. Dana Holding Corp., Bruges, Be
- Hugues Sert, **PhD** 2010-2013, currently Eng. EOS Innovation Paris, France
- Stanislav Aranovskiy, **Post-Doc** 2015-2016, currently Ass.Prof. Supelec Rennes, Fr
- Anja Korporal, **Post-Doc** 2013-2015, currently Ass.Prof. U.Aachen, Germany
- Hector Rios Barajas, **Post-Doc** 2014-2015, cur. Researcher Univ. Laguna, Mexico
- Jose Antonio Estrada, **Post-Doc** 10/2012-02/2014, cur. Res. CINVESTAV Mexico
- Romain Delpoux, **Post-Doc** 10/2013-08/2014, cur. Ass.Prof. INSA Lyon, France
- Jorge Palos Ladeiro, **Engineer** 2012-2014, cur. Eng. Ensam ParisTech Lille, France
- Xin Jin, **Engineer** 2013-2014, currently Eng. Amadeus, Sophia, France
- Zaopeng Qiu, **Engineer** 2013-2014, currently Eng. General Electric, Paris, France

1.6 Last Inria enlistments

- Rosane Ushirobira, Feb.2017, CR1
- Roudy Dagher, Jan.2016, Research Engineer
- Alban Quadrat, Oct.2015, DR2
- Andrey Polyakov, Oct.2013, CR1

1.7 Other comments:

Various regularly visiting scientists: Prof. Francisco Javier Bejarano Rodriguez [Instituto Politechnico Nacional, Mexico, Jul.2014, Jul.2015, Jul.2017], Prof. Emilia Fridman [Tel Aviv State University, Israel, one month/year], Prof. Leonid Fridman [UNAM, Mexico, Jul.2014, Jul.2015, Jul.2016], Prof. Arie Levant [Tel Aviv State Univ., Israel, 4 months Oct.2015-Jan.2016].

Various visiting scientists: Prof. Lou Cattafesta [Florida State Univ., US, Jan.2017], Prof. Isaac Chairez [IPN, Mexico, Sept.2016], Prof. Ilya Kolmanovsky [U.Michigan, USA, Nov.2016], Prof. Andrey Medvedev [U. Upsala, Sweden, Oct.2015], Prof. Wim Michiels [KUL, Belgium, May2014], Prof. Jaime Moreno [UNAM, Mexico, July2016], Prof. Toshiki Ogushi [U.Tokyo, Japan, Oct.2015], Prof. Tarek Raïssi [CNAM Paris, France, Oct.2016], Dr. Damiano Rotondo [NTNU Trondheim, Norway, Oct.2016], Prof. Markus Rosenkranz

[U.Kent, UK, Jan.2016], Jan van Schuppen [U.T.Delft, NL, Sept.2016], Prof. Yutaka Yamamoto [U.Kyoto, Japan, Oct.2015].

Various visiting students: Andrea Aparicio Martinez [PhD Std. UNAM, Mexico, Sept.-Dec.2015 - grant UNAM], Emmanuel Cruz Zavala [PhD std. UNAM, Nov.-Dec.2014], Manuel Mera Hernandez [Post-Doc. IPN Mexico, Jul.2014-Jul.2015 - grant CONACYT], Ivan de Jesus Salgado Ramos [PhD Std. IPN Mexico, Jul.2014-Apr.2015 - grant IPN], Gustavo Juan Rudea Escobedo [PhD std. UNAM, Oct.-Nov.2016], Tonametl Sanchez Ramirez [PhD Std. UNAM, Oct.-Nov.2016], Carlos Vasquez Aguliera [Post-Doc. Univ. Umeå, Nov.2014], Konstantin Zimenko [PhD Std. ITMO, Russia, Nov.2014, Jul.2015, Oct.2016 - grant ITMO]

MSc. Internships: Kwassi Gérard Degue [March-Jul.2015], BaiHui Du [May-Jul.2016], Yasutaka Hayashida [Master Std, U.Tokyo, Oct.-Dec.2015 - grant U.Tokyo], Djahid Rabehi [Apr.-Jul.2016], Andre Murillo Geraldo Correa [Univ. Sao Paulo, Feb.2015]

2 Research goals and results

2.1 Keywords

- estimation, control, numerical differentiation, observer
- non-asymptotic, finite-time, algebra, operational calculus, homogeneity, (implicit) Lyapunov function, sliding mode, interval observer, attractive ellipsoid
- deterministic systems, nonlinear systems, ODE (ordinary differential equations), TDS (time delay systems), DI (differential inclusions), HS (hybrid/impulsive/switched systems), PDE (partial differential equations), asynchronous sampling
- robotics, networked systems, water quality monitoring, HCI (Human-Computer Interaction), biosensing, model-free control, i-PID

Keywords from Inria classification:

- *"Computer Science and Digital Science":* 5.1.1. Engineering of interactive systems / 5.10.3. Planning / 5.10.4. Robot control / 5.10.6. Swarm robotics / 5.9.1. Sampling, acquisition / 5.9.2. Estimation, modeling / 6.1.1. Continuous Modeling (PDE, ODE) / 6.4.1. Deterministic control / 6.4.3. Observability and Controlability / 6.4.4. Stability and Stabilization
- *"Other Research Topics and Application Domains":* 2.5.3. Assistance for elderly / 3.4.3. Pollution / 4.4. Energy consumption / 5.2.3. Aviation / 5.6. Robotic systems / 6.4. Internet of things / 7.1. Traffic management

2.2 Context and overall goals of the project

For engineers, a wide variety of information cannot be directly obtained through measurements. Some parameters or internal variables are unknown or unmeasured, and the available sensor signals are tainted by noises. In order to analyze, to control or to supervise such processes, one has to *estimate* parameters or variables. Estimation techniques are, under various guises, present in many parts of control, signal processing and applied mathematics. Such an important area gave rise to a huge international literature. From a general point of view, the performance of an estimation algorithm can be characterized by *three indicators*:

[i1] The computation time (the time needed to obtain the estimation). Obviously, the estimation algorithms should have as small as possible computation time in order to provide fast, real-time, online estimations for processes with fast dynamics.

[i2] The algorithm complexity (the easiness of design and implementation). Estimation algorithms should have as low as possible complexity, so to allow an embedded real-time estimation. Another question about complexity is the way an engineer can appropriate and apply the algorithms (for instance, application is easier if the parameters have a physical meaning).

[i3] The robustness. The algorithms should exhibit as much as possible robustness with respect to a large class of perturbations: measurement noises, unknown inputs, parameter uncertainties, discretization steps, etc. A complementary point of view on robustness is to manage a compromise between existence of theoretical proofs versus universalism of the algorithm (guaranty of performance in a particular case *vs.* success in "most of the cases" but possible failure in few situations).

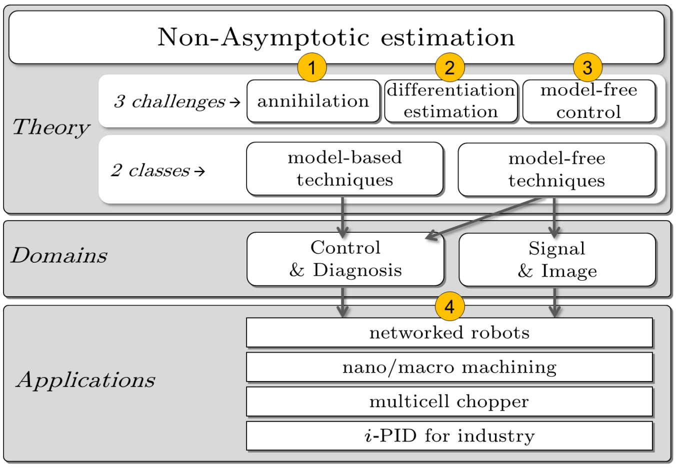

Fig. 1: The Non-A initial roadmap (2011) [1]

Within the very wide area of estimation, Non-A is a *method-driven project, centered around non-asymptotic estimation techniques*. With "non-asymptotic", we mean that our estimates are provided *in finite-time*, which is strongly related to indicator [i1] since, mathematically speaking, any finite-time convergence is faster than any exponential one. Moreover, we aim at reducing the (finite) convergence time: with this in mind, the concept of fixed-time convergence has been introduced so to characterize a convergence time independent of the estimation algorithm initialization. In the meanwhile, we aim at developing real-time algorithms [i2] able to cope with real-world applications [i3]. **Three theoretical challenges** are addressed by the initial roadmap of Non-A:

1) General annihilators: *"Design algebraic annihilators for some general class of perturbations".* Our algebraic estimation techniques can successfully get rid of perturbations of the so-called structured type, which means the ones that can be annihilated by some differential operator, called the annihilator. Open questions are: ***OQ1)*** *Does a normal form exist for such annihilators?* ***OQ2)*** *Or, at least, does there exist an adequate basis representation of the annihilator in some adequate algebra?* ***OQ3)*** *And lastly, can the annihilator be chosen from efficient tuning rules?* The two first questions will directly impact [i1] (time) and [i2] (complexity), whereas the last one will impact [i3] (robustness).

2) Numerical differentiation and finite-time estimation: *"Estimate online the derivatives of a signal, the unmeasured states, the unknown inputs".* This challenge addresses numerical differentiation in finite-time (differentiators or observers), but also various linked estimation problems such as parameter identification, state observation, left-inversion... Two classes of techniques are considered here (Model-Based and Model-Free), both of them aiming at non-asymptotic estimation. In what we call Model-Based techniques, the derivative estimation is regarded as an observation problem, needing the software-based reconstruction of unmeasured variables and, more generally, some left inversion[2]. This involves various classes of state models, including ordinary equations (ODE), time-delay systems (TDS), hybrid systems (HDS), PDEs... One advantage in Model-Based is the existence of some theoretical framework for the robustness/speed analysis based on

[1]Some of these applications have been considered separately by our collaborators: Nano/macro machining by the Ensam Lille (see projects Usine Agile and ColRobot), and Multicell chopper and electrical engineering by ENSEA Cergy [80, 111, 122, 70, 81, 41, 18]. We will not detail them in this report. In Lille, we also worked on asynchronous sampling for networked/embedded control [9, 67, 79, 92, 91] (collaboration with CNRS CRIStAL): again, we do not detail it since it is not in the direct scope of Non-A (except for some results, on interval observers for instance [48]).

[2]*i.e.*, recovering the state ("observation") together with some of the inputs ("unknown input observers").

the Lyapunov theory. One drawback lays in the complexity: building a model takes time, and finding a "good" Lyapunov function may take much more. On the other side, Model-Free techniques need the only information contained in the output signal, including its derivatives: there, numerical differentiation becomes the crux of the matter. The corresponding algorithms rely either on our algebraic annihilation viewpoint, or on various differentiation algorithms related to the seminal super-twisting algorithm by A. Levant (1993) and which, today, are studied in the framework of the so-called "homogeneity" property. Within Model-Based techniques, we also include set-membership estimation which relies on uncertain models, the uncertainty of which can be included in intervals, polytopes or ellipsoids. Most of the works can also be adapted to the question of observer design. Open questions are: ***OQ4)*** *Can homogeneity address large classes of models (i.e. not limited to ordinary differential equations)?* ***OQ5)*** *How can the finite/fixed-time convergence be proven in an adequate Lyapunov-like framework?* ***OQ6)*** *How to build a framework for the comparison of the various estimation (and control) techniques (Model-Based, Model-Free)?* The first question mainly impacts [i2] (complexity), the second, [i1] and [i3] (time, robustness). The last one (comparison) has to be based on the three [i1], [i2] and [i3], together with experiments.

3) Control without a sophisticated model: *"Design the control without a model (Model-Free Control) or without much knowledge on the model (set-theoretic control)".* Writing down simple and reliable differential equations for describing a real-world plant is almost always a tough job. This is why industry is eager for simple and powerful controllers, derivable from the most basic models. The tuning simplicity of the classical PID controller explains its omnipresence in industrial control, although its performances drop when the working conditions change. The challenge we consider is to define control techniques which, instead of using sophisticated models, use the information contained in the output signal and its estimated derivatives, which can be regarded as "model-free" or "signal-based" controllers. Set-membership estimation also gives a promising control framework when one has quite a rough model: here, one needs a model of given order, but few information about it. Open question is: ***OQ7)*** *Can such techniques, with the associated online estimation, be applied (by engineers) in any application field and in the presence of complex phenomena (non-minimum phase, delay effects, switches...)?* It addresses all three [i1], [i2] and [i3] (time, complexity, robustness).

For Non-A, all three of these challenges are connected with the central idea of designing or exploiting algorithms with the finite-time convergence property. Concerning the mathematical approaches we develop, there are three kinds:

(ALG) [*Algebra*, Model-Free] Our *algebraic tools* rely on differential algebra, and more recently on integro-differential algebra. This framework allows for finite-time estimation algorithms by giving constructive ways of annihilating parameters or variables, so to keep only the ones targeted by the estimation. The finite time property comes from explicit formula depending on the signal values over a short window of past times. These tools are within the continuity of the project-team ALIEN [FSR03][3], ended Dec.2010 and the predecessor of Non-A in the Inria genealogy.

(HOM) [*Homogeneity*, Model-Based and Model-Free] Our nonlinear techniques are based on the *homogeneity concept* [PFM08] and on the *fixed-time property* [Pol12]. Here, the finite-time property is proven via Lyapuvov-like techniques. Homogeneous dynamical systems constitute an exciting class of continuous-time, nonlinear systems: its complexity is half-way between linear systems and general nonlinear ones. Depending on the degree, they can exhibit finite-time convergence. The concept was initially developed for ODE (ordinary differential equations) but we contributed to

[3] The introduction of this seminal paper gives a most basic example for catching the idea.

enlarge it to more general classes. It allows for developing observers with the finite- or fixed- time property, but has various other interesting extensions.

(SET) [*Set-membership*, Model-Based] This approach relies on *set-theoretic estimation*. Interval [ERCZ13] or ellipsoidal [305] estimation techniques can be regarded as particular finite-time algorithms, since they provide guaranteed estimates from the initial time. The approach relies on both Lyapunov techniques and positive systems (interval estimation gives over- and under- values of the variables to be estimated: the corresponding bound are defined by two dynamical systems which have to maintain a positive difference, say: $\max - \min > 0$).

As said before, Non-A is a method-driven project, but we also want to confront these issues with application. The initial roadmap (indicated in Fig.1) has increased along time, and one can regroup our **application-related challenges** into 4 categories:

1) Robots and networked systems (involving both ALG and HOM);

2) Living systems: ecological monitoring, modelling, estimation and identification of biological systems, human-computer interaction (ALG and HOM);

3) Turbulent flow control (HOM) for aircrafts and vehicles;

4) Industry and society: i-PID for industry and society (ALG), mechatronics (ALG), etc.

2.3 Research axis 1: General annihilators (tools: ALG)

2.3.1 Personnel

Permanent members: L. Belkoura, T. Floquet, W. Perruquetti, A. Quadrat, R. Ushirobira, G. Zheng. **Post-Docs:** A. Korporal. **External collaborators:** M. Mboup, C. Join. **Ph.D. students:** Z. Kader.

2.3.2 Project-team positioning

One of the main achievements of our algebraic estimation approach is to provide closed form expressions for the desired parameters. These expressions follow from differential algebraic elimination in a constructive way. As originally introduced in the context of linear identification by M. Fliess and H. Sira-Ramirez [FSR03], differential operators can be used to isolate desired parameters in an operational domain expression. The time domain representation of the resulting expression provides parameter estimations containing only integrals and no derivatives. We call "*annihilators*" the aforementioned differential operators, the nature of which can determine the robustness of the corresponding algebraic estimator. Until 2013, some specific forms of annihilators have been considered further, leading to interesting results for numerical differentiation [MJF09, LGP11] and, more generally, to new tools in control and signal processing (such as "model-free control"). During the period, the first results on the underlying algebraic structure have been investigated.

The algebraic basis of our general problem has a longstanding history. In a few words, it concerns the annihilator of a left module on a ring, which is an ideal of the ring. In certain cases, when the ring satisfies particular properties, such an annihilator can be nicely characterized. However, in the parameter estimation problem, no general characterization has been carried out taking into account the algebraic properties of the resulting structure (namely, the Weyl algebra structure endowed by the considered ring). At the present time, there is no other Inria team working on this specific objective. Research groups using the algebraic estimation are: V.F. Battle (Spain), G. Fedele (Italy), J. Rudolph (Germany), H. Sira-Ramirez (Mexico), J.R. Trapero (Spain), and in France: B. d'Andrea-Novel (Mines Paris), E. Delaleau (ISEN Brest), H. Mounier (LSS).

2.3.3 Scientific achievements

Non-A continued to develop the theoretical support for this algebraic approach, together with trends for an effective package development. **[Multi-sinusoidal signal:]** The well-know problem of parameter identification in the case of a multi-sinusoidal signal was tackled.: [282, 117] presents algebraic continuous time parameter estimation for a biased sum of sinusoidal waveform signals in a noisy environment (*i.e.*, estimate amplitudes, frequencies, and phases of sum of complex exponential sinusoidal signals with bias and noise). The resulting parameter estimates are given by original closed formulas, constructed as integrals acting as time-varying filters of the noisy measured signal. In comparison with the modified Prony's method (Osborne *et al.*1995), our results appear to be faster and more robust w.r.t. noise. Note this issue occurs in many practical engineering problems such as: communications (signal demodulation, pitch perception in sounds), power systems (dynamic energy balance, power converters), bio-medics (electromyography, circadian rhythms), flexible mechanics, etc. (see references in [117]). **[Partial derivatives:]** A natural problem to carry out our investigation was multiviate context: [281] provides an overview on algebraic techniques for numerical differentiation and parameter estimation for linear PDE systems, as well as *novel algebraic methods in the case of several variables.* For the estimation of partial derivatives of a multivariate noisy signal, the signal is expressed as a truncated Taylor expression in a small time interval, and an algebraic method (based on the notion of annihilator) is then used in the operational domain: Stafford's theorem can be applied to formalize the left ideal in the Weyl algebra formed by the annihilators. Examples in the multidimensional case illustrate that, in the spatial domain, iterated integrals present in the estimates yield noise filtering. Apart from this work, note that the specific PDE class of fractional order systems has also been studied [83, 84]. **[Time-delays]** Algebraic analysis for the Ore extension ring of differential *time-varying delay* operators has been proposed in [264]. Observability analysis and observer design based on non-commutative / commutative rings were respectively investigated in [307] / [224] for *nonlinear constant-delay* systems with unknown inputs, and in [25, 126, 125] for *linear time-delay* systems with/without unknown inputs. **[Orthogonal basis:]** One main problem with the algebraic approach is that the final numerical estimators are generally ill-conditioned [Mbo09]. Orthogonal basis decomposition performed in the operational domain represents an interesting way to anticipate the conditionning issues. The idea is developped in [283] for continuous-time noisy biased signals. On the one hand, we write the signal as an orthogonal polynomial series expansion and provide an algebraic estimation of its coefficients. On the other hand, the dynamical system described by the signal may be given by an ordinary differential equation associated with classical orthogonal polynomials. The signal may be recovered through the coefficients identification. As an example, we illustrate our algebraic method on the parameter estimation in the case of Hermite polynomials. **[Integro-Differential Equations:]** In the framework of differential algebra, the only way to get integral terms (and thus, noise filtering) in the time-domain is to divide by s in the operational domain. With integro-differential algebra, operators allow for a larger diversity and may be a richer tool for anticipating the conditionning question. We started presenting the IDE framework in [311] and proposed annihilation techniques in [317]. Some algorithms for converting fractions of differential polynomials into integral equations have been presented in [163]. **[Symbolic computation:]** Within the effective algebraic analysis approach, the parameter estimation problem has been formulated in [318] for signals defined by ODE with polynomial coefficients. This class of signals encompasses the ones already studied in previous works as well as special functions and finite expansions of signals into a basis of L^2 defined by a family of orthogonal polynomials (*e.g.*, Chebyshev, Jacobi, Legendre, Laguerre, Hermite). Based on elimination techniques (*e.g.*, Gröbner bases) for noncommutative polynomial rings of differential operators with polynomial coefficients, a general algorithm was developed for the computation of annihilators of polynomials with parameters. Moreover, a second algorithm for the computation of a set of generators of the annihilators which only contain fixed parameters was obtained. Finally, we developed a third algorithm for the effective computation of the set of generators of the annihilators which do not annihilate a given polynomial. The combination of these three algorithms, which are implemented in a dedicated package Non-A−built upon OreModules [CQR07]−helps solving the parameter estimation problem for the classes of signals considered.

Our answers to open questions of research axis 1 are: ***OQ1)*** *Does a normal form exist for such annihilators?* In the framework of Weyl algebra, a complete description of the annihilators is obtained by considering the algebra of differential operators with polynomials coefficients in both the Laplace variable and the parameters. ***OQ2)*** *Or, at least, does there exist an adequate basis representation of the annihilator in some adequate algebra?* From the answer to OQ1), using elimination techniques (*e.g.*, Gröbner bases for noncommutative polynomial rings of differential operators), we can derive generating sets of annihilators or left common multiples which only depend on given parameters. We can then compute towers of annihilators which depend on parameters which have already been estimated. ***OQ3)*** *And lastly, can the annihilator be chosen from efficient tuning rules?* Based on Gröbner basis techniques and the Maple package OreModules, we have implemented our algorithms, which helps solving the parameter estimation problem. Current research on different errors arising from the estimation is being carried.

2.3.4 Collaborations

[**Partial derivatives:**] D. Liu (INSA Val Loire) for fractional order; [**Time-delays**] F.J. Bejarano IPN Mexico; [**Integro-Differential Equations &**][**Symbolic computation:**] F. Boulier and his team CFHP at CRIStAL (symbolic computation).

2.3.5 External support

MSDOS (ANR); Invited Professor position: F.J. Bejarano - see "Funding" p.28.

2.3.6 Self assessment

[**Strengths:**] Algebraic methods are historically a research axis for Non-A. These methods have been developed now in various directions, such as PDEs, orthogonal polynomials, integro-differential operators. The computer algebra part was also expanded with the local collaborations and the arrival of Alban. [**Weaknesses:**] Noticeable progress in the theoretical part, in particular on the choice of annihilators, was done. Nevertheless, the error analysis based on the different possible annihilators is still underdeveloped. [**To be continued/modified/stopped:**] The research on this topic should be reoriented so as to enlarge it to computer algebra for control and systems theory, which is larger than the only spectrum of estimation that we consider today. This is motivated, for instance, by the promising results we had on parametric stabilization (see Subsection 2.6.3) and encompasses the only estimation goal. See also Section 6 on the objectives for the next four years.

2.4 Research axis 2: Numerical differentiation and finite-time estimation (tools: HOM [4])

2.4.1 Personnel

Permanent members: L. Belkoura, D. Efimov, T. Floquet, W. Perruquetti, A. Polyakov, A. Quadrat, J.P. Richard, R. Ushirobira, G. Zheng. **Post-docs:** A. Estrada, L. Etienne, H. Rios. **PhD students:** Z. Kader, D.K. Langueh, D. Mincarelli, F. Lopez Ramirez, H. Silm, J. Thomas. **External collaborators:** J.P. Barbot, C. Join, M. Mboup.

2.4.2 Project-team positioning

Differentiators are important for many applications: PID controllers implementation, system states observation, fault detection algorithms, digital filtering in signal processing, system identification, *etc.* From a theoretical point of view, the differentiators can provide the exact values of the k derivatives of a $\mathcal{C}^k$ signal. However, any such exact differentiator is a mathematical abstraction: due to measurement noises and finite computational precision of digital devices, it will give approximate solutions only, in practice.

The problem of numerical differentiation is ill-posed in the sense that a small error in measurement data can induce a large error in the approximate derivatives. Therefore, various numerical methods have been developed to obtain stable algorithms more or less sensitive to additive noise. They mainly fall into two categories: ***1)*** *Signal approximation-based* approaches, where signal approximation is calculated in time domain, and next derivative estimate is derived from the obtained approximation: Savitzky-Golay method; wavelet approximations; Fourier approximations; **algebraic method.** ***2)*** *Differential operator approximation-based* approaches, where the differentiation operation is replaced by an approximate calculation, as for instance in: finite differences method; dynamic filtration (observation) algorithms (*e.g.* **homogeneous differentiator**); mollification method; Tikhonov regularization methods; Lanczos generalized derivatives; method of weak derivatives.

Non-A contributes to both of the categories, based on methods well-recognized in the field of control theory. Namely, the homogeneous differentiator developed in Non-A [PFM08] is a special nonlinear case of dynamic high-gain observers (operator approximation-based approach). The algebraic differentiator is a signal approximation-based approach, essentially assumpting that the signal can be approximated by some function obeying differential equation (*e.g.*, polynomial, sum of sines...). *Since algebraic methods have been well described previously, this part will mainly present the homogeneous differentiators.* Both, homogeneous finite-time estimators and algebraic observers, have certain robustness with respect to external disturbances and measurement noises. Regarding noise, the algebraic approach is ubiquitously better due to integration presented in these algorithms. Homogeneous observers have smaller delay: having achieved the finite-time convergence, there is no more delay. Both have also extensions for different estimation problems (of states, parameters, inputs, *etc.*). Despite they are model-free, they do not take into account the system uncertainty in an explicit way: the next section (axis 3) will present how such uncertaintainty is explictly considered in the interval / set-membership estimation framework.

The history of homogeneous, time-invariant, ordinary differential equations is not new (1958) in control theory [Zub58, Ros92]). These nonlinear systems (see [108] for mathematical definitions) have a very interesting characteristic: the local and global behaviors

[4]As it is explained in this section, this section focuses on the advances in homogeneity (HOM) for differentiation and finite-time estimation, even if ALG and SET (Sections 2.3 and 2.5, respectively) are also contributing to this research axis.

are the same and the properties on a sphere can be extended using the scaling property (dilation matrix) defining the homogeneity. For the stability/instability analysis, a Lyapunov/Chetaev function of a homogeneous system can also be chosen homogeneous, and its negativeness can be checked only on the unit radius sphere. Such strong properties have been found useful for stability analysis [APA+08, Hon02], approximation of system dynamics/solutions [Her91][88], stabilization [BB05, Grü00, MP06, SA96], and estimation [257]. Numerical analysis and design of homogeneous systems may be simpler since, for example, a Lyapunov function has to be constructed on a sphere only. In addition, the homogeneous systems have certain intrinsic robustness properties [Rya95, Hon01][31]. For instance, if a system is homogeneous (considering disturbance as an auxiliary variable) and asymptotically stable without disturbances, then it is robustly stable: input-to-state stable (ISS) or integral ISS (iISS).

2.4.3 Scientific achievements

Non-A has obtained a lot of results for analysis and design of homogeneous estimation and of control algorithms. For brevity, only the main lines (and main references) are presented here[5].

[Generalizations:] First, the notion of homogeneity has been generalized to Differential Inclusions (**DI**) [301] (the geometric homogeneity framework and local approximations, existence of homogeneous Lyapunov function), to time-delay systems (**TDS**) [58] and time-varying systems (**TVS**) [106] and, finally, to partial differential equations (**PDE**) [93]. To give an idea of the technical issues behind such extensions, let us mention that, considering TDS, TVS or PDE, the scaling /dilation operations also affect the parameters (*e.g.* delay) and the spaces of solutions.

[Local homogeneity:] Homogeneity is a demanding property for general nonlinear systems, which generaly exhibit local (non global) properties. Thus, local homogeneous approximations have been proposed [55] so to enlarge the class of systems where the homogeneity theory can be (locally) applied.

[Robustness:] Special attention has been paid to the robustness notions of homogeneous systems, especially: input-to-state stability property (ISS) [27, 31], insensitivity with respect to delays [132] and to time-varying perturbations of a given frequency spectrum in the TVS case [108].

[Homogeneous/Implicit Lyapunov Functions:] The main issue for stability analysis of nonlinear systems is the selection of a Lyapunov function, which can be frequently avoided, or significantly simplified, for homogeneous systems: two cases of highly nonlinear or hybrid control and estimation algorithms have been presented recently [49, 236], for example. And it becomes even more simpler using the Implicit Lyapunov Function (ILF) method *[97, 95, 96]*, where an explicit representation of Lyapunov functions is replaced by an implicit form.

[Comparisons:] Globally, as said in the positioning of this axis, our algebraic approach is better regarding noise, and homogeneous estimators are better reagrding delay. More technically, in addition to the our previous comparisons [Liu11], the report [320] compares various differentiation techniques, including algebraic (with various polynomials) and homogeneous (sliding mode), in terms of the algorithm complexity and algorithm accuracy under noise and quantization: For instance, on a signal $e^{\sin 15t}$, the algebraic technique based on Jacobi polynomials exhibits better performance. Additional comparisons

[5] For instance, for quasi-periodic motions, we had a nice result on finite-time position and velocity estimation from to acceleration measurements [65]

have been provided in [280] in the application context of prediction for Human-Computer Interaction (TURBOTOUCH, see Section 2.6).

[Unexpected consequences:] The main advantage of homogeneity is that it is an algebraic property of the vector field describing the model, which is easy to check, and then many useful consequences can be deduced from homogeneity, simplifying both the analysis (of stability, robustness, rate of convergence,...) and the design. In this sense, we consider that homogeneous models should become a fruitful generalization of the usual linearization techniques: in the future, one can think of designing a local controller from a local homogeneous approximation, or a global one after some "state feedback homogeneization". The appealing properties of homogeneous systems are their rates of convergence, which are finite-time (for a negative degree of homogeneity) or fixed-time [96, 236][Pol12] with respect to any ball (for a positive degree), making the designed homogeneous control and estimation algorithms non-asymptotic.

To conclude with, here are some **answers to open questions of research axis 2**: ***OQ4)*** *Can homogeneity address large classes of models?* Yes, definitely: notion exists now for ODE, DI, TDS, TVS, PDE. Moreover, local approximations of non homogeneous systems still enlarge the scope. ***OQ5)*** *How can the finite/fixed-time convergence be proven in an adequate Lyapunov-like framework?* Various Lyapunov approaches have been defined, including implicit techniques. Also, the nature of the fast, hyper-exponential convergence has to be adapted to the class: with TDS, for instance, finite-time seems too demanding. ***OQ6)*** *How to build a framework for the comparison of the various estimation (and control) techniques (Model-Based, Model-Free)?* This question was partly answered by our theoretical works on the two past periods and our experience within the TURBOTOUCH project. However, it stays partly open from the user's point of view. The platform ControlHub (see p.20 and 23) will be our next step to address the question in an open way, as well are more general control questions.

2.4.4 Collaborations

A. Levant, Tel Aviv Univ., Israel; E. Fridman, Tel Aviv Univ., Israel; K. Zimenko, ITMO Univ., Russia; J. Moreno, UNAM, Mexico; L. Fridman, UNAM, Mexico ; H. Ríos, Univ. of Laguna, Mexico; L.B. Freidovich, Umeå Univ., Sweden; I.d.J. Salgado Ramos, IPN Mexico.

2.4.5 External support

Inria Associate Team HoTSMoCE; Inria North-European Associate Team PImIR; ANR Finite4SoS; H2020 EJC UCoCoS; Invited Professor positions: A. Levant (4 months), E. Fridman (4 months), F.J. Bejarano (1 month) - see "Funding" p.28.

2.4.6 Self assessment

Strong points: Many useful theoretical results have been obtained during the last 5 years, including developments of the *homogeneity theory* and the *theory of Implicit Lyapunov Functions* for various classes of complex systems (ODE, DI, TVS, TDS, first steps for PDE). **To be continued:** In the coming years, in parallel with continuation of developing the theory for *distributed estimation and consensus*, for example, some additional effort has to be put to design the improved control and estimation tools benefiting the advantages of homogeneous systems (finite/fixed rates of convergence, robustness w.r.t. external disturbances and measurement noises, insensitivity to delays). The development of *tuning rules for nonlinear homogeneous control and estimation algorithms* is another important direction of future research. Finally, *analysis of interconnections of homogeneous systems of different nature* (described by ordinary, functional or partial differential equations) has to be considered. This should motivate a new, full project, exploiting the finite-time property in the context of interconnected systems (Systems of Systems) without restricting to estimation (see Section 6 on the objectives for the next four years).

2.5 Research axis 3: Control without sophisticated models (tools: ALG-HOM-SET)

2.5.1 Personnel

Permanent members: Denis Efimov, Wilfrid Perruquetti, Andrey Polyakov, J.P. Richard. **PhD students:** T. Kharkovskaia, S. Maalej. **External collaborators:** Cédric Join, Samer Riachy

2.5.2 Project-team positioning

Control theory usually deals with mathematical models of real (physical) plants, which are described in the time domain by means of differential equations or in the frequency domain by means of transfer functions. If the plant model is unknown, a possible way of control design is to make some mild assumptions on the plant behaviour and/or its closeness (in some sense) to a sufficiently simple model. In this context there are several "model-free" approaches. Plenty of solutions are provided by *computer science*, *e.g.* data-driven and/or machine learning-based control. The corresponding methods are developed by various teams in France (Inria for instance) and in the world (in USA for instance). They use, for example, Markov chains as plant models to be identified online by using system outputs and/or other experimental data.

Non-A develops alternative approaches which are mainly based on *control theory*. In particular: **Model-free control (MFC)** [FJ09] was developed by M. Fliess and C. Join in ALIEN, then in their start-up AL.I.E.N. SAS[6] (Cédric is now an external collaborator of Non-A). It has a certain relation with Poncelet's invariance principle. Recall that MFC [68] involves the simplest, "ultralocal" model (*i.e.* valid on a very short time window) of the kind $y^{(i)} = F + \alpha u$ where $i = 1$ generally (and $i \leq 2$ in all application cases they dealt with), and F results from the online algebraic estimation of the corresponding fast perturbation (F can be seen as the modeling error). One of the applications, traffic control, is also considered by NECS but with other techniques. The **Mollifiers-based approach** refers to "universal integral control" (UIC) by H.K. Khalil [Kha00] for the semi-global stabilization of nonlinear systems. It requires the knowledge of the output relative degree and the sign of the control gain. An integral term compensates *a priori* unknown constant bias and, for 2nd order systems, UIC reduces to a PID regulator. **Sliding mode control** (SMC) is historically the first robust control methodology introduced more than 50 years ago, also based on mild modelling assumptions. It is a non-smooth control, also studied by BIPOP (note a joint work on discretization issues [167]). The modern so-called *higher order sliding mode control* (HOSMC) basically needs to know the relative degree in order to design a universal controller. **Interval estimation/control** [REZ12] as well as **Attractive ellipsoids technique** can be possessed as set-theoretic methods [BM08] in control. They need a bit more modelling information but no exact value of the parameters.

[6]Simplified joint stock company, Young University Company status and certification for "crédit impôt recherche".

2.5.3 Scientific achievements

[**Model-Free Control**] As expected in the roadmap, MFC is developed within AL.I.E.N. SAS and mainly aims at applications (note however an improvement of MFC for systems with time-delay [182] by introducing a time-varying gain α), in a continuation of projects undertaken over the past few years (including the control of hydroelectric power plants with EDF or engines throttles with PSA). Here, the work development in new domains is always the result of fruitful collaborations. During the period, MFC has mainly considered two application domains: ***[Traffic control:]*** an algorithm, named as ALINEA [13], has been proposed, showing the possibility to control the traffic without the knowledge of density and free-flow speed. From September 2015, it was applied to control the traffic on the French highway $A25$ (access ramp 'La Chapelle-d'Armentières'): users and DiRN are satisfied with first results. An important project should begin in 2017 on ramp metering for highways A1 and A22, where the problem of distributed control will be considered. ***[Biological systems:]*** Biological systems consitute a renewed and large applicative framework for MFC, since the problem of precise modeling of living systems is very complex. Our interest includes immune therapy, microalgae growth, denitrification and wastewater treatment. On these items some works are only submitted (patent pending) and it would therefore be premature to develop innovative ideas here (see also next section on applications).

[**Mollifiers-based Approach:**] The paper [102] considers the robustness of UIC w.r.t. high-frequency, big-magnitude noises. A definition of a big-magnitude and high-frequency noise is given as a function in a Sobolev space with negative index. A mollified version of the UIC is proposed and the low pass filtering character of the mollified controller is demonstrated as well as the practical stability of the closed loop. Note the underlying tools have been firstly presented for parameter estimation purpose [104].

[**Higher Order SMC:**] Non-A contributed a lot the higher order sliding mode theory: For example, the unified framework for non-asymptotic (finite-time/fixed-time) analysis and design of HOSMC systems has been developed and summarized in two survey papers [98, 27] (more than 30 pages each) published in a special issue of the J. of Franklin Institute. Many issues of practical implementation have been studied: we considered the digital implementation of HOSMC [233] and the fundamental problem in sliding modes (chattering reduction or "chattering-free sliding modes") has also been treated based on homogeneity theory [96], implicit Euler discretization [167], time-delay approximations [57]. Also note an application to quadrotor control [118].

[**Interval Estimation/Control:**] Model uncertainty (unknown parameters or/and external disturbances) is a key issue for development of control and observation algorithms. Presence of uncertainty implies that design of a conventional estimator, converging to the ideal value of the state, is difficult to achieve. In this case an interval estimation becomes more attainable: an observer can be constructed such that using input-output information it evaluates the set of admissible values (interval) for the state at each instant of time. The interval width is proportional to the size of the model uncertainty (it has to be minimized by tuning the observer parameters). During the last 5 years, in Non-A team, the interval observers have been proposed for different kinds of systems. In continuous-time, mention the classes of systems: linear or nonlinear [291] (even unobservable [128]); LPV [32, 188] and time-varying [116]; singular [127, 290]; time-delay [195, 52, 193, 199, 47]; descriptor time-delay [59]; impulsive [177]; sampled [48]. In discrete-time: linear [192]; LPV [60] and time-varying [51]; PDE [227]. The corresponding interval estimates have also resulted in interval controllers for uncertain dynamical systems [94, 60, 188] with applications [176, 188, 169].

[**Attractive Ellipsoids Method:**] Introduced in the monograph [305], it is a newly developed robust control design technique for a wide class of continuous-time dynamical systems. This book proposes high-performance robust feedback controllers that work in the absence of complete information assuming that the nonlinear plant model is sufficiently close (in some topological sense) to a good (*e.g.* controllable) system. The numerous examples illustrate how to apply the attractive ellipsoid method to mechanical and electromechanical systems. While theorems are proved systematically, the emphasis is on understanding and applying the theory to real-world situations. The *non-asymptotic* verion of attractive ellipsoids method has been proposed recently [89]. It is essentially based on the novel technique developed by Non-A: the *Implicit Lyapunov Function Method* [96] for non-asymptotic control and estimation. This method allows the ideas of quadratic stability to be extended to nonlinear homogeneous system. In the latter case, the quadratic-like Lyapunov function is defined in an implicit form. It has ellipsoidal level sets, which are symmetric with respect to homogeneous dilation.

Now, here are our **answers to the open question *OQ7)*** *Can such techniques, with the associated online estimation, be applied (by engineers) in any application field and in the presence of complex phenomena (non-minimum phase, delay effects, switches...)* [**MFC:**] this case is particular since we were not looking for theoretical proofs, but for a variety of application cases. Based on this experience, today we conjecture that MFC is robust enough to switches (even if it may appear extreme cases that were not yet encountered on any application we had to deal with). We also have good lines for adapting it to delays (with time-varying gains, see above). But MFC seems to be unsuitable for non-minimum phase systems. [**Unexpected results:**] Set-theoretic methods were not explicit in our intial roadmap, but have been growing up over the period. Today, we have adapted *interval techniques* to a wide variety of classes (nonlinear, unobservable, LPV, time-varying, time-delay, singular/descriptor, impulsive, sampled, some PDE). Note that in the case of "ordinary" systems (say, ODE), interval techniques have already met a great industrial success for diagnosis and supervision: see the ABB SafeProcess award in our highlights (Section 3.6), but also the 2016 Medal of Innovation awarded by the CNRS to our colleague Ali Zolghadri (Bordeaux). Concerning *attractive ellipsoids* method, the monograph [305] surveys the corresponding solutions to the also very wide class of control systems (with delay, switching, sampling effects). We are expecting to use those approaches in a number of applications in the near future.

2.5.4 Collaborations

[**Model-Free Control:**] Univ. of Tennessee USA; L2S Paris/GEPEA Nantes; MOCOPEE (SIAPP project). [**Mollifiers:**] Ø. [**Sliding Mode Control:**] A. Levant Tel Aviv Univ. (5 joint publications); L. Fridman UNAMMexico and HoTSMoCE (>10 joint publications). [**Interval Estimation/Control:**] A. Zolghadri Bordeaux Univ. (>10 joint publications, 1 award); F.J. Bejarano IPN Mexico; T. Raïssi CNAM Paris (more than 10 joint publications); S. Chebotarev, ITMO University, Russia. [**Attractive Ellipsoids:**] A. Poznyak CINVESTAV, Mexico (1 monograph and 2 papers).

2.5.5 External support

[**Model-Free Control:**] internat. program MOCOPEE. [**Mollifiers:**] Ø; **Sliding Mode Control**: ANR Chaslim 2011-2015; Inria Assoc.Team HoTSMoCE 2016-2018. [**Attractive Ellipsoids:**] Various visits funded by CINVESTAV, Mexico - see "Funding" p.28.

2.5.6 Self assessment

[Strengths/Weaknesses:] In the presentation of this axis, we included Model-Free Control for historic reasons, even if it is now fully developed in AL.I.E.N. SAS. It receives attention by various funding partners. On the other aspects, thanks to a strong theoretical production and activity of its members in the community, Non-A got a large recognition on "robust" control in the sense of above items. Non-A has contributed a lot to the theoretical background of HOSM in the context of homogeneity, Lyapunov function method, Input-to-State Stability, etc. However, the issue of practical implementation of algorithms are still not well developed despite of the fact that many teams all other the world deal with HOSM methodology. For example, the effective computational schemes for HOSM controller/observer parameters tuning are still not developed, the qualitative analysis of their sensitivity with respect to measurements noises and mismatched perturbations is not provided, etc. The method of Implicit Lyapunov function looks very promising for this purposes, since it allows the parameters of controller/observer to be selected from Linear Matrix Inequalities. **[To be continued/stopped:]** 1) Now *interval observers* theory has been extended to almost all classes of systems (in many cases by the works of members of Non-A team), and the future development lies in its use for applications, like fault detection, for example. On this topic, we have recognized skills (see the ABB best application paper ABB Award at IFAC SafeProcess 2015). 2) Investigation of *non-asymptotic attractive ellipsoid* techniques is just introduced and should be continued: development of robust non-asymptotic control/estimation algorithms supported with effective computational schemes will necessarily deal with optimal tunning of attraction domains. This research direction is very perspective for non-asymptotic control and estimation. 3) Concerning mollifiers, from one hand we note that low-pass filtering of noise is achieved by our new universal integral control. On the other hand, it is known that most of physical nonlinear systems can be seen as low-pass filters. As an example, the pulse-width-modulated control signals generated by power electronic converters contain undesired high-frequency and big magnitude components which are filtered by the driven motor inductance. A characterization of "low-pass filtering" for nonlinear systems should receive a systematic treatment, even if it is not in our main scope.

2.6 Research axis 4: Applications (tools: ALG-HOM-SET)

Personnel

Permanent members: All. **Engineer:** R. Dagher, J. Palos, X. Jin, Z. Qiu. **External collaborators:** J.P. Barbot, C. Join, S. Riachy. **Post-Docs:** Y. Bouzidi, R. Delpoux. **PhD students**: H. Ahmed, S. Aranovskyi, M. Feingesicht, M. Guerra,Y. ElAfou, Q. Guo, A. Martin, N. Martinez-Fonseca, G. Perozzi, G. Rance, M. Oueslati, H. Sert, Z. Shao, Y. Wang.

Project-team positioning

As explained in Section 2.2, Non-A aims at developing new theoretic methods (challenges 1, 2 and 3) for non-asymptotic online estimation and control, to be applied in a large variety of domains. Whereas traditional methods pertain to optimization and asymptotic statistics, Non-A is the only research group focusing on non-asymptotic, online estimation and control by using differential algebra and homogeneity. In this sense, Non-A is a *method-driven project*, not linked to a specific domain of application. However, the applicability of our techniques is as much crucial as their theoretical proof: During these 4 years, our techniques have already shown their efficiency in many applications: only some of them are presented in this report, regrouped into 5 items: 1) Robots and networked systems; 2) Estimation for living systems; 3) Turbulent flow control; 4) Industry and society; 5) Our future open platform “ControlHub” for rapid controller prototyping.

Scientific achievements [7]

1) [Robotics and networked systems:] (ALG, HOM). Inria Lille and team FUN are hosting an “equipment of excellence” named FIT-IoT lab and giving a remote access to thousands of wireless sensors to be connected with hundreds of mobile robots. Today, many sensor senarios are available, with few robot testbeds (see this link). The package SLIM, developed by Non-A under ROS (Robot Operating System) with the support of an Inria ADT (Section 4.0.4), already contributes to this environment. The self deployment of autonomous groups of mobile robots in an unknown and variable environment is a next step for IoT-lab, involving localization, path planning and robust control problems. Our ROS package SLIM combines various algorithms developed by Non-A (localization, path planning, robust control, see the PhDs [Ser13][4] as well as [74] and SYSIASS European grant with ISEN on autonomous wheel chair). SLIM offers a software library for multi-robot (see a video), including: Optimal local planner based on flatness; Plugin for communication between different ROS cores; Module Multi-Mapping for robot cooperation; Plugin for YEI IMU. Following this, the top German company in Laser scanners SICK donated us three of his latest scanners so to test them with our results. A public demonstrator, named RCG (see video), is also presented since 2014 at Euratechnologies Lille: it monitors the Inria area with mobile robots avoiding obstacles and detecting anomalies. That’s how the start-up “La Maison Attentive” signed with us a contract to prototype its autonomous mobile table for hospitals (see Zephyr here). Results on fixed-time stabilization of nonholonomic [35] or multi-agent [36] systems have been given.
The extension of our works from 2D (mobile robots) to 3D (flying robots) is ongoing, containing the estimation and control of quad-rotors (PhD work of G. Perozzi with ONERA) and Blimp (PhD of Y. Wang, with a targeted industrial partner in 2017). We are also in touch with EOS Innovation on area collaborative monitoring.
Last, concerning manipulation robots, the PhD of Q. Guo [5] used fast estimation for the acurate control of cheap manipulators [214, 215] and a joint PhD with IPN Mexico (N. Martinez-Fonseca) started on the control of micro-manipulator for biological cells.
2) [Estimation for living systems:] (ALG, HOM) Modelling, estimation and detection for living are difficult because such systems cannot be isolated from external influences. Our numerical differentiation tools, together with modelling techniques, have been checked in 3 contexts (+1 submitted): ***[Biosensing]*** Unlike classical approaches deploying physical sensors, biological systems can be used as the living sensor: The marine biology lab EPOC has developed underwater sensors for bivalve molluscs (such as oysters), measuring and sending through GPRS the opening gap between the two valves[8]. In the ANR WAQMOS, we use it for water quality monitoring, by either identifying oyster’s rythm I/O models, or by using our differentiation tools [1][15]. Spawning detection has also been studied [16]. ***[Human-Computer Interaction]*** In the ANR TURBOTOUCH (with Inria MJOLNIR and CNRS PMB) we apply these tools to reduce the latency between the human input and the system visual response in HCI. We developed a simple forecasting algorithm for latency compensation in indirect interaction using a mouse (patent [321]). An optimized procedure is developed for tuning the parameters of the algorithm. The efficiency is demonstrated on real data, measured at 1kHz, in comparison with other dif-

[7] Most of the videos mentionned are on http://chercheurs.lille.inria.fr/~jrichard/manips.htm
[8] See their MolluSCAN-Eye website

ferentiators [280]. Another contribution comes from the design of a completely original dynamical model for pointing tasks in the HCI [152]. ***[Smart bracelet]*** With NEOTROPE (start-up developing a bracelet intended for strong human emotion detection), we designed a dynamical model for the GSR and developed an online algorithm making the GSR signal independent of the user movements. Most resulting computations are embedded in the bracelet. We expect a second contract with the same company for providing more reliable signals for the emotions detection, and applying our technique for latency compensation. ***[Microbial populations]*** An Inria Project Lab, COSY, is also under evaluation for real-time control of synthetic microbial communities.
3) [Turbulent flow control:] (HOM) Non-A is active in a Regional consortium gathering microtechnologies ONERA, IEMN, LAMIH, LML (and PPrime lab, Univ. of Poitiers) which develops methods of active control of separated flows (ContrATech subprogram of CPER ELSAT). Aerodynamic losses are believed to be a major source of energy wastage for a vehicle at speeds higher than $50km/h$. Optimization of the vehicles shapes has reached its limit and such a passive control approach cannot deal with unsteady incoming flow. Similarly, in aeronautics, controlling boundary layer airflow could reduce stall drastically. In such contexts, active control strategies (air blowers, hot film sensors...) are very attractive. But the natural phenomena ruling turbulent flows lead to highly nonlinear, infinite-dimension dynamics. Till now, researchers use either nonlinear PDEs (NSE, Navier-Stokes) convenient for analysis but improper for control design, or unrealistic linear finite-dimension models for classical - but non robust - control. Non-A proposed a model with intermediate complexity (bilinear with time delays, "grey-box" identification on experimental data, presented at ECC2016). Next the model-based sliding mode and optimal control algorithms have been developed and tested on numerical simulations: experimental validation is planned for the spring 2017. Our next theoretical step is to look at NSE models from the point of view of homogeneity. PhD of M. Feingesicht is jointly supervised with CNRS UPR InstitutP' Poitiers), and a postdoc will be recruited in September 2017.
4) [Industry and society:] (ALG) ***[Model-Free Control, AL.I.E.N. SAS]*** Industry is keen on simple and powerful controllers. The tuning simplicity of the classical PID controller explains its omnipresence in industrial control systems, although its performances drop when the working conditions change. AL.I.E.N SAS was created end of 2011 as a spin-off of the Inria project ALIEN, which gave rise to Non-A, working on algebraic estimation and i-PID controller (*i.e.*, using algebraic estimation of the perturbations and apply a simple PID control on some "ultra-local" model). This control technique uses the information contained in the output signal and its estimated derivatives, which can be regarded as "signal-based" controllers. Model-free control technique has been applied in many different domains (electronics, hydroelectric power...). Recent research is focused on 1) traffic control and 2) biology. 1) The quality of traffic control laws depends on a good knowledge of the highway characteristics, especially the critical density and the free-flow speed, which are unfortunately most difficult to estimate in real time. At this aim, an algorithm, named as ALINEA, has been proposed, which has been shown the possibility to control the traffic without the knowledge of density and free-flow speed. From September 2015, this algorithm was applied to control the traffic on the French highway $A25$ (access ramp 'La Chapelle-d'Armentières'): users and DiRN are satisfied with first results. 2) Our ongoing research on model-free control for biology has also been applied with success on a real process of wastewater treatment. A new pressure control scheme has been developed and a patent application with Suez Environnement (n.d.l.r. anciennement Degrémont) is pending. AL.I.E.N. SAS also joined the consortium MOCOPEE (modeling, control and optimizaton of wastewater treatment processes) as one of its 4 industrial partners. ***[Mechatronics, SAFRAN]*** A collaboration with the SAFRAN Electronics & Defense

company has been developed (CIFRE PhD thesis, 2014-2018) on the parametric stabilization of gyrostabilized platforms. To do that, we develop a new symbolic-numeric approach (*e.g.*, Gröbner bases, Rational Univariate Representations, discriminant varieties, certified root isolation) for the standard H_∞-loop shaping design problem for models of gyrostabilized platforms in terms of the physical parameters (masses, inertia, etc.) considered as unknown parameters [265]. Combining these results with parameter estimation methods, we plan to develop new embeddable and adaptive controllers for the robust stabilization of gyrostabilized platforms. Note that algebraic estimation was also applied to PMSM (permanent magnet synchronous motor) and magnet bearings, with successfull experimental results [39, 38]. ***[Renault]*** A PhD grant (CIFRE) with the car company has started in 2017, jointly with Inria SEQUEL: the topic is kept confidential.
5) [Platform ControlHub:] (ALG, HOM) ControlHub is a software platform that will leverage collaborative research and experimentations in the field of automatic control. This project was launched in March 2016 after the recruitment of SED Engineer Roudy Dagher, thus it is still under development. The driving idea is to interconnect a group of actors (researchers, engineers, etc.) around a control problem and grant them remote access to existing experimental facilities, thus allowing them to verify their theoretical results online, and finally share them with the project members. The main expected features of the platform are: Model-based simulation (using Matlab/Simulink as reference, but open to others such as Scilab, ControlLab); Rapid controller prototyping (automatic native code generation from simulation code, on-target validation, online parameters tuning); Open architecture (APIs and abstraction layers to allow integration of new experimental facilities).

We also dealt with various other applications, which are not presented here: Electrical engineering [18, 37, 38, 40, 41, 63, 70, 80, 81, 82, 104, 111, 112, 122]; Aircraft systems [34, 43, 76, 77, 133]; Engine control [50]; Oscillators and synchronization [14, 17, 28, 64]; Networks and sampling [48, 67, 78, 79, 92, 91, 123], to mention only the journal papers.

2.6.1 Collaborations

- Industry: Neotrope Tourcoing, La Maison Attentive Loos, EOS Innovation Paris, SICK Germany, Safran Paris, AL.I.E.N SAS Nancy (created by C. Join and M. Fliess)
- Inria: FUN (Lille), MJOLNIR (Lille), SEQUEL (Lille), DISCO (Saclay)
- CNRS: EPOC Bordeaux (oysters), PMB Marseille (HCI), InstitutP' Poitiers, IEMN Lille, LML Lille , LAMIH Valenciennes (flow control)
- Other academics: ONERA Lille and Meudon (flow control), ISEN Lille (handi robots), Tel Aviv Univ. Israel, Sliding Mode Control Lab. UNAM Mexico, Dept Control Automatico, CINVESTAV-IPN Mexico, National Polytechnic Institute Mexico (ControlHub), LGi2A Béthune (traffic).

2.6.2 External support

Robots and networked systems: contract LaMaisonAttentive, CPER CIA, ADT SLIM, Europe SYSIASS, Demonstrator RCG (supported by Inria Lille), PhD ONERA-Region. **Estimation for living systems:** WaQMoS (ANR), TurboTouch (ANR), contract Neotrope. **Turbulent flow control:** CPER ELSAT/ContrATech (Region). **Industry and society:** contract Safran, contract Renault, DiRN (program MOCOPEE).

2.6.3 Self assessment

[Strengths:] Thanks to a strong theoretical production, Non-A becomes the world-recognized project on finite-time estimation and control. Without sacrificing fundamental exploration, we now consider many *interdisciplinary* applications (note that the 5 CNRS labs and the 4 Inria teams above are not control specialists). Considerable effort has been also invested in *industry projects* during the past 4 years in Lille. Over time, we note that these projects are moving closer to our original research results (in particular, online estimation), whereas they were initially more related to our technical know-how (robotics). **[Weaknesses:]** 1) At the beginning of the period the project was probably not organized enough to capitalize all its software development. There has been a large engineering effort (about 36 months of *non-permanent* Engineer) resulting in the SLIM package, which may be not enough. Thanks to the Research Engineer provided by Inria, we feel now more efficient on this point. 2) Even we are well recognized in the control community, our presence in the robotics community is rather new, we still have to improve our visibility, for instance by increasing our participation to the major robotics conferences and journals, which means to change the nature of the production (less theory, more protypes and videos).

2.7 Evolution of research directions during the evaluation period

At the time of last evaluation (March 2013), Non-A was 9 months old, thus the original objectives (see Fig. 1) were maintained, namely:

Fundamental research: 1) General annihilators, 2) Numerical differentiation, 3) Model-Free control, 4) Applications. The mathematical tools were (ALG) *Algebra*, and (HOM) *Homogeneity*.

Our development of (SET) *Set-membership* tools was not that put forth. However, in this report, (SET) techniques are a bit more spotlighted since they have received substantial contributions.

Applied research: This was corresponding to the applications in Fig. 1 (Networked robots, nano/micro machining, multicell chopper, i-PID for industry).

We finally focused on robots, living systems, flow control and industry/economy. Few comments about networked robots will be given in Section 5 "Follow up to the previous evaluation". Living systems are a new and fruitful application area, which we intend to develop in the future, as well as flow control. The other application domains have been considered, mainly, by our collaborators (see footnote p.6).

Globally, our objectives have been reached, most of the open questions have received answers and unexpected results have been obtained.

3 Knowledge dissemination

3.1 Publications

	2013	2014	2015	2016+
PhD Theses	4	3	3	2
H.D.R. (*)			1	
Journals	25	26	32	39
Conference proceedings (**)	40	42	32	46
Book chapters	2	1	2	2
Books (written)	1	1	0	0
Books (edited)			1	
Patents	1	1		1
General audience papers				
Technical reports			3	8

(*) HDR Habilitation à diriger des Recherches
(**) Conferences with a program committee

Indicate the major journals in the field and, for each, indicate the number of papers coauthored by members of the project-team that have been accepted during the evaluation period.

1. Automatica 27
2. IEEE TAC 15
3. IEEE CST 5
4. SIAM JOC 1
5. Int. J. Nonlinear and Robust Control 6
6. J. of the Franklin Institute 4
7. Systems & Control Letters 3
8. IEEE TIE 2

Indicate the major conferences in the field and, for each, indicate the number of papers coauthored by members of the project-team that have been accepted during the evaluation period.

1. CDC 33
2. ECC 33
3. ACC 9
4. IROS 3

3.2 Software

SLIM *(Software Library for cooperative Multi-robots) is a ROS package (Robot Operating System) combining some of the algorithms (localization, path planning and robust control) developed by Non-A team, and offers a simple and complete software library for the cooperation of multi-robots. The following functionalities have been implemented in the package: • Optimal local planner based on flatness • Plugin for communication between different ROS cores • Module Multi-Mapping for robot cooperation • Plugin for YEI IMU.*

Web site: https://bil.inria.fr/en/software/view/2278/tab. Self-assessment:

- Audience: A-2 (used by people in the team or close to the team) Research: PhD M. Guerra, Z. Shao + FiT mobile robots (WifiBot, TurtleBot). Tech. Transfer: demos RCG Euratech and LaMaisonAttentive.
- Software originality: SO-3 (original software reusing known ideas and introducing new ideas)

- Software maturity: SM-2 (basic usage works, terse documentation)
- Evolution and maintenance: EM-2 (basic maintenance to keep the software alive)
- Software distribution and licensing: SDL-2 up (privately distributed within the close community)(up = adaptable in a contractual setting).

BLIMP *is a homemade prototype for experimenting and demonstrating control algorithms for autonomous airship. The developed blimp demonstrator was built from scratch and consists of two main domains: - Blimp electronic board: o Arduino controller board: sensors, actuators and com management o Sensors: camera, IMU, range (ultrasonic) o Actuators: Three DC motors with their drivers. o Communication: ZigBee link - Base station computer: o Qt-based application for manoeuvring the blimp and displaying sensors data o ROS integration via dedicated ROS package o Matlab interface for controller design o OptiTrack integration for camera-based indoor localization. Research: PhD of Y. Wang. Transfer under discussion with Leroy Merlin Ltd.*

Web site: https://bil.inria.fr/en/software/view/2279/tab. Self-assessment:

- Audience: A-2 (used by people in the team or close to the team)
- Software originality: SO-4 (original software implementing a fair number of original ideas)
- Software maturity: SM-2 (basic usage works, terse documentation)
- Evolution and maintenance: EM-2 (basic maintenance to keep the software alive)
- Software distribution and licensing: SDL-2 (privately distributed within the close community)

ControlHub *is a software platform that leverages collaborative research and experimentation in the field of automatic control. The driving idea is to interconnect a group of actors (researchers, engineers, etc.) around a control problem and grant them remote access to existing experimental facilities, thus allowing them to verify their theoretical results online, and finally share them with the project members. The platform architecture relies on three key principles: - Problem centric: The control problem to be solved is the core project, whereas the software resources, tools and online experiments are web services available to support experimental verification of the solutions. - Separation of concerns: setup and maintenance of experiment facilities, installation of software tools, problem formulation and theoretical analysis, etc. - Resource sharing: software packages, experimental facilities, open problems. The main expected features of the platform are the following: - Model-based simulation: with tools like Matlab/Simulink as reference, but open to others such as Scilab, ControlLab, etc. - Rapid controller prototyping: automatic native code generation from simulation code, on-target validation, online parameters tuning - Open architecture: APIs and abstraction layers to allow integration of new experimental facilities. The software is in early stage development and relies on WebLab-Deusto for managing experiments, and users. Control experiments under development and integration: inverted pendulum, synchronization of analog Brockett oscillators.*

Web site: https://bil.inria.fr/en/software/view/2830/tab. Self-assessment:

- Audience: A-2 (used by people in the team or close to the team)
- Software originality: SO-3/SO-4 (original software reusing known ideas and introducing new ideas)/(original software implementing a fair number of original ideas)
- Software maturity: SM-2 up (basic usage works, terse documentation) (up = with some well-developed software, good documentation, reasonable software engineering)
- Evolution and maintenance: EM-2 up (basic maintenance to keep the software alive)(up = with some good quality middle-term maintenance)
- Software distribution and licensing: SDL-2 up (privately distributed within the close community)(up = adaptable in a contractual setting)

Non-A *NON-A is a package dedicated to the effective study of the parameter estimation via the algebraic approach developed by M. Fliess, H. Sira-Ramirez and the Non-A team. It is based on the OreModule package (https://bil.inria.fr/en/software/view/2034/tab), itself based on the commercial Maple package Ore-algebra. Non-A computes differential annihilators of parametrized polynomials and towers of annihilators which are useful for the theory of algebraic parameter esti-*

mation..
Web site: https://bil.inria.fr/en/software/view/2929/tab. Self-assessment:

- Audience: A-2 (used by people in the team or close to the team)
- Software originality: SO-4 (original software implementing a fair number of original ideas)
- Software maturity: SM-2 (basic usage works, terse documentation)
- Evolution and maintenance: EM-2 up (basic maintenance to keep the software alive)(up = with some good quality middle-term maintenance)
- Software distribution and licensing: SDL-2 up (privately distributed within the close community)(up = adaptable in a contractual setting)

3.3 Technology transfer and socio-economic impact

1) Local, Small Size Enterprises: We think our local socioeconomic impact is *becoming a continuous action* thanks to the following context: Inria Lille got the 2016 Inria Award "Support for Research and Innovation" for setting up the InriaTech initiative in April 2015. With the support of our regional partners, this initiative aims at facilitating the transfer of key technologies from research to companies, in a field that creates added value, innovation and employment: digital. The development of relations with SMEs and the accelerated production of conceptual evidence to respond to industrial problems are the major challenges of this technological transfer platform, the first of its kind, but which will be extended to other Inria centers and other regions. In this context, Non-A participated to two grants with SMEs (LMA, Neotrope). As told in 2.6.3, we note that contacts regarding these projects are increasing and moving closer to our original research results (in particular, online estimation), whereas they were initially more related to our technical know-how (classical robotics). Note that InriaTech has permanent engineers devoted to such transfer actions, two of them are covering the programming tasks related to robotics and signal processing.

2) Large companies: we have contiuous relations (CIFRE) with Safran and, recently, Renault. We hope Leroy-Merlin, Tactual Labs Co or Barco will follow the same path in 2017 (CIFRE or grants). In this context, the engineering resources are placed on the partner's side.

Note we produced **3 patents**: [321] related to TurboTouch, and [322, 323] in relation with IMS Bordeaux (A. Zolghadri) and their activities with AirBus.

3.4 Teaching

Most of the permanent members are involved in the local teaching activities: Some of our faculty members obtained teaching reductions (W. Perruquetti, 100% CNRS, J.P. Richard 50% Inria).

- L. Belkoura is heading the Master SMaRT at Univ. Lille (around 30 students /year)

- J.P. Richard is heading the last year training "Research" at Centrale Lille (around 30 students registered to some research Master2 in addition to their engineering studies)

- Around 200h/y in Engineering Schools: ISEN (D. Efimov, R. Ushirobira, G. Zheng), Centrale Lille (D. Efimov, A. Quadrat, J.P. Richard, R. Ushirobira, G. Zheng)

- Around 200h/y hours at University of Lille: L-M (Lotfi Belkoura, D. Efimov, J.P. Richard, G. Zheng)

Concerning doctoral programs, we started joint PhD with TU/e (The Netherlands) and KUL (Belgium) in the framework of H2020 Marie Curie EJC UCoCoS (4 PhD students at the moment), and also 1 with ITMO St Petersbourg (1 PhD). It is expected to settle such relations also with Mexico since we already receive/supervise various visiting students with these IPN and UNAM.

3.5 General audience actions

Various actions have been conducted to promote our activities and, more generally, digital sciences. For instance:

2017 Contribution to the prospective report "Systems & Control for the Future of Humanity" coordinated by F. Lamnabhi-Lagarrigue, Research Agenda Task Force (to appear, special issue of Annual Reviews in Control to be given during the IFAC 2017).

2016 [mediation] *BeyondLab community.* A co-working night event within BeyondLab on using "Living sensors " for water quality monitoring, featuring our PhD student Hafiz Ahmed (Lille, 16/03/2016).

2016 [mediation] *Scientific baccalaureate students.* Meeting on the Inria platform EuraTechnologies (23/03/2016, Lille): "ISN Lille Académie: à la découverte des sciences numériques!"

2015 [mediation] *Inria magazine and website.* A nice comic strip on networked oysters in the magazine "Lille by Inria" (12/06/2015), together with general news on living sensors (14/04/2015) by the communication dept. of Inria Lille - Nord Europe.

2015 [mediation] *BeyondLab community.* A co-working night event within BeyondLab on "Robotics, from research to enterprise" (Initiative & Cité, Lille, J.P. Richard 19/02/2015)

2015 [demonstrator] *Inria "The plateau"* at Lille EuraTechnologies[9]: Open since 2015, RCG (Robot Cop Guard) is a public demonstrator which illustrates ideas for area monitoring using a Tortlebot (see a video).

2015 [newspaper] A paper in "La Voix du Nord" (in French) presents the first results obtained with model-free-control for traffic regulation. It mentions a change in the algorithm more advanced, more soft algortithm ("nous avons changé d'algorithme. Celui-là est plus évolué, plus souple..."[10]) but... does not mention AL.I.E.N. SAS.

2014 [mediation] *CNRS INS2I website.* On "lazy sampling" (asynchronous sampling): "Communiquer uniquement si nécessaire, pour économiser"

2014 [industrial exhibition] *InnoRobo show.* Mobile robotics (18-20/03/2014, Lyon): a video realized by the Inria media services and illustrating a collaborative SLAM scenario, was presented to the public and companies.

2014 [demonstrator] *Inria "The plateau"* at Lille EuraTechnologies. Stopped in 2014, RobotCity was a public demonstrator exhibiting robots playing cops-and-robbers.

2014 [publication] *ERCIM news.* A paper [105] on Non-Asymptotic estimation (in the framework of FP7 HYCON2 actions) by the quarterly magazine targetting the European Community on Information Technology and Applied Mathematics (04/2014).

3.6 Visibility

Editorial Boards of Journals (IF = 2015 Thomson Impact Factor)

IJRNC Int. Journal of Robust and Nonlinear Control: Editor - A. Polyakov (IF: 2.527)

[9] The Plateauis the Inria ICT innovation ecosystem: with its unique 200m² exhibition space at EuraTechnologies Lille, it presents the work of Inria Lille - Nord Europe's teams, the aim being to promote interactions between the scientific community, the business world and wider society. As a result, a collaborative workspace has been made available to all stakeholders and a coordination programme is in place throughout the year.

[10] "We changed the algorithm. This one is more advanced, more flexible..."

Franklin Journal of the Franklin Institute: Associate Editor - A. Polyakov (IF: 2.327) until 2015

MSSP Multidimensional Systems and Signal Processing: Editorial Board - A. Quadrat (IF: 1.436)

JOTA Journal of Optimization Theory and Applications: Editorial Board - A. Polyakov (IF: 1.160)

MPE Mathematical Problems in Engineering: Editorial Board - T. Floquet (IF: 0.644)

A&RC Automation and Remote Control: Editorial Board - A. Polyakov (IF: 0.265)

Plenary talks

Plenary "*Time-delay systems for networked control problems*", J.P. Richard, Plenary Lecture IEEE CEIT, 3rd Int.Conf.on Ctrl,Eng.&Inf.Tech., Tlemcen, Algeria, 2015

Plenary *"Model-Free Control: a mathematical tool for industrial applications"*, C. Join, Invited Lecture at the conference dedicated to the the scientific legacy of Marcel-Paul Schützenberger, Bordeaux 2016. MFC has been presented in front of prestigious other speakers (Fields Medal, academicians...).

Tutorial "Tutorial on arbitrary and state-dependent sampling", J.P. Richard with C. Fiter, H. Omran, L. Hetel: ECC'14, Strasbourg, France, 24-27 June 2014 - Tutorial session on "Time-Delay and Sampled-Data Systems", org. E.M. Fridman.

Keynote "*Networked Control Systems: to buff, or not to buff?*", J.P. Richard, Keynote paper GDRi DelSys CNRS, LAAS, Toulouse, Nov. 20-23, 2013

Keynote "*Non-Asymptotic estimation for online systems: Finite-time algorithms and applications*", J.P. Richard, W. Perruquetti, HYCON2-BALCON joint FP7 workshop, Belgrade, Serbia, 2-3 July 2013

Awards and Highlights

Award ABB best application paper at IFAC SafeProcess 2015: Zolghadri, Cieslak, Efimov, Henry, Goupil, Dayre, Gheorghe, Le-Berre: *Signal and model-based fault diagnosis for aircraft systems.*

Award Outstanding TAC Reviewer 2016: D. Efimov, awarded by the Editorial Board of IEEE Trans. on Automatic Control.

Special-Issue on sliding mode algorithms at J. Franklin Institute, 2014, Guest Editors: M. Basin (UANL, Mexico), L. Fridman (UNAM, Mexico), W. Perruquetti (Centrale Lille): it includes two survey papers [98, 27] of more than 30 pages each.

Special-Issue on differentiators at Int. J. of Control, 2017, Guest Editors: M. Reichhartinger (Graz UT, Austria), D. Efimov (Inria), L. Fridman (UNAM Mexico).

Survey A long survey paper [78] just appeared in Automatica, dealing with asynchronous sampling (collaboration with CNRS CRIStAL, see footnote p.6).

Technical Program Committees

Boards/Chairs: J.P. Richard member of the EUCA Conference Editorial Board since 2015. W. Perruquetti chair of the IFAC TC Chair of the IFAC TC9.2 "Social impact of automation" since 2014, member of the Steering Comitee of IFAC CPHS 2016 (Florianopolis, Brazil), National Projects Vice-Chair of EUCA-IEEE ECC 2014 (Strasbourg, France)

Associate-Editorship: 20th IFAC World Congress (Toulouse, France), 19th IFAC World Congress (Cape Town, South Africa), IFAC TDS 2013 (Grenoble, France). IEEE VSS 2014 (Nantes, France, 2014, J.P. Barbot IPC Chair). EUCA-IEEE ECC 2015 (Linz, Austria). IEEE MED 2015 (Torremolinos, Spain). IFAC TDS 2015 (Ann Arbor, USA). SIAM CT 2015 (Paris, France). IFAC TDS 2016 (Istanbul, Turkey).

IEEE MED 2016 (Athens, Greece). EUCA-IEEE ECC 2016 (Aalborg, Denmark). EUCA-IEEE ECC 2014 (Strasbourg, France). EUCA-IEEE ECC 2013 (Zurich, Switzerland).

IPC of numerous conferences (at least 35, list not provided here, see yearly activity reports).

Organization Committees

NOC J.P. Richard and W. Perruquetti members of the advisory panel (NOC) of 20th IFAC World Congress (Toulouse, France, 2017: 4256 submissions)

Responsibilities

CNRS-National W. Perruquetti Vice-Deputy of INS2I CNRS (national level), see `http://www.cnrs.fr/ins2i/spip.php?article727`.

CNRS-local J.P. Richard manager of Group CO2 at CRIStAL. L. Belkoura head of team SYNER.

Inria-local Most of our Inria permanents have memberships in at least one of the Inria Lille North-Europe committees (scientific recruitments, tech. development, mediation, health & safety, etc.)

Faculties J.P. Richard is a member of the Scientific Council of Centrale Lille (and ENSEA Cergy until 2016). L. Belkoura is a member of the Pedagogic Council and Recruiting committes of his Department at Univ. Lille. T. Floquet is a member of the board of domain AGITSI (aut. control, comp. eng., signal & im. proc.) of the regional Doctoral School ED SPI 077.

Miscellaneous

IFAC Presently, one or more Non-A members belong to the following IFAC Technical Committees: TC1.2 “Adaptive and Learning Systems”, TC1.3 “Discrete and Hybrid Systems”, TC2.3 “Nonlinear Control Systems”, TC 2.5 “Linear Systems”, TC9.2 “Social impact of automation”. Until 2014, there was also TC1.5 “Networked Systems”.

CNRS-GdR(i) Regular activity of Non-A within various CNRS “GdR” (national research networks): mainly GdR 717 MACS devoted to control, but also GdR 2502 CdD (fluid mechanics), GdR 2995 SOC-SIP and GdR 2025 GPL (informatics), as well as international “GdRi”: DelSys (until 2016) and its continuation SPaDisCo (delay systems, PDEs, recently accepted by CNRS).

Reviewing/expertise The members of Non-A are reviewers of all top-ranked journals in the field of automatic control (IEEE Transactions on Automatic Control, Automatica, SIAM Journal of Control and Optimization, International Journal of Robust and Nonlinear Control, etc). J.P. Richard is an expert for the French Ministery (MENESR/MEIRIES) since 2008.

4 Funding

4.0.1 National initiatives

ANR CHASLIM [10/2011-09/2015][**112.5k€**, Inria] (jointly with Inria BIPOPand IRCCYN CNRS Nantes) ANR-11-BS03-0007. Two objectives are aimed at: 1) the design of new methodologies of high order and discrete-time sliding mode controllers, in order to reduce the chattering and improve the disturbance rejection; 2) the development of softwares dedicated to sliding mode control design: 2a) formal computation software, based on the IRCCyN software NOLIACPA; 2b) simulation tool using the INRIA/SICONOS library for the simulation of nonsmooth dynamical systems.

ANR MSDOS [01/2014-01/2018][**25k€**, Inria] (jointly with XLIM CNRS Limoges and LIAS Poitiers, grant started in the framework of DISCO). In nD systems, the information propagates not only in 1 direction (usually the time for $1D$ systems) but in 2 or more directions. These directions can be either time/space or space/space variables. MSDOS questions the stability and stabilization of this class of infinite dimensional systems.

ANR ROCC-SYS [10/2014-10/2018][**159k€**, CNRS] (jointly with CRIStAL). The project aims at providing new methodologies for the analysis and design of Cyber-Physical Systems, *i.e.* networks of interacting embedded computers with sensors as physical inputs and actuators as outputs. It is a challenging problem to understand the interaction between discrete control algorithms and physical processes in a networked/embedded configuration. From the Control Theory point of view, it implies the study of complex, hybrid models.

ANR FINITE4SOS [10/2015-09/2019][**223.7k€**, Inria] (jointly with LJLL UMR7598 CNRS Paris and CAOR Mines de Paris). Finite4SoS aims at developing a new promising framework to address control and estimation issues in Systems of Systems. The goal is to deal with the model diversity (DI, TDS, PDE...), while achieving robustness as well as severe time response constraints. The key ingredients are: finite-time concepts, homogeneity and time-varying feedback, which will help for both cascade and feedback connections.

ANR WAQMOS [10/2015-09/2019][**95.7k€**, Inria] (jointly with EPOC Bordeaux) The main goal of this interdisciplinary project (marine biology – electronics – applied mathematics) is to obtain a remote online detection of coastal water pollution and climate change consequences, based on measurements and interpretation of bivalves mollusks behavior. The biosensor developed by EPOC (CNRS UMR 5805, Univ. Bordeaux) involves a technology of high-frequency noninvasive valvometry for mollusks. The generated signals are processed from a system and control point of view by Non-A, making use of our online differentiating techniques.

ANR TURBOTOUCH [10/2014-04/2018][**106.6k€**, Inria] (jointly with Inria MJOLNIR for HMI and PMB Marseille for experimental psychology). Grant ANR-14-CE24-0009. After years of pressing and moving mechanical parts, a lot of our interactions with computing systems are now touch-based. Transfer function design and latency are two problems requiring cross examination to improve human performance with touch systems.

CPER [11]CONTRATECH [2015-2020][**261.4k€**, Inria] subproject of ELSAT20202 (Ecomobilité, Logistique, Sécurité, Adaptabilité dans les Transports) is a Regional consortium gathering aeronautics (ONERA), micro/nano technologies (IEMN), control sciences (Non-A) and fluid mechanics (LAMIH, LML) and working on technologies

[11]CPER: *Contrat de Projets Etat-Region*, French Government, Regional Council and European FEDER

and methods for the active control of separated flows.

CPER DATA 2016-2020 (involved in two projects: "FIT" related to the wireless robots and sensors network FIT IoT-lab (French "Equipement d'Excelence"); "DATA", related to GRID5000 platform). FIT includes our robotic activity and DATA corresponds to our computation need in fluid mechanics as well as possible security issues in the ControlHub development platform.

CPER CIA [09/2012-09/2015 + 09/2013-08/2016][**110k€**, Inria] "Campus Intelligence Ambiante" has funded some of our engineers working on the robotic platform. There we started our collaboration with the team FUN and its Equipex platform FIT. Supported by Region Hauts de France and French Ministery (65k€+45k€).

ARCIR ESTIREZ [09/2013-08/2017][**96.3k€**, Inria] (Estimation distribuée de systèmes dynamiques en réseaux) The aim of this project is to investigate the problem of control, estimation and system identification of networked control systems. Supported by Region Hauts de France.

4.0.2 European projects

FP7 HYCON2 [2010-2015][**107.8k€**, CNRS] "Highly-complex and networked control systems". In this global NoE program, we have been working (Deliverable D2.1.3) on two kinds of models for networked control systems: time delay systems, and hybrid systems. The PhD [9] has been funded on CRIStAL in the HYCON2 framework, joint supervision with F. Lamnabhi-Lagarrigue at L2S.

Interreg SYSIASS [04/2013-09/2014][**51.9k€**, Centrale Lille[12]] InterReg IV-A Two Seas 6-020-FR. 6 Partners: Univ.of Kent, Univ.of Essex, East Kent Hospitals Univ., Groupe Hospitalier ICL, Centrale Lille, ISEN (A. Kökösy, PI). Autonomous and Intelligent Healthcare System. SYSIASS - *disability and independance* - started in 2010, aiming at assisting patient's mobility and securing the provision of communication services. The corresponding technology was an intelligent wheelchair able to provide mobility to the patient and allowing healthcare providers to transport patients to desired locations in a clinical or domestic environment. We contributed to control and estimation algorithms for localization, path-planning and path-tracking. They were successfully implemented on a wheel chair.

H2020 UCOCOS (EJD) [04/2015-03/2019][**489.8k€**, Centrale Lille] Horizon 2020 Grant Agreement No 675080. KULeuven (W. Michiels, PI), TU/Eindhoven (H. Nijmeijer), Centrale Lille (J.P. Richard), TNO, EOS Innovation, CITC, FIT IoT-lab. "Understanding and Controlling Complex Systems" is a European Joint Doctorate aiming at defining common methods, tools and software for the complexity scientist. Its strongly relies on a control theory point of view. Six ESR (early stage researchers) perform a cutting-edge project, also benefiting from training by 4 non-academic partners from different sectors. ESR1: Analytical and numerical bifurcation analysis of delay-coupled systems; ESR2: Estimation in complex systems; ESR3: Grip on partial synchronization in delay-coupled networks; ESR4: Reduced modelling of large-scale networks; ESR5: Network design for decentralized control; ESR6: Networks with event triggered computing. Non-A is firstly invested on ESR 2 (Haik Silm), 4 (Quentin Voortman), 5 (Deesh Dileep), 6 (Jijju Thomas).

[12] European funding on the complete period 2010-2014 of SYSIASS: 236k€

4.0.3 Industrial contracts

InriaTech LMA [01/2016-02/2016][**8k€**] led by G. Zheng. La Maison Attentive develops design and health services, including robotic solutions for residential care homes and Elderly. We helped them to implement a demonstration prototype of an autonomous hospital table. It was based on a Tortlebot equiped with our SLIM ROS software (localization, path-planing, tracking). Collaboration with Noolitic.

InriaTech NEOTROPE [06/2016-07/2016][**8k€**] led by R. Ushirobira and D. Efimov. Neotrope develops "affect-tag" biosensors for marketing applications. We helped them by implementing our numerical differentiation algorithms for improving the robustness in emotion detection. This illustrated the portability of our algorithms in real-time, embedded contexts.

CIFRE Safran Electronics & Defense [04/2015-03/2018][**21.4k€**, Inria] (jointly within DISCO and L2S, led by A. Quadrat). "Parametric stabilization of flexible mechatronic systems with delays - Applications to optical viewfinders".

CIFRE RENAULT [02/2017-01/2020][**80k€**, Inria] (jointly with SEQUEL) led by D. Efimov and Odalric-Ambrym Maillard, W. Perruquetti and Ph. Preux. Confidential.

Expected Leroy-Merlin [2017?] in the InriaTech framework, Tactual Labs Co and Barco in the TurboTouch framework [2017?].

4.0.4 Inria Project Labs (IPL), Exploratory Research Actions and Technological Development Actions (ADT)

IPL COSY [under evaluation][proposal:**123k€**, Inria] (Real-time Control of Synthetic microbial communities, PI: E. Cinquemani). While some precursory work has appeared in recent years, the control of microbial communities remains largely unexplored. This proposal aims at exploiting the potential of state-of-art biological modelling, control techniques, synthetic biology and experimental equipment to achieve a paradigm shift in control of microbial communities. We will investigate, design, build and apply an automated computer-driven feedback system for control of synthetic microbial communities. An interdisciplinary consortium will provide the diverse competences required by the endeavor: 4 Inria teams (IBIS, BIOCORE, COMMANDS, Non-A), the Inria Exploratory Action INBIO and external partners BIOP (CNRS), MaIAge (INRA), and YoukLAB (TU Delft).

ADT SLIM [2013-2014] "Software LIbrary for cooperative Multi-robots", led by G. Zheng and devoted to mobile robots. Concerning cooperation of mobile multirobots, 3 key issues have been considered: Localization / Path planning / Robust control, for which Non-A has worked and proposed new algorithms. Thanks to this ADT, we have implemented our algorithms and integrated them into ROS (Robotic Operating System) as a package of the same name "SLIM".

ADT SEEC [2016-2017] Tech. Dev. Action of the Lille's center, giving the framework to our ControlHub project led by A. Polyakov with R. Dagher. Here we started to build a connected collaborative platform dedicated to fast prototyping and comparison of controllers (but also, of course, of the possible corresponding estimators). The idea is to support collaborative research around control problems, allowing for fast prototyping of controllers with validation on both simulation (ex. Matlab/Simulink) and experiments (sharing problems/solutions/testbeds/code, without being limited to our own plaforms). This will be possible thanks to an open architecture (APIs, abstraction layers).

4.0.5 Associated teams and other international projects

AssociateTeam HoTSMoCE [2016-2018][**36k€**, Inria] "Homogeneity Tools for Sliding Mode Control and Estimation", with UNAM Mexico. PI D. Efimov and Leonid Fridman (Professor, head of the "Sliding Mode Control" laboratory of UNAM). There exists a strong intersection of interests of both teams (application of homogeneity for design of sliding mode control and estimation algorithms, and analysis of finite-time stability), together with a long history of collaboration between them. HoTMoCE aims at developing control and estimation algorithms converging in fixed or in finite time by applying the last generation of sliding mode techniques and the homogeneity theory. The project realization is planned in the form of short-time visits of permanent staff and visits of PhD students for a long period of stay. Such visits are important for young scientists, and also help Non-A to prepare and find good PhDs/post-docs for future.

Mexico Reversely, various UNAM or CONACYT grants allow our Mexican partners to visit/invite us (such as UNAM project PAPIIT 113613 on "Controladores por modos deslizantes de orden superior" 2013-2015).

North-European-AssociateTeam PImIR [10/2013-12/2015][**14k€**, Inria] with Norwegian UST Trondheim,(Norway) and Umeå Univ. (Sweden). The project aimed at developing algorithms used in software of industrial robots for estimation, regulation and trajectory planning in order to improve accuracy and repeatability of robots in the presence of varying parameters, perturbations and noises. Conventional calibration procedures fail to guarantee the required technical parameters in order to make the effector realize a complex 3D movement with a good precision (3D surface profiling). The long-term applications led by the partners are smart (autonomous) cranes for the Swedish forest industry, and manipulators in relation with the robot manufacturer ABB (IRB 140 / IRB 1600).

JointLab LaFCAS "Laboratoire Franco-Chinois d'Automatique et de Signal", joint lab between CRIStAL and Nanjing University of Science and Technology. Supported by the ambassies (see a pdf document in French) and headed by Prof. HaoPing Wang, this joint lab supports regular visits on both sides (participating members: L. Belkoura and G. Zheng [115, 118, 127]).

PHC Amadeus CAFE 2016-2018: "Computer Algebra for Functional Equations". PIs: T. Cluzeau (XLIM, Limoges), G. Regensburger (JKU Linz), A. Quadrat (initiated within DISCO, then Non-A). The idea is to apply theoretical results of constructive algebra to design algorithms for the study of linear functional equations, then to implement them in computer algebra software so they can be used in applications. We focus on linear ODE, IDE, and IDTDE (integro-differential time-delay equations).

GDRI DELSYS (CNRS, associated partner) 2012-2016 (10 countries, delay systems). This international research group was devoted to delay systems and is continued with SPA-DISCO.

GDRI SPA-DISCO (CNRS+Inria, partner) 2017-2019, International Research Group "Distributed Parameter Systems and Constraints". PI G. Valmorbida (L2S) and promoted by DISCO. 1rst workshop DECOD (Delays, Constraints in Distributed param. syst.) planned on 20 Nov. 2017.

Internat.Program MOCOPEE [2014-2030] "Modeling, control and optimization of wastewater treatment processes". France, Canada, Belgium. AL.I.E.N. SAS is one of the 4 industrial partners of this international program in 4 four-year phases: 2014-2017, etc. Financial partner SIAAP (Syndicat Public de l'Assainissement Francilien).

4.0.6 Other funding

PhD Hafiz Ahmed [10/2013-09/2016][**45.5k€**, Inria] joint funding by Région Hauts de France.

PhD Maxime Feingesicht [01/2015-12/2017][**45.5k€**, Centrale Lille] joint funding by Région Hauts de France.

SICK [06/2014][~**5.5k€**, Inria Lille] We have been given by Sick 3 Lidar TiM551 in June 2014 for the implementation of our SLAM algorithms on Tortlebot robots.

IPP (Invited Professor Position) Arie Levant [10/2015-01/2016], joint funding by Inria and Region Hauts de France.

IPP (Invited Professor Position) Emilia Fridman [06/2013, 06/2014, 06/2015, 06/2016], funding Centrale Lille, 1 month/year 2013-2017.

IPP (Invited Professor Position) Francisco Javier Bejarano Rodriguez [06/2015], funding Centrale Lille, 1 month.

5 Follow up to the previous evaluation

5.1 Quoted from the 2013 evaluation concerning Non-A

Report by the panel Specific evaluators: Tamer Basar, Franck Guillemard, Vladimir Kucera, Pierre Rouchon

Section 10.4. Industry transfer and partnership. *The transfer of knowledge to industry is very good. By the end of 2011, the start-up company AL.I.E.N. SAS was created in Nancy. It is the only company to hold the model-free control know-how. [...] The project-team also participates in two European projects, including the FP7 Network of Excellence HYCON2. One recommendation here is for the group* ***to increase the number of "conventions CIFRE"*** *(industrial support for PhD students).*

Section 10.6. Principal strengths and weaknesses of the project-team. *Strengths. The principal strengths of the project-team are the quality of the investigators, international visibility in delay/nonlinear systems, the new and exciting research topics that have been introduced (both algebraic and homogeneity approaches), the start-up company AL.I.E.N. SAS, and a good cooperation between the Lille and Nancy research groups. The PhD graduates are employed by prestigious universities and prospering industries. Weaknesses. The principal weakness relates to the new and challenging research topics, and particularly dissemination of algebraic approaches to a broader community.* ***More emphasis is to be paid to knowledge dissemination also to recruit new researchers. The group also needs to find industrial contacts in Lille.***

Section 10.9. Recommendations actions and suggested measures of success *The Non-A project-team is new but draws upon the results achieved by the ALIEN project-team. The research topics are highly original, theoretically challenging, and widely applicable. The progress made by the project-team during the 1rst two years is excellent, as evidenced by high quality publications and numerous industrial collaborations. The creation of SAS is also a noteworthy achievement. The recommendations from the last committee (that evaluated ALIEN) have been well followed (more contacts with industry, working on original subject, increasing the number of PhDs, etc.), and this has been appreciated.* ***The project should continue with the objectives formulated at the outset, with the same balance between theory and applications****. The robotic platform is a real opportunity for the project-team to increase the dissemination of non-asymptotic methods for online systems in the next few years and also an important source of motivation and training for the project-team. It is therefore* ***recommended that the project-team focus on work on this platform*** *especially since it is linked to the Inria strategy for the coming years.* ***The project-team may consider it vital to retain specialists*** *like R. Ushirobira (non-permanent fellow) and A. Polyakov (post-doc). It is recommended that Inria supports the SAS created by the project-team and especially facilitates administrative procedures in order to reduce the risk. Inria can help with long-term success and stability of the group by providing more human resources, particularly 2 new permanent research staff.*

Report by the EC 2013

9.1 Panel Report Summary *Note: the panel report covers the last two years of ALIEN and the 1rst two years of Non-A. The publication output is rated as excellent by the* *panel, with high impact journals and prestigious conferences. The scientific achievements are considered numerous and important, with sometimes a "highly original approach". In addition research software is being developed. The transfer is rated as "very good" by the panel, in particular with the award winning start-up ALIEN. Collaboration with industry are numerous and the project is involved in European projects. The quality of the researchers, their visibility and their new and exciting topics are considered as the team's main strengths while, for the weaknesses, the panel mentions the dissemination of the new algebraic approaches and a lack of industrial contacts in Lille. The robotic platform is considered to be an opportunity on which the team should concentrate. The panel also mentions administrative difficulty related to the start-up creation. Recommendations: The team is new, with topics that are highly original, theoretically challenging, and widely applicable. The panel recommends to continue with the team objectives and to consider the robotic platform as a source of motivation and training.*

9.2 CP recommendation *The committee congratulates Non-A for its strong evaluation. The committee considers that the evaluation critics focused on minor points that the team was already aware of and most of the time already addressed. The team recognised that they should strengthen their industrial relationships. The committee agrees with the answers presented by the team.*

9.3 EC recommendation *The EC congratulates Non-A for the quality of its scientic production and the international visibility of its researchers. Non-A is a young team with an original and promising project. The EC expresses its confidence for the future and recommends the continuation for four years.*

5.2 How it was taken into account

Most of these recommendations have been taken into account:

Continue on the formulated objectives, keeping the balance between theory and applications (done) Concerning theory, let us recall some of our contributions: Algebraic techniques have been extended in several ways (PDEs, integral equations, integro-differential algebras ongoing) and adapted to various kinds of signals and applications (biology, HCI...); Our other concepts (finite/fixed-time properties, weighted homogeneity, implicit Lyapunov functions, set-theoretic tools) have been extended to complex classes of systems (delayed, LPV, hybrid/impulsive, differential inclusions, MIMO, multi-agent, sampled, PDE) with appropriate formulations and/or results (in particular, in terms of robustness via the ISS property). Concerning applications, we have mentioned: Robotics (manipulators, ground robots, as well as drones which are the next step in the Lille robotic platform); (2) Living systems: (biosensors, HCI, smart bracelet), (3) Turbulent flow control; Industry and society (traffic control, mechatronics...), as well as various other fields not presented here (electrical engineering [18, 37, 38, 40, 41, 63, 70, 80, 81, 82, 104, 111, 112, 122], aircraft systems [34, 43, 76, 77, 133], engine control [50], oscillators and synchronization [14, 17, 28, 64])...

Focusing on the robotic platform (partly done) We kept on working on parts the FIT-IoTlab platform, by developing various strategies and ROS packages (SLIM library) including collaborative SLAM, obstacle avoidance, path planning and tracking of ground robots (see a video here or few videos uploaded on `https://semeval.inria.fr`). At least two of the starting PhD students[13] from our H2020 EJD program UCoCoS will also use the platform as an illustration of complexity issues in networks. Besides, we are developing autonomous control strategies for flying drones (quadrotor and blimp), which constitutes a coming step in the FIT-IoTlab roadmap. However, note that our works address components of the platform but are not yet integrated in its global context, *i.e.* offering a remote access. Today, FIT-IoTlab is remotely accessible only for its wireless sensors and single-robot aspects, while making several robots cooperating remotely is not yet implemented. Note that the integration or our multi-robot results in the platform is an engineering task to be led by EquipEx project FIT-IoTlab.

Retaining specialists (done) Andrey won the Inria Researcher competition in 2013 (CR2, promoted to CR1). Rosane won it in 2016 (CR1 position open on February 1rst, 2017). Moreover, we attracted another researcher, Alban, previously in the project-team DISCO at Inria Saclay and who won the Inria senior researcher competition (DR2).

Going on developing more contacts with industry, in particular CIFRE PhD grants - Find industrial contacts in Lille (done) In 2013, our transfer activity was positively evaluated but mainly linked to the SAS AL.I.E.N in Nancy. Today, we are also invested in various transfer actions centered on the Lille members and the recommendations (also belonging to our goals) are being met. Concerning CIFRE: Alban came in Lille with a starting CIFRE PhD student (Sagem) on algebraic tools and formal methods for stabilization of systems with delays. Another CIFRE was recently started with Renault (joint PhD with the Inria project-team SEQUEL). We have also been much supported in our transfer activities since the birth of the Inria program "InriaTech": various grants with local start-up have been started (La Maison Attentive, Neotrope, another one is pending). Our patent on HCI is also something positive for us: we have ongoing discussions with industrial partners (Tactual Labs Co and Barco) and hope agreements will be reached in 2017.

Emphasis is to be paid to knowledge dissemination Various journal and conference publications have helped to disseminate our non-asymptotic techniques (including one dissemination paper in ERCIM news 2014). We think our results on nonlinear theory for finite-time are well recognized. Concerning the algebraic techniques and model-free control, let us remind that our choice was clearly to target the dissemination in industry, thus to implement them in real-world contexts: Various of the corresponding results have been published in application-oriented journals as IEEE CST, CEP... The AL.I.E.N. SAS exhibits various successes, in particular with the control of hydroelectric power plants and regulation of road traffic flow (see `http://alien-sas.com/references/`).

[13] D. Dileep, H. Silm, J. Thomas, Q. Voortman

6 Objectives for the next four years

We think the researches conducted by Non-A are to be prolongated according to two main ways, partly corresponding to the tools and applications we presently develop:

- A first branch has to be devoted to computer algebra for control and systems theory, which is larger than the only spectrum of algebraic estimation that we consider today. Fruitful links between algebra, symbolic computation, mathematical theory of systems, and control, are still to be explored. In particular, the study of dynamical systems described by functional equations, and containing free parameters, can be enriched by some dedicated software in an efficient and safety way. We got this conviction both from our works on estimation and on the experience with Sagem: we experimented that engineers find it very interesting to characterize classes of admissible parameters and controllers, instead of computing some guaranteed, but particular, tuning.

- Another branch has to go on exploiting the finite-time property, which appears as a key tool for guidance in the analysis and design of complex, heterogeneous systems, also know as "Systems of Systems": the finite-time property allows for splitting (in time) transients of different interconnected (in space) subsystems. Today, we have the ideas and the right toolbox for this purpose: 1) The theory of approximation by homogeneous systems gives a global framework for analysis of finite-time convergence and stability. 2) The variety of the classes of homogeneous dynamical systems (finite/infinite dimension, differential equations/inclusions...) handled by this framework allows for considering heterogeneity issues in an optimistic way. 3) Uncertainty general treatment can be planned by invoking Input-to-State Stability (ISS) theory. Note the first steps of this work are considered in our ANR project Finite4SoS and the H2020 UCoCoS program.

Since those two branches are pretty wide and cannot be handled in a single project-team, we intend to split Non-A into two smaller projects. The recent enlistments during the past period give us a critical mass of Inria researchers so to make this dynamics possible.

7 Bibliography of the project-team

Doctoral Dissertations and Habilitation Theses

[1] H. Ahmed, *Modeling and synchronization of biological rhythms: from cells to oyster behavior*, Theses, Université Lille 1, 2016, [hal:tel-01439847]. 2.6

[2] E. Bernuau, *Robustness and stability of nonlinear systems : a homogeneous point of view*, Theses, Ecole Centrale de Lille, October 2013, [hal:tel-00917798].

[3] Y. El Afou, *Stratégies de contrôle des paramètres climatiques sous verre*, Theses, Université Lille 1, 2014, [hal:???].

[4] M. Guerra, *Finite time deployment and collision avoidance for wheeled mobile robots*, Theses, Ecole Centrale de Lille, December 2015, [hal:tel-01294338]. 2.6

[5] Q. Guo, *Online identification and control of robots using algebraic differentiators*, Theses, Ecole Centrale de Lille, December 2015, [hal:tel-01259471]. 2.6

[6] Y. Ma, *Path planning and control of non-holonomic mobile robots*, Theses, Ecole Centrale de Lille, December 2013, [hal:tel-00979604].

[7] S. Maalej, *Commande robuste des systèmes à paramètres variables*, Theses, Université Lille 1, December 2014, [hal:???].

[8] D. Mincarelli, *Parameters and state estimation for switched systems*, Theses, Université Lille 1, 2016, [hal:???].

[9] H. Omran, *Contribution to the control of nonlinear systems under aperiodic sampling*, Theses, Ecole Centrale de Lille, March 2014, [hal:tel-01127625]. 1, 4.0.2

[10] M. Oueslati, *Contribution to dynamic modeling, identification and synthesis of control laws for flexible industrial robot.*, Theses, Ecole nationale supérieure d'arts et métiers - ENSAM, December 2013, [hal:pastel-01016462].

[11] Z. Shao, *Identification et commande des robots manipulateurs à bas prix*, Theses, Ecole Centrale de Lille, 2016, [hal:???].

[12] G. Zheng, *Observability Analysis and Observer Design for Complex Dynamical Systems*, Habilitation à diriger des recherches, Universite Lille 1, November 2015, [hal:tel-01258527].

Articles in International Journals

[13] H. Abouaissa, M. Fliess, C. Join, *On ramp metering: Towards a better understanding of ALINEA via model-free control*, International Journal of Control, 2017, [doi:10.1080/00207179.2016.1193223], [hal:hal-01326514]. 2.5.3

[14] H. Ahmed, R. Ushirobira, D. Efimov, W. Perruquetti, *Robust synchronization for multistable systems*, IEEE Transactions on Automatic Control, May 2016, p. 1–6, [hal:hal-01185112]. 2.6, 5.2

[15] H. Ahmed, R. Ushirobira, D. Efimov, D. Tran, M. Sow, P. Ciret, J.-C. Massabuau, *Monitoring biological rhythms through the dynamic model identification of an oyster population*, IEEE transactions on systems, man, and cybernetics, October 2015, [hal:hal-01220311]. 2.6

[16] H. Ahmed, R. Ushirobira, D. Efimov, D. Tran, M. Sow, L. Payton, J.-C. Massabuau, *A fault detection method for an automatic detection of spawning in oysters*, IEEE Transactions on Control Systems Technology 24, 3, March 2016, p. 1140–1147, [hal:hal-01185118]. 2.6

[17] H. Ahmed, R. Ushirobira, D. Efimov, *On Robustness of Phase Resetting to Cell Division under Entrainment*, Journal of Theoretical Biology, October 2015, [hal:hal-01211491]. 2.6, 5.2

[18] B. Amghar, A.-M. Darcherif, J.-P. Barbot, *Z(TN)-Observability and control of parallel multicell chopper using Petri nets*, IET Power Electronics Volume 6, *issue 4, May 2013, p. 710 – 720*, [doi:10.1049/iet-pel.2012.0374], [hal:hal-00826043]. 1, 2.6, 5.2

[19] D. Angeli, D. Efimov, *Characterizations of Input-to-State Stability for systems with multiple invariant sets*, IEEE Transactions on Automatic Control, *December 2015, p. 1–13*, [hal:hal-01136819].

[20] V. Azhmyakov, A. Polyakov, A. Poznyak, *Consistent approximations and variational description of some classes of sliding mode control processes*, Journal of The Franklin Institute 351, *4, January 2013, p. 1964–1981*, [doi:10.1016/j.jfranklin.2013.01.011], [hal:hal-00922390].

[21] J.-P. Barbot, D. Boutat, K. Busawon, *Utility of high-order sliding mode differentiators for dynamical left inversion problems*, IET Control Theory & Applications 9, *4, April 2015, p. 538–544*, [doi:10.1049/iet-cta.2014.0124], [hal:hal-01419075].

[22] F. J. Bejarano, T. Floquet, W. Perruquetti, G. Zheng, *Observability and Detectability of Singular Linear Systems with Unknown Inputs*, Automatica 49, *2, 2013, p. 6*, [hal:hal-00753706].

[23] F. J. Bejarano, W. Perruquetti, T. Floquet, G. Zheng, *Observation of Nonlinear Differential-Algebraic Systems with Unknown Inputs*, IEEE Transactions on Automatic Control 60, *7, 2015, p. 1957–1962*, [hal:hal-01075275].

[24] F. J. Bejarano, G. Zheng, *Observability of linear systems with commensurate delays and unknown inputs*, Automatica 50, *8, April 2014, p. 2077–2083*, [doi:10.1016/j.automatica.2014.05.032], [hal:hal-00967944].

[25] F. J. Bejarano, G. Zheng, *Observability of singular time-delay systems with unknown inputs*, Systems and Control Letters 89, *March 2016, p. 55–60*, [doi:10.1016/j.sysconle.2015.12.002], [hal:hal-01410648]. 2.3.3

[26] D. Benmerzouk, J.-P. Barbot, *Symmetries impact in chaotification of piecewise smooth systems*, Nonlinear Dynamics and Systems Theory 16, *2, 2016, p. 149–164*, [hal:hal-01322942].

[27] E. Bernuau, D. Efimov, W. Perruquetti, A. Polyakov, *On homogeneity and its application in sliding mode control*, Journal of The Franklin Institute, *January 2014*, [doi:10.1016/j.jfranklin.2014.01.007], [hal:hal-00942326]. 2.4.3, 2.5.3, 3.6

[28] E. Bernuau, D. Efimov, W. Perruquetti, *Scale invariance analysis for genetic networks applying homogeneity*, Journal of Mathematical Biology, *December 2015, p. 1–10*, [hal:hal-01185119]. 2.6, 5.2

[29] E. Bernuau, W. Perruquetti, D. Efimov, E. Moulay, *Robust finite-time output feedback stabilization of the double integrator*, International Journal of Control 88, *3, December 2014, p. 451–460*, [doi:10.1080/00207179.2014.956340], [hal:hal-01056207].

[30] E. Bernuau, W. Perruquetti, E. Moulay, *Retraction obstruction to time-varying stabilization*, Automatica 49, *6, 2013, p. 1941–1943*, [hal:hal-00862934].

[31] E. Bernuau, A. Polyakov, D. Efimov, W. Perruquetti, *Verification of ISS, iISS and IOSS properties applying weighted homogeneity*, Systems & Control Letters 62, *12, December 2013, p. 1159–1167*, [hal:hal-00877148]. 2.4.2, 2.4.3

[32] S. Chebotarev, D. Efimov, T. Raïssi, A. Zolghadri, *Interval Observers for Continuous-Time LPV Systems with L1 /L2 Performance*, Automatica, *December 2015, p. 1–12*, [hal:hal-01149982]. 2.5.3

[33] J. Cieslak, D. Efimov, D. Henry, *Transient management of a supervisory fault-tolerant control scheme based on dwell-time conditions*, International Journal of Adaptive Control and Signal Processing 29, *January 2015, p. 123–142*, [doi:10.1002/acs.2465], [hal:hal-00924618].

[34] J. Cieslak, D. Efimov, A. Zolghadri, D. Henry, P. Goupil, *Design of a non-homogeneous differentiator for actuator oscillatory failure case reconstruction in noisy environment*, Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering 229, *3, March 2015, p. 266–275*, [doi:10.1177/0959651814561091], [hal:hal-01095741]. 2.6, 5.2

[35] M. Defoort, G. Demesure, Z. Zuo, A. Polyakov, M. Djemai, *Fixed-time stabilization and consensus of nonholonomic systems*, IET Control Theory and Applications, *September 2016*, [doi:10.1049/iet-cta.2016.0094], [hal:hal-01405104]. 2.6

[36] M. Defoort, A. Polyakov, G. Demesure, M. Djemai, *Leader-follower fixed-time consensus for multi–agent systems with unknown nonlinear inherent dynamics*, IET Control Theory and Applications, *September 2015*, [hal:hal-01215015]. 2.6

[37] R. Delpoux, M. Bodson, T. Floquet, *Parameter estimation of permanent magnet stepper motors without mechanical sensors*, Control Engineering Practice 26, *May 2014, p. 178–187*, [doi:10.1016/j.conengprac.2014.01.015], [hal:hal-00933297]. 2.6, 5.2

[38] R. Delpoux, T. Floquet, *High order sliding mode control for sensorless trajectory tracking of a PMSM*, International Journal of Control, *March 2014, p. 2140–2155*, [doi:10.1080/00207179.2014.903563], [hal:hal-00957787]. 2.6, 5.2

[39] R. Delpoux, T. Floquet, *On-line parameter estimation via algebraic method: An experimental illustration*, Asian Journal of Control, *January 2014*, [hal:hal-00933292]. 2.6

[40] R. Delpoux, L. Hetel, A. Kruszewski, *Parameter Dependent Relay Control: application to PMSM*, IEEE Transactions on Control Systems Technology, *December 2014, p. 12*, [doi:10.1109/TCST.2014.2378173], [hal:hal-01093759]. 2.6, 5.2

[41] N. Djeghali, M. Ghanes, S. Djennoune, J.-P. Barbot, *Sensorless Fault Tolerant Control for Induction Motors*, International Journal of Control, Automation and Systems 11, *3, July 2013, p. 563–576*, [hal:hal-00923749]. 1, 2.6, 5.2

[42] M. T. Duong, R. Ushirobira, *Singular quadratic Lie superalgebras*, Journal of Algebra 407, *2014, p. 372 – 412*, [doi:10.1016/j.jalgebra.2014.02.034], [hal:hal-01114188].

[43] D. Efimov, J. Cieslak, A. Zolghadri, D. Henry, *Actuator fault detection in aircraft systems: Oscillatory Failure Case study*, Annual Reviews in Control 37, *1, 2013, p. 180 – 190*, [doi:10.1016/j.arcontrol.2013.04.007], [hal:hal-00801660]. 2.6, 5.2

[44] D. Efimov, C. Edwards, A. Zolghadri, *Enhancement of adaptive observer robustness applying sliding mode techniques*, Automatica 72, *December 2016, p. 53–56*, [hal:hal-01315009].

[45] D. Efimov, A. Fradkov, T. Iwasaki, *Exciting multi-DOF systems by feedback resonance*, Automatica 49, *6, May 2013, p. 1782–1789*, [hal:hal-00813506].

[46] D. Efimov, A. Fradkov, *Design of impulsive adaptive observers for improvement of persistency of excitation*, International Journal of Adaptive Control and Signal Processing, *October 2014, p. 1–18*, [doi:10.1002/acs.2506], [hal:hal-01016332].

[47] D. Efimov, E. Fridman, A. Polyakov, W. Perruquetti, J.-P. Richard, *Linear interval observers under delayed measurements and delay-dependent positivity*, Automatica, *December 2016*, [hal:hal-01312981]. 2.5.3

[48] D. Efimov, E. Fridman, A. Polyakov, W. Perruquetti, J.-P. Richard, *On Design of Interval Observers with Sampled Measurement*, Systems and Control Letters, *December 2016*, [hal:hal-01353919]. 1, 2.5.3, 2.6

[49] D. Efimov, A. Levant, A. Polyakov, W. Perruquetti, *Supervisory Acceleration of Convergence for Homogeneous Systems*, International Journal of Control, *February 2017*, [doi:10.1080/00207179.2016.1269949], [hal:hal-01411088]. 2.4.3

[50] D. Efimov, V. Nikiforov, H. Javaherian, *Supervisory Control of Air-Fuel Ratio in Spark Ignition Engines*, Control Engineering Practice 30, *9, December 2014, p. 27–33*, [hal:hal-00974225]. 2.6, 5.2

[51] D. Efimov, W. Perruquetti, T. Raissi, A. Zolghadri, *Interval Observers for Time-Varying Discrete-Time Systems*, IEEE Transactions on Automatic Control, *December 2013*, [hal:hal-00820937]. 2.5.3

[52] D. Efimov, W. Perruquetti, J.-P. Richard, *Interval estimation for uncertain systems with time-varying delays*, International Journal of Control, *May 2013*, [hal:hal-00813314]. 2.5.3

[53] D. Efimov, W. Perruquetti, J.-P. Richard, *Development Of Homogeneity Concept For Time-Delay Systems*, SIAM Journal on Control and Optimization, *December 2014*, [hal:hal-00956878].

[54] D. Efimov, W. Perruquetti, A. Shiriaev, *On existence of oscillations in hybrid systems*, Nonlinear Analysis: Hybrid Systems, *June 2014*, [hal:hal-00906088].

[55] D. Efimov, W. Perruquetti, *On Conditions of Oscillations and Multi-Homogeneity*, Mathematics of Control, Signals, and Systems 28, *February 2016*, [hal:hal-01223154]. 2.4.3

[56] D. Efimov, A. Polyakov, E. Fridman, W. Perruquetti, J.-P. Richard, *Comments on Finite-time Stability of Time-Delay Systems*, Automatica 50, *7*, *September 2014*, *p. 1944–1947*, [hal:hal-00986004].

[57] D. Efimov, A. Polyakov, L. Fridman, W. Perruquetti, J.-P. Richard, *Delayed Sliding Mode Control*, Automatica, *December 2015*, [hal:hal-01213703]. 2.5.3

[58] D. Efimov, A. Polyakov, W. Perruquetti, J.-P. Richard, *Weighted Homogeneity for Time-Delay Systems: Finite-Time and Independent of Delay Stability*, IEEE Transactions on Automatic Control 60, *December 2015*, *p. 1–6*, [hal:hal-01145321]. 2.4.3

[59] D. Efimov, A. Polyakov, J.-P. Richard, *Interval Observer Design for Estimation and Control of Time-Delay Descriptor Systems*, European Journal of Control 23, *5*, *June 2015*, *p. 26–35*, [hal:hal-01108432]. 2.5.3

[60] D. Efimov, T. Raissi, W. Perruquetti, A. Zolghadri, *Design of Interval Observers for Estimation and Stabilization of Discrete-Time LPV Systems*, IMA Journal of Mathematical Control and Information, *December 2015*, *p. 1–16*, [doi:10.1093/imamci/dnv023], [hal:hal-01162680]. 2.5.3

[61] D. Efimov, T. Raissi, A. Zolghadri, *Set adaptive observers for LPV systems: Application to fault detection*, ASME Journal of Dynamic Systems, Measurement and Control, *December 2013*, [hal:hal-00843639].

[62] D. Efimov, T. Raïssi, *Design of interval observers for uncertain dynamical systems*, Automation and Remote Control / Avtomatika i Telemekhanika 77, *2*, *2016*, *p. 191–225*, [doi:10.1134/S0005117916020016], [hal:hal-01276439].

[63] D. Efimov, J. Schiffer, R. Ortega, *Robustness of delayed multistable systems with application to droop-controlled inverter-based microgrids*, International Journal of Control 89, *5*, *2016*, *p. 909–918*, [hal:hal-01211454]. 2.6, 5.2

[64] D. Efimov, *Phase resetting for a network of oscillators via phase response curve approach*, Biological Cybernetics (Modeling) 109, *1*, *February 2015*, *p. 95–108*, [hal:hal-01061988]. 2.6, 5.2

[65] A. Estrada, D. Efimov, W. Perruquetti, *Finite-Time Position and Velocity Estimation Adapted to Noisy Biased Acceleration Measurements from Periodic Motion*, International Journal of Control, *March 2016*, [hal:hal-01295716]. 5

[66] L. Etienne, Y. Khaled, S. Di Gennaro, J.-P. Barbot, *Asynchronous event-triggered observation and control of linear systems via impulsive observers*, Journal of The Franklin Institute 354, *1*, *January 2017*, *p. 372–391*, [hal:hal-01441605].

[67] C. Fiter, L. Hetel, W. Perruquetti, J.-P. Richard, *A robust stability framework for LTI systems with time-varying sampling*, Automatica 54, *2015*, *p. 56–64*, [doi:10.1016/j.automatica.2015.01.035], [hal:hal-01194561]. 1, 2.6

[68] M. Fliess, C. Join, *Model-free control*, International Journal of Control 86, *12*, *December 2013*, *p. 2228–2252*, [doi:10.1080/00207179.2013.810345], [hal:hal-00828135]. 2.5.2

[69] M. Ghanes, J. Deleon, J.-P. Barbot, *Observer design for nonlinear systems under unknown time-varying delays*, IEEE Transactions on Automatic Control, *June 2013*, [hal:hal-00749682].

[70] M. Ghanes, M. Trabelsi, X. Lin-Shi, J.-P. Barbot, J.-M. Rétif, K. Busawon, *High gain observer for a three-cell chopper: Design and experimental results*, International Journal of Robust and Nonlinear Control, *September 2013*, [doi:10.1002/rnc.3063], [hal:hal-00923689]. 1, 2.6, 5.2

[71] O. Gibaru, L. Gajny, E. Nyiri, *L1C1 polynomial spline approximation algorithms for large data sets*, Numerical Algorithms, *November 2013*, [doi:10.1007/s11075-014-9828-x], [hal:hal-00927555].

[72] S. Govindaswamy, T. Floquet, S. K. Spurgeon, *Discrete time output feedback sliding mode tracking control forsystems with uncertainties*, International Journal of Robust and Nonlinear Control 24, *15*, *2014*, *p. 2098–2118*, [doi:10.1002/rnc.2978], [hal:hal-01114888].

[73] M. Guerra, D. Efimov, G. Zheng, W. Perruquetti, *Avoiding local minima in the potential field method using input-to-state stability*, Control Engineering Practice 55, *2016*, *p. 174 – 184*, [doi:10.1016/j.conengprac.2016.07.008], [hal:hal-01405349].

[74] M. Guerra, D. Efimov, G. Zheng, W. Perruquetti, *Finite-Time Obstacle Avoidance for Unicycle-like robot Subject to Additive Input Disturbances*, Autonomous Robots, *February 2016*, [hal:hal-01232203]. 2.6

[75] F. Hamerlain, T. Floquet, W. Perruquetti, *Experimental Tests of a Sliding Mode Controller for Trajectory Tracking of a Car-like Mobile Robot*, Robotica 32, *1*, *2014*, *p. 63–76*, [hal:hal-00924745].

[76] D. Henry, J. Cieslak, A. Zolghadri, D. Efimov, *A non-conservative H_-/H_∞ solution for early and robust fault diagnosis in aircraft control surface servo-loops*, Control Engineering Practice 31, *October 2014*, *p. 183–199*, [doi:10.1016/j.conengprac.2013.12.010], [hal:hal-00942311]. 2.6, 5.2

[77] D. Henry, J. Cieslak, A. Zolghadri, D. Efimov, *Hinfinity/H- LPV solutions for fault detection of aircraft actuator faults: Bridging the gap between theory and practice*, International Journal of Robust and Nonlinear Control 25, *5*, *2015*, *p. 649–672*, [doi:10.1002/rnc.3157.2014], [hal:hal-00946216]. 2.6, 5.2

[78] 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*, Automatica 76, *2017*, *p. 309–335*, [doi:http://dx.doi.org/10.1016/j.automatica.2016.10.023], [hal:hal-01363448]. 2.6, 3.6

[79] L. Hetel, E. Fridman, T. Floquet, *Variable Structure Control with Generalized Relays: A Simple Convex Optimization Approach*, IEEE Transactions on Automatic Control 60, *2*, *January 2015*, *p. 497 – 502*, [doi:10.1109/TAC.2014.2331417], [hal:hal-01006389]. 1, 2.6

[80] M. Hilairet, O. Béthoux, M. Ghanes, V. Tanasa, N.-C. Dorothée, J.-P. Barbot, *Experimental Validation of a Sampled-Data Passivity-Based Controller for Coordination of Converters in a Fuel Cell System*, IEEE Transactions on Industrial Electronics 62, *8*, *August 2015*, *p. 5187 – 5194*, [doi:10.1109/TIE.2014.2362497], [hal:hal-01419162]. 1, 2.6, 5.2

[81] M. Hiliaret, M. Ghanes, O. Béthoux, J.-P. Barbot, D. Normand-Cyrot, *A Passivity-Based Controller for coordination of converters in a Fuel Cell System*, Control Engineering Practice 21, *8*, *August 2013*, *p. 1097–1109*, [doi:10.1109/TVT.2013.2246202], [hal:hal-00923716]. 1, 2.6, 5.2

[82] L. Kiltz, C. Join, M. Mboup, J. Rudolph, *Fault-tolerant control based on algebraic derivative estimation applied on a magnetically supported plate*, Control Engineering Practice 26, *May 2014*, *p. 107–115*, [doi:10.1016/j.conengprac.2014.01.009], [hal:hal-00945564]. 2.6, 5.2

[83] D.-Y. Liu, O. Gibaru, W. Perruquetti, T.-M. Laleg-Kirati, *Fractional order differentiation by integration and error analysis in noisy environment*, IEEE Transactions on Automatic Control, *2015, p. 16*, [hal:hal-01134780]. 2.3.3

[84] D.-Y. Liu, G. Zheng, D. Boutat, H.-R. Liu, *Non-asymptotic fractional order differentiator for a class of fractional order linear systems*, Automatica, *2017*, [hal:hal-01420910]. 2.3.3

[85] Y. Ma, G. Zheng, W. Perruquetti, Z. Qiu, *Local path planning for mobile robots based on intermediate objectives*, Robotica, *April 2014, p. 1–15*, [doi:10.1017/S0263574714000186], [hal:hal-00960019].

[86] S. Maalej, A. Kruszewski, L. Belkoura, *Robust Control for Continuous LPV System with Restricted-Model-Based Control*, Circuits, Systems, and Signal Processing, *September 2016*, [doi:10.1007/s00034-016-0404-6], [hal:hal-01410300].

[87] M. Mbaye, M. Diallo, M. Mboup, *LU based Beamforming schemes for MIMO systems*, IEEE Transactions on Vehicular Technology, *2016*, [hal:hal-01307533].

[88] T. Menard, E. Moulay, W. Perruquetti, *Homogeneous approximations and local observer design*, ESAIM: Control, Optimisation and Calculus of Variations 19, *03, July 2013, p. 906–929*, [hal:hal-00787926]. 2.4.2

[89] M. Mera, A. Polyakov, W. Perruquetti, *Finite-time Attractive Ellipsoid Method: Implicit Lyapunov Function Approach*, International Journal of Control, *December 2015, http://dx.doi.org/10.1080/00207179.2015.1118660*, [doi:10.1080/00207179.2015.1118660], [hal:hal-01227455]. 2.5.3

[90] S. C. Olteanu, A. Aitouche, L. Belkoura, A. Jouni, *'Embedded PEM Fuel cell Stack. Nonlinear Observer by means of TS approach*, Studies in Informatics and Control 24, *1, February 2016, p. 61–70*, [hal:hal-01291046].

[91] H. Omran, L. Hetel, M. Petreczky, J.-P. Richard, F. Lamnabhi-Lagarrigue, *Stability analysis of some classes of input-affine nonlinear systems with aperiodic sampled-data control*, Automatica 70, *2016, p. 266–274*, [doi:10.1016/j.automatica.2016.02.013], [hal:hal-01343851]. 1, 2.6

[92] H. Omran, L. Hetel, J.-P. Richard, F. Lamnabhi-Lagarrigue, *Stability analysis of bilinear systems under aperiodic sampled-data control*, Automatica 50, *4, April 2014, p. 1288–1295*, [doi:10.1016/j.automatica.2014.02.033], [hal:hal-00829865]. 1, 2.6

[93] A. Polyakov, D. Efimov, E. Fridman, W. Perruquetti, *On Homogeneous Distributed Parameter Systems*, IEEE Transactions on Automatic Control, *2016*, [doi:10.1109/TAC.2016.2525925], [hal:hal-01318134]. 2.4.3

[94] A. Polyakov, D. Efimov, W. Perruquetti, J.-P. Richard, *Output Stabilization of Time-Varying Input Delay Systems Using Interval Observation Technique*, Automatica, *December 2013*, [hal:hal-00847565]. 2.5.3

[95] A. Polyakov, D. Efimov, W. Perruquetti, J.-P. Richard, *Implicit Lyapunov-Krasovski Functionals For Stability Analysis and Control Design of Time-Delay Systems*, IEEE Transactions on Automatic Control, *2015, p. 6*, [doi:10.1109/TAC.2015.2422451], [hal:hal-01160061]. 2.4.3

[96] A. Polyakov, D. Efimov, W. Perruquetti, *Finite-time and fixed-time stabilization: Implicit Lyapunov function approach*, Automatica 51, *2015, p. 332 – 340*, [doi:10.1016/j.automatica.2014.10.082], [hal:hal-01098099]. 2.4.3, 2.5.3

[97] A. Polyakov, D. Efimov, W. Perruquetti, *Robust Stabilization of MIMO Systems in Finite/Fixed Time*, International Journal of Robust and Nonlinear Control, *2015, p. 23*, [doi:10.1002/rnc], [hal:hal-01160052]. 2.4.3

[98] A. Polyakov, L. Fridman, *Stability notions and Lyapunov functions for sliding mode control systems*, Journal of The Franklin Institute, *January 2014*, [doi:10.1016/j.jfranklin.2014.01.002], [hal:hal-00942319]. 2.5.3, 3.6

[99] A. Polyakov, L. Hetel, *Relay Control Design for Robust Stabilization in a Finite-Time*, IEEE Transactions on Automatic Control, *2016*, [doi:10.1109/TAC.2016.2591725], [hal:hal-01347196].

[100] A. Polyakov, *Time-suboptimal feedback design via linear matrix inequalities*, Automation and Remote Control / Avtomatika i Telemekhanika 76, *5, 2015, p. 847–862*, [doi:10.1134/S0005117915050100], [hal:hal-01215035].

[101] S. Rahme, Y. Labit, F. Gouaisbaut, T. Floquet, *Sliding Modes for Anomaly Observation in TCP Networks: From Theory to Practice*, IEEE Transactions on Control Systems Technology 21, *3, May 2013, p. pp. 1031–1038*, [doi:10.1109/TCST.2012.2198648], [hal:hal-00734325].

[102] S. Riachy, D. Efimov, M. Mboup, *Universal integral control: An approach based on mollifiers*, IEEE Transactions on Automatic Control, *January 2016, p. 16*, [hal:hal-01145601]. 2.5.3

[103] S. Riachy, M. Ghanes, *A nonlinear controller for pneumatic servo systems: Design and experimental tests*, IEEE Transactions on Mechatronics, *September 2013*, [doi:10.1109/TMECH.2013.2280956], [hal:hal-00867054].

[104] S. Riachy, *A continuous-time framework for least squares parameter estimation*, Automatica, *October 2014, p. 6*, [doi:10.1016/j.automatica.2014.10.055], [hal:hal-01080376]. 2.5.3, 2.6, 5.2

[105] J.-P. Richard, W. Perruquetti, *Non-Asymptotic estimation for on-line systems: Finite-time algorithms and applications*, ERCIM News 97, *April 2014, p. 30 – 31*, [hal:hal-01103687]. 3.5

[106] H. Ríos, D. Efimov, L. Fridman, J. Moreno, W. Perruquetti, *Homogeneity based Uniform Stability Analysis for Time-Varying Systems*, IEEE Transactions on Automatic Control, *April 2016, p. 1–11*, [hal:hal-01162678]. 2.4.3

[107] H. Ríos, D. Efimov, D. Jorge, T. Raissi, L. Fridman, A. Zolghadri, *Non-Minimum Phase Switched Systems: HOSM-Based Fault Detection and Fault Identification via Volterra Integral*, International Journal of Adaptive Control and Signal Processing, *October 2013*, [doi:10.1002/acs.2448], [hal:hal-00986405].

[108] H. Ríos, D. Efimov, A. Polyakov, W. Perruquetti, *Homogeneous Time-Varying Systems: Robustness Analysis*, IEEE Transactions on Automatic Control 61, *12, December 2016, p. 4075–4080*, [hal:hal-01284741]. 2.4.2, 2.4.3

[109] H. Ríos, M. Mera, D. Efimov, A. Polyakov, *Robust output-control for uncertain linear systems: Homogeneous differentiator-based observer approach*, International Journal of Robust and Nonlinear Control, *2016*, [doi:10.1002/rnc.3643], [hal:hal-01405383].

[110] H. Ríos, D. Mincarelli, D. Efimov, W. Perruquetti, J. Davila, *Continuous and Discrete State Estimation for Switched LPV Systems using Parameter Identification*, Automatica, *December 2015, p. 1–8*, [hal:hal-01188367].

[111] F. Salinas, M. Ghanes, J.-P. Barbot, M. Escalante, B. Amghar, *Modeling and Control Design Based on Petri Nets for Serial Multicellular Choppers*, IEEE Transactions on Control Systems Technology 23, *1, January 2015, p. 91 – 100*, [doi:10.1109/TCST.2014.2313553], [hal:hal-01419063]. 1, 2.6, 5.2

[112] F. Salinas, G. Malek, J.-P. Barbot, M. Escalante, B. Amghar, *Modeling and Control Design Based on Petri Nets for Serial Multicellular Choppers*, IEEE Transactions on Control Systems Technology 23, *1, April 2014, p. 13*, [hal:hal-01092189]. 2.6, 5.2

[113] R. Tami, D. Boutat, G. Zheng, *Extended output depending normal form*, Automatica 7, *April 2013, p. 2192–2198*, [doi:10.1016/j.automatica.2013.03.025], [hal:hal-00817332].

[114] R. Tami, D. Boutat, G. Zheng, *Observateur non linéaire étendu*, Journal Européen des Systèmes Automatisés (JESA) 47, *4-8, September 2013, p. 503–518*, [doi:10.3166/HSP.x.1-16], [hal:hal-01094932].

[115] R. Tami, G. Zheng, D. Boutat, D. Aubry, H. Wang, *Partial observer normal form for nonlinear system*, Automatica 64, *2016, p. 54–62*, [doi:10.1016/j.automatica.2015.10.041], [hal:hal-01239583]. 4.0.5

[116] R. E. H. Thabet, T. Raïssi, C. Combastel, D. Efimov, A. Zolghadri, *An effective method to interval observer design for time-varying systems*, Automatica 50, *10, 2014, p. 2677–2684*, [doi:10.1016/j.automatica.2014.08.035], [hal:hal-01126406]. 2.5.3

[117] R. Ushirobira, W. Perruquetti, M. Mboup, *An algebraic continuous time parameter estimation for a sum of sinusoidal waveform signals*, International Journal of Adaptive Control and Signal Processing, *2016*, [doi:10.1002/acs.2688], [hal:hal-01342210]. 2.3.3

[118] H. Wang, Y. Xuefei, Y. Tian, G. Zheng, N. Christov, *Model-Free Based Terminal SMC of Quadrotor Attitude and Position*, IEEE Transactions on Aerospace and Electronic Systems, *October 2016*, [hal:hal-01410899]. 2.5.3, 4.0.5

[119] L. Yu, H. Sun, G. Zheng, J.-P. Barbot, *Model based Bayesian compressive sensing via Local Beta Process*, Signal Processing 108, *March 2015, p. 259–271*, [doi:10.1016/j.sigpro.2014.09.018], [hal:hal-01094927].

[120] L. Yu, C. Wei, G. Zheng, *Adaptive Bayesian Estimation with Cluster Structured Sparsity*, IEEE Signal Processing Letters, *2015*, [doi:10.1109/LSP.2015.2477440], [hal:hal-01252325].

[121] L. Yu, G. Zheng, D. Boutat, *Adaptive observer for simultaneous state and parameter estimations for an output depending normal form*, Asian Journal of Control 19, *1, January 2017, p. 1–6*, [hal:hal-01410734].

[122] J. Zerad, S. Riachy, P. Toussaint, J.-P. Barbot, *Novel Phasor Transformation for Feedback Control Design for Induction Heating Systems with Experimental Results*, IEEE Transactions on Industrial Electronics, *2015, p. 8*, [doi:10.1109/TIE.2015.2424394], [hal:hal-01195551]. 1, 2.6, 5.2

[123] B. Zhang, A. Kruszewski, J.-P. Richard, *A novel control design for delayed teleoperation based on delay-scheduled Lyapunov-Krasovskii functionals*, International Journal of Control, *January 2014*, [doi:10.1080/00207179.2014.883464], [hal:hal-00939507]. 2.6

[124] G. Zheng, J.-P. Barbot, D. Boutat, *Identification of the delay parameter for nonlinear time-delay systems with unknown inputs*, Automatica 6, *2013, p. 1755–1760*, [doi:10.1016/j.automatica.2013.02.020], [hal:hal-00817331].

[125] G. Zheng, F. J. Bejarano, W. Perruquetti, J.-P. Richard, *Unknown input observer for linear time-delay systems*, Automatica 61, *2015, p. 35–43*, [doi:10.1016/j.automatica.2015.07.029], [hal:hal-01252331]. 2.3.3

[126] G. Zheng, F. J. Bejarano, *Observer design for linear singular time-delay systems*, Automatica, *2017*, [hal:hal-01420897]. 2.3.3

[127] G. Zheng, D. Efimov, F. J. Bejarano, W. Perruquetti, H. Wang, *Interval observer for a class of uncertain nonlinear singular systems*, Automatica 71, *2016, p. 159–168*, [hal:hal-01292475]. 2.5.3, 4.0.5

[128] G. Zheng, D. Efimov, W. Perruquetti, *Design of interval observer for a class of uncertain unobservable nonlinear systems*, Automatica, *2015, p. 0*, [hal:hal-01199021]. 2.5.3

[129] G. Zheng, Y. Orlov, W. Perruquetti, J.-P. Richard, *Finite-time-observer design for nonlinear impulsive systems with impact perturbation*, International Journal of Control 87, *10, April 2014, p. 2097–2105*, [hal:hal-00960059].

[130] S. Zhuk, A. Polyakov, O. Nakonechnyi, *Note on Minimax Sliding Mode Control Design for Linear Systems*, IEEE Transactions on Automatic Control, *2016*, [doi:10.1109/TAC.2016.2612058], [hal:hal-01371091].

[131] D. Zimenko, A. Polyakov, D. Efimov, A. Kremlev, *Feedback sensitivity functions analysis of finite-time stabilizing control system*, International Journal of Robust and Nonlinear Control, *2016*, [doi:10.1002/rnc.3693], [hal:hal-01405766].

[132] K. ZIMENKO, D. EFIMOV, A. POLYAKOV, W. PERRUQUETTI, *A note on delay robustness for homogeneous systems with negative degree*, Automatica, *June 2017*, [hal:hal-01419131]. 2.4.3

[133] A. ZOLGHADRI, J. CIESLAK, D. EFIMOV, G. PHILIPPE, R. DAYRE, *Practical design considerations for successful industrial application of model-based fault detection techniques to aircraft systems*, Annual Reviews in Control, *December 2016*, [doi:10.1016/j.arcontrol.2016.07.003], [hal:hal-01385577]. 2.6, 5.2

Articles in National Journals

[134] C. JOIN, G. ROBERT, M. FLIESS, *Une "commande sans modèle" pour aménagements hydroélectriques en cascade*, Flash X - La revue scientifique de l'Ecole polytechnique 15, *July 2013, p. 33–38*, [hal:hal-00843678].

Invited Conferences

[135] L. AMET, M. GHANES, J.-P. BARBOT, *Sensorless control of a DC series motor*, in: IFAC ALCOSP, *Caen, France, July 2013*, [hal:hal-00923720].

[136] J.-P. BARBOT, *An epistemology of observation theory and its application in the design of software sensor in power electronics.*, in: The 5th International Conference on Electronics Engineering (ICEE 2013), *Alipacha Adda, Oran, Algeria, November 2013*, [hal:hal-00908432].

[137] M. FLIESS, C. JOIN, *Towards a new viewpoint on causality for time series*, in: Colloque Modélisation, Contrôle et Analyse des Systèmes en l'honneur du Professeur Abdelhaq EL JAI, CMACS 2014 - Colloque de Modélisation, Analyse et Contrôle des Systèmes, 49 (February 2015), *Samira El Yacoubi, Larbi Afifi, El Hassan Zerrik and Abdessamad Tridane (Eds.), EDP Sciences, p. pp. 37–52, Ifrane, Morocco, May 2014*, [hal:hal-00991942].

[138] J. GAMIOCHIPI, M. GHANES, W. AGGOUNE, J. DELEON, J.-P. BARBOT, *Observer design for a class of nonlinear systems under a persistent excitation*, in: 10th IFAC Symposium on Nonlinear Control Systems, NOLCOS,, *Monterey, United States, August 2016*, [hal:hal-01333821].

[139] K. A. LANGUEH, O. DATCU, J.-P. BARBOT, G. ZHENG, K. BUSAWON, *Observabilty singularities and observer design: dual immersion approach*, in: 10th IFAC Symposium on Nonlinear Control Systems, NOLCOS, *Monterey, United States, August 2016*, [hal:hal-01333688].

[140] D.-Y. LIU, T.-M. LALEG-KIRATI, O. GIBARU, W. PERRUQUETTI, *Fractional Order Numerical Differentiation with B-Spline Functions*, in: The International Conference on Fractional Signals and Systems 2013, *Ghent, Belgium, October 2013*, [hal:hal-00859455].

[141] D.-Y. LIU, T.-M. LALEG-KIRATI, W. PERRUQUETTI, O. GIBARU, *Non-asymptotic state estimation for a class of linear time-varying systems with unknown inputs*, in: the 19th World Congress of the International Federation of Automatic Control 2014, *Cape Town, South Africa, August 2014*, [hal:hal-00968974].

International Conferences with Proceedings

[142] H. ABOUAISSA, M. FLIESS, C. JOIN, *On short-term traffic flow forecasting and its reliability*, in: 8th IFAC Conference on Manufacturing Modelling, Management & Control (MIM 2016), 8th IFAC Conference on Manufacturing Modelling, Management & Control, *IFAC, Troyes, France, June 2016*, [hal:hal-01275311].

[143] H. AHMED, R. USHIROBIRA, D. EFIMOV, W. PERRUQUETTI, *On conditions of robust synchronization for multistable systems*, in: Proc. ECC'15, *Linz, Austria, July 2015*, [hal:hal-01140326].

[144] H. AHMED, R. USHIROBIRA, D. EFIMOV, D. TRAN, J.-C. MASSABUAU, *Dynamical model identification of population of oysters for water quality monitoring*, in: Proc. European Control Conference (ECC) 2014, *Strasbourg, France, June 2014*, [hal:hal-00986038].

[145] H. Ahmed, R. Ushirobira, D. Efimov, D. Tran, J.-C. Massabuau, *Velocity estimation of valve movement in oysters for water quality surveillance*, in : IFAC MICNON 2015, *Saint-Petersburg, Russia, June 2015*, [hal:hal-01162688].

[146] H. Ahmed, R. Ushirobira, D. Efimov, D. Tran, M. Sow, J.-C. Massabuau, *Automatic spawning detection in oysters: a fault detection approach*, in : Proc. ECC'15, *Linz, Austria, July 2015*, [hal:hal-01140324].

[147] H. Ahmed, R. Ushirobira, D. Efimov, *On the robust synchronization of Brockett oscillators*, in : PSYCO'2016 - 6th IFAC International Workshop on Periodic Control Systems, 49, *p. 142 – 147, Eindhoven, Netherlands, June 2016*, [doi:10.1016/j.ifacol.2016.07.999], [hal:hal-01380180].

[148] H. Ahmed, R. Ushirobira, D. Efimov, *Robust synchronization of genetic oscillators subjected to cell division and common entrainment*, in : ECC 2016 - 15th annual European Control Conference, *Aalborg, Denmark, June 2016*, [hal:hal-01380247].

[149] L. Amet, M. Ghanes, J.-P. Barbot, *HOSM control under quantization and saturation constraints: Zig-Zag design solutions*, in : CDC - 51st IEEE Conference on Decision and Control - 2012, *Maui, United States, December 2013*, [hal:hal-00749840].

[150] B. Amghar, A.-M. Darcherif, J.-P. Barbot, D. Boukhetala, *Modeling and control of series resonant converter for high voltage applications*, in : IEEE Energycon 2014, *p. 216 – 221, Dubrovnik, France, May 2014*, [doi:10.1109/ENERGYCON.2014.6850431], [hal:hal-01092213].

[151] A. Aparicio, D. Efimov, L. Fridman, *ISS-Lyapunov Functions for Output Feedback Sliding Modes*, in : Proc. 55th IEEE Conference on Decision and Control (CDC), *Las Vegas, United States, December 2016*, [hal:hal-01371277].

[152] S. Aranovskiy, R. Ushirobira, D. Efimov, G. Casiez, *Modeling Pointing Tasks in Mouse-Based Human-Computer Interactions*, in : CDC 2016 - 55th IEEE Conference on Decision and Control, *Las Vegas, United States, December 2016*, [hal:hal-01380318]. 2.6

[153] O. Bara, M. Fliess, C. Join, J. Day, S. M. Djouadi, *Model-free immune therapy: A control approach to acute inflammation*, in : 15th European Control Conference, ECC'16, *Aalborg, Denmark, June 2016*, [hal:hal-01341060].

[154] N. Barabanov, J. Schiffer, R. Ortega, D. Efimov, *Almost Global Attractivity of a Synchronous Generator Connected to an Infinite Bus*, in : Proc. 55th IEEE Conference on Decision and Control (CDC), *Las Vegas, United States, December 2016*, [hal:hal-01371271].

[155] J.-P. Barbot, A. Levant, M. Livine, D. Lunz, *Discrete Sliding-Mode-Based Differentiators*, in : The 14th International Workshop on Variable Structure Systems (VSS 2016), *Nanjing, Jiangsu, China, June 2016*, [hal:hal-01338297].

[156] F. J. Bejarano, G. Zheng, *Unknown Input Functional Observability of Descriptor Systems with Delays*, in : CDC2016, *IEEE, Las Vegas, United States, December 2016*, [hal:hal-01410874].

[157] E. Bernuau, D. Efimov, E. Moulay, W. Perruquetti, *Homogeneous continuous finite-time observer for the triple integrator*, in : ECC'15 - 14th annual European Control Conference, *Linz, Austria, July 2015*, [hal:hal-01140339].

[158] E. Bernuau, D. Efimov, W. Perruquetti, A. Polyakov, *On an extension of homogeneity notion for differential inclusions*, in : European Control Conference 2013, *Zurich, Switzerland, July 2013*, [hal:hal-00801818].

[159] E. Bernuau, D. Efimov, W. Perruquetti, *Analysis of scale invariance property applying homogeneity*, in : 19th IFAC World Congress 2014, *Cape Town, South Africa, August 2014*, [hal:hal-00964081].

[160] E. Bernuau, D. Efimov, W. Perruquetti, *On the robustness of homogeneous systems and a homogeneous small gain theorem*, in : IEEE MSC 2014, *Nice/Antibes, France, October 2014*, [hal:hal-01082174].

[161] E. Bernuau, D. Efimov, W. Perruquetti, *Robustness of homogeneous and locally homogeneous differential inclusions*, in : Proc. European Control Conference (ECC) 2014, *Strasbourg, France, June 2014*, [hal:hal-00986032].

[162] E. Bernuau, A. Polyakov, D. Efimov, W. Perruquetti, *On ISS and iISS properties of homogeneous systems*, in : European Control Conference 2013, *Zurich, Switzerland, July 2013*, [hal:hal-00801817].

[163] F. Boulier, A. Korporal, F. Lemaire, W. Perruquetti, A. Poteaux, R. Ushirobira, *An Algorithm for Converting Nonlinear Differential Equations to Integral Equations with an Application to Parameter Estimation from Noisy Data*, in : Computer Algebra in Scientific Computing, *p. 28 – 43, Warsaw, Poland, September 2014*, [hal:hal-01114187]. 2.3.3

[164] D. Boutat, J.-P. Barbot, M. Darouach, *A New Algorithm to Compute Inverse Dynamic of a Class of Nonlinear Systems*, in : 52nd IEEE Conference on Decision and Control, *Florence, Italy, December 2013*, [hal:hal-00923663].

[165] Y. Bouzidi, A. Poteaux, A. Quadrat, *Computer algebra methods for the stability analysis of differential systems with commensurate time-delays*, in : 13th IFAC Workshop on Time Delay Systems, *p. 6, Istanbul, Turkey, June 2016*, [hal:hal-01415282].

[166] Y. Bouzidi, F. Rouillier, *Certified Algorithms for proving the structural stability of two dimensional systems possibly with parameters*, in : MNTS 2016 - 22nd International Symposium on Mathematical Theory of Networks and Systems, Proceedings of the 22nd International Symposium on Mathematical Theory of Networks and Systems, *Minneapolis, United States, July 2016*, [hal:hal-01366202].

[167] B. Brogliato, A. Polyakov, *Globally Stable Implicit Euler Time-Discretization of a Nonlinear Single-Input Sliding-Mode Control System*, in : 54th conference on Decision and Control 2015, *IEEE, Osaka, Japan, December 2015*, [hal:hal-01212601]. 2.5.2, 2.5.3

[168] S. Chebotarev, D. Efimov, T. Raissi, A. Zolghadri, *On Interval Observer Design for a Class of Continuous-Time LPV Systems*, in : IFAC Nolcos 2013, *Toulouse, France, September 2013*, [hal:hal-00844390].

[169] S. Chen, D. Efimov, J.-P. Richard, Z. Jiao, *Interval estimation for systems with unknown input delays and gains*, in : 33rd Chinese Control Conference, *Nanjing, China, July 2014*, [hal:hal-00987063]. 2.5.3

[170] J. Cieslak, D. Efimov, A. Zolghadri, A. Gheorghe, P. Goupil, R. Dayre, *A Method for Actuator Lock-in-place Failure Detection in Aircraft Control Surface Servo-loops*, in : IFAC World Congress'14, *Cape Town, South Africa, August 2014*, [hal:hal-00950287].

[171] J. Cieslak, D. Efimov, A. Zolghadri, D. Henry, P. Goupil, *Oscillatory Failure Case Detection for Aircraft using Non-Homogeneous Differentiator in Noisy Environment*, in : 2nd CEAS Specialist Conference on Guidance, Navigation & Control, *co-sponsored by IEEE and AIAA, p. –, Delft, Netherlands, April 2013*, [hal:hal-00787966].

[172] J. Cieslak, D. Henry, D. Efimov, A. Zolghadri, *Enhanced distinguishability in Supervisory Fault Tolerant Control*, in : IFAC World Congress'14, *Cape Town, South Africa, August 2014*, [hal:hal-00950278].

[173] O. Datcu, R. Tauleigne, J.-P. Barbot, *A new algorithm for the analysis of strange attractors*, in : International Symposium on Signals, Circuits and Systems (ISSCS), *Iasi, Romania, July 2013*, [hal:hal-00923697].

[174] O. Datcu, R. Tauleigne, A. Vlad, J.-P. Barbot, *Observability-singularity manifolds in the context of chaos based cryptography*, in : International Conference on systems and Control (ICSC'13), *Alger, Algeria, October 2013*, [hal:hal-00923700].

[175] J. De Miras, C. Join, M. Fliess, S. Riachy, S. Bonnet, *Active magnetic bearing: A new step for model-free control*, in : 52nd IEEE Conference on Decision and Control (CDC 2013), *p. 7449–7454, Florence, Italy, December 2013*, [hal:hal-00857649].

[176] K. H. Degue, D. Efimov, A. Iggidr, *Interval estimation of sequestered infected erythrocytes in malaria patients*, in : European Control Conference (ECC16), CDROM, *Aalborg, Denmark, June 2016*, [hal:hal-01295741]. 2.5.3

[177] K. H. Degue, D. Efimov, J.-P. Richard, *Interval Observers for Linear Impulsive Systems*, in : 10th IFAC Symposium on Nonlinear Control Systems (NOLCOS 2016), *Monterey, California, United States, August 2016*, [hal:hal-01356972]. 2.5.3

[178] R. Delpoux, R. Béarée, A. Olabi, O. Gibaru, *Toward on-line robot vibratory modes estimation*, in : American Control Conference (ACC), *IEEE, Portland, United States, June 2014*, [doi:10.1109/ACC.2014.6858969], [hal:hal-00957809].

[179] R. Delpoux, L. Hetel, A. Kruszewski, *Permanent Magnet Synchronous Motor control via Parameter Dependent Relay Control*, in : American Control Conference (ACC), *Portland, United States, June 2014*, [doi:10.1109/ACC.2014.6858935], [hal:hal-00957800].

[180] R. Delpoux, H. Sira-Ramirez, T. Floquet, *Acceleration Feedback via an algebraic state estimation method*, in : 52th IEEE Conference on Decision and Control,, *Florence, Italy, December 2013*, [hal:hal-00881164].

[181] P. Djondiné, J.-P. Barbot, M. Ghanes, *Nonlinear phenomena study in serial multicell chopper*, in : 4th IFAC Conference on Analysis and Control of Chaotic Systems, *Tokyo, Japan, August 2015*, [doi:10.1016/j.ifacol.2015.11.019], [hal:hal-01340064].

[182] m. Doublet, C. Join, F. Hamelin, *Model-free control for unknown delayed systems*, in : 3rd Conference on Control and Fault-Tolerant Systems, SysTol 2016, *Barcelone, Spain, September 2016*, [hal:hal-01369776]. 2.5.3

[183] E. Edjekouane, Y. Khaled, M. Ghanes, J.-P. Barbot, *Road type detection based on impulsive observer with synchronous and asynchronous measurements*, in : IEEE Conference on Control Application, *Sydney, Australia, September 2015*, [doi:10.1109/CCA.2015.7320677], [hal:hal-01419028].

[184] E. Edjekouane, S. Riachy, M. Ghanes, J.-P. Barbot, *Robust control of pneumatic actuators based on a simplified model with delayed input*, in : 13th International Workshop on Variable Structure Systems, *p. 1 – 6, Nante, France, June 2014*, [doi:10.1109/VSS.2014.6881117], [hal:hal-01084398].

[185] D. Efimov, C. Edwards, A. Zolghadri, *A note on improvement of adaptive observer robustness*, in : 19th IFAC World Congress, *Cape Town, South Africa, August 2014*, [hal:hal-00967893].

[186] D. Efimov, E. Fridman, A. Polyakov, W. Perruquetti, J.-P. Richard, *On Design of Sampled-Data Interval Observers*, in : European Control Conference (ECC16), *Aalborg, Denmark, March 2016*, [hal:hal-01295752].

[187] D. Efimov, A. Levant, A. Polyakov, W. Perruquetti, *On Acceleration of a Class of Asymptotically Stable Homogeneous Systems*, in : Proc. 55th IEEE Conference on Decision and Control (CDC), *Las Vegas, United States, December 2016*, [hal:hal-01371274].

[188] D. Efimov, S. Li, Y. Hu, S. Muldoon, H. Javaherian, V. Nikiforov, *Application of Interval Observers to Estimation and Control of Air-Fuel Ratio in a Direct Injection Engine*, in : Proc. ACC'15, *Chicago, United States, July 2015*, [hal:hal-01140347]. 2.5.3

[189] D. Efimov, R. Ortega, J. Schiffer, *ISS of multistable systems with delays: application to droop-controlled inverter-based microgrids*, in : Proc. ACC'15, *Chicago, United States, July 2015*, [hal:hal-01140346].

[190] D. Efimov, R. Ortega, J. Schiffer, *ISS of multistable systems with delays: application to droop-controlled inverter-based microgrids*, in : ACC'15, Proceedings of the 2015 American Control Conference ACC'15, *Chicago, United States, July 2016*, [hal:hal-01262189].

[191] D. Efimov, W. Perruquetti, M. Petreczky, *On necessary conditions of instability and design of destabilizing controls*, in : IEEE CDC2014, *LA, United States, December 2014*, [hal:hal-01066282].

[192] D. Efimov, W. Perruquetti, T. Raissi, A. Zolghadri, *On Interval Observer Design for Time-Invariant Discrete-Time Systems*, in : European Control Conference 2013, *Zurich, Switzerland, July 2013*, [hal:hal-00801806]. 2.5.3

[193] D. Efimov, W. Perruquetti, J.-P. Richard, *On reduced-order interval observers for time-delay systems*, in : European Control Conference 2013, *Zurich, Switzerland, July 2013*, [hal:hal-00801809]. 2.5.3

[194] D. Efimov, W. Perruquetti, A. Shiriaev, *Conditions of existence of oscillations for hybrid systems*, in : IFAC Nolcos 2013, *Toulouse, France, September 2013*, [hal:hal-00844408].

[195] D. Efimov, A. Polyakov, E. Fridman, W. Perruquetti, J.-P. Richard, *Delay-Dependent Positivity: Application to Interval Observers*, in : Proc. ECC'15, *Linz, Austria, July 2015*, [hal:hal-01140336]. 2.5.3

[196] D. Efimov, A. Polyakov, L. Fridman, W. Perruquetti, J.-P. Richard, *A Note on Continuous Delayed Sliding Mode Control*, in : Proc. ECC'15, *Linz, Austria, July 2015*, [hal:hal-01140334].

[197] D. Efimov, A. Polyakov, A. Levant, W. Perruquetti, *Discretization of Asymptotically Stable Homogeneous Systems by Explicit and Implicit Euler Methods*, in : Proc. 55th IEEE Conference on Decision and Control (CDC), *Las Vegas, United States, December 2016*, [hal:hal-01371275].

[198] D. Efimov, A. Polyakov, W. Perruquetti, J.-P. Richard, *Stability Analysis for Nonlinear Time-Delay Systems Applying Homogeneity*, in : IEEE CDC 2014, *LA, United States, December 2014*, [hal:hal-01066296].

[199] D. Efimov, A. Polyakov, J.-P. Richard, *Interval estimation for systems with time delays and algebraic constraints*, in : Proc. European Control Conference (ECC) 2014, *Strasbourg, France, June 2014*, [hal:hal-00986034]. 2.5.3

[200] A. Estrada, D. Efimov, W. Perruquetti, *Position and velocity estimation through acceleration measurements*, in : 19th IFAC World Congress, *Cape Town, South Africa, August 2014*, [hal:hal-00966200].

[201] L. Etienne, S. Di Gennaro, J.-P. Barbot, *Event Triggered observer-based control for linear systems with time varying uncertainties*, in : American Control Conference, *Chicago, United States, July 2015*, [doi:10.1109/ACC.2015.7170950], [hal:hal-01195559].

[202] L. Etienne, S. Digennaro, J.-P. Barbot, *Active Ground Vehicle Control with use of a Super-Twisting Algorithm in the Presence of Parameter Variations*, in : 3d International Conference on Systems and Control (ICSC13), *Alger, Algeria, October 2013*, [hal:hal-00923757].

[203] M. Feingesicht, C. Raibaudo, A. Polyakov, F. Kerherve, J.-P. Richard, *A bilinear input-output model with state-dependent delay for separated flow control*, in : European Control Conference 2016, *Aalborg, Denmark, June 2016*, [hal:hal-01298166].

[204] C. Fiter, L. Hetel, W. Perruquetti, J.-P. Richard, *A Robust Polytopic Approach for State-Dependent Sampling*, in : ECC 2013 : 12th European Control Conference, *p. 2603 – 2608, Zurich, Switzerland, July 2013*, [hal:hal-00849833].

[205] C. Fiter, L. Hetel, W. Perruquetti, J.-P. Richard, *A Self-Triggered Control Based on Convex Embeddings for Perturbed LTI Systems*, in : 9th IFAC Symposium on Nonlinear Control Systems, 9, *1, p. 335–340, Toulouse, France, September 2013*, [doi:10.3182/20130904-3-FR-2041.00176], [hal:hal-00849840].

[206] C. Fiter, H. Omran, L. Hetel, J.-P. Richard, *Tutorial on arbitrary and state-dependent sampling*, in : 13th European Control Conference, *p. 1440–1445, Strasbourg, France, June 2014*, [doi:10.1109/ECC.2014.6862643], [hal:hal-01194572].

[207] M. Fliess, C. Join, *Systematic and multifactor risk models revisited*, in : First Paris Financial Management Conference, *p. http://khuongnguyen.free.fr/PFMC–2013/Program_Papers.pdf, Paris, France, December 2013*, [hal:hal-00920175].

[208] M. Fliess, C. Join, *Stability margins and model-free control: A first look*, in : 13th European Control Conference, ECC'14, *p. pp.454–459, Strasbourg, France, June 2014*, [hal:hal-00966107].

[209] M. Guerra, D. Efimov, G. Zheng, W. Perruquetti, *Finite-Time Supervisory Stabilization for a Class of Nonholonomic Mobile Robots Under Input Disturbances*, in : 19th IFAC World Congress, *Cape Town, South Africa, August 2014*, [hal:hal-00972605].

[210] M. Guerra, D. Efimov, G. Zheng, W. Perruquetti, *Robust Decentralized Supervisory Control in a Leader-Follower Configuration with Obstacle Avoidance*, in : IFAC MICNON 2015, *Saint-Petersburg, Russia, June 2015*, [hal:hal-01162686].

[211] M. Guerra, C. Vázquez, D. Efimov, G. Zheng, L. Freidovich, W. Perruquetti, *ϵ-Invariant Output Stabilization: Homogeneous Approach and Dead Zone Compensation*, in : 54th IEEE Conference on Decision and Control (CDC), 2015, *Osaka, Japan, December 2015*, [hal:hal-01218958].

[212] M. Guerra, C. Vázquez, D. Efimov, G. Zheng, L. Freidovich, W. Perruquetti, *Interval Differentiators: on-line estimation of differentiation accuracy*, in : European Control Conference (ECC16), *Aalborg, Denmark, June 2016*, [hal:hal-01295745].

[213] M. Guerra, G. Zheng, D. Efimov, W. Perruquetti, *An ISS based Solution to avoid Local Minima in the Potential Field Method*, in : Proc. ECC'15, *Linz, Austria, July 2015*, [hal:hal-01140322].

[214] Q. Guo, M. Gautier, D.-Y. Liu, W. Perruquetti, *Identification of Robot Dynamic Parameters Using Jacobi Differentiator*, in : 2015 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), *IEEE/ASME, Busan, South Korea, July 2015*, [hal:hal-01164109]. 2.6

[215] Q. Guo, W. Perruquetti, D. Efimov, *Universal Robust Adaptive Control of Robot Manipulators Using Real Time Estimation*, in : IFAC MICNON 2015, *Saint-Petersburg, Russia, June 2015*, [hal:hal-01162682]. 2.6

[216] Q. Guo, W. Perruquetti, M. Gautier, *On-line robot dynamic identification based on power model, modulating functions and causal Jacobi estimator*, in : Advanced Intelligent Mechatronics (AIM), 2014 IEEE/ASME International Conference on, *p. 494 – 499, Besancon, France, July 2014*, [hal:hal-01063052].

[217] F. Hamerlain, T. Floquet, W. Perruquetti, *Experimental testing of a sliding mode control for trajectory tracking of a mobile robot including motor dynamics*, in : 3rd International Conference on Control, Robotics and Informatics, *Hong Kong, China, 2014*, [hal:hal-01114895].

[218] L. Hetel, E. Fridman, T. Floquet, *Sampled-data control of LTI systems with relays: a convex optimization approach*, in : 9th IFAC Symposium on Nonlinear Control Systems, *Toulouse, France, September 2013*, [hal:hal-00923825].

[219] C. Join, F. Chaxel, M. Fliess, *"Intelligent" controllers on cheap and small programmable devices*, in : 2nd International Conference on Control and Fault-Tolerant Systems, SysTol'13, *p. CDROM, Nice, France, October 2013*, [hal:hal-00845795].

[220] C. Join, M. Fliess, C. Voyant, F. Chaxel, *Solar energy production: Short-term forecasting and risk management*, in : 8th IFAC Conference on Manufacturing Modelling, Management & Control (MIM 2016), *Troyes, France, June 2016*, [doi:10.1016/j.ifacol.2016.07.790], [hal:hal-01272152].

[221] C. Join, C. Voyant, M. Fliess, M. Muselli, M.-L. Nivet, C. Paoli, F. Chaxel, *Short-term solar irradiance and irradiation forecasts via different time series techniques: A preliminary study*, in : 3rd International Symposium on Environment-Friendly Energies and Applications, EFEA 2014, *Paris, France, November 2014*, [hal:hal-01068569].

[222] Z. Kader, C. Fiter, L. Hetel, L. Belkoura, *Observer-based relay feedback controller design for LTI systems*, in : European Control Conference (ECC 2016), *Aalborg, Denmark, June 2016*, [hal:hal-01415095].

[223] Z. Kader, C. Fiter, L. Hetel, L. Belkoura, *Stabilization of LTI systems by relay feedback with perturbed measurements*, in : American Control Conference (ACC 2016), *Boston, United States, July 2016*, [hal:hal-01415039].

[224] Z. Kader, G. Zheng, J.-P. Barbot, *Left inversion of nonlinear time delay system*, in : IEEE CDC, *Los Angeles, United States, December 2014*, [hal:hal-01094918]. 2.3.3

[225] Y. Khaled, J.-P. Barbot, K. Busawon, D. Benmerzouk, *Impulsive observer-based control for linear systems using irregularly sampled measurements*, in : IEEE AFRICON 2013, *Mauritius, Mauritius, September 2013*, [hal:hal-00923640].

[226] Y. Y. K. Khaled, J.-P. Barbot, K. Busawon, D. Benmerzouk, *From restricted isometry property to observability under sparse measurement*, in: International Conference on Systems and Control, *Alger, Algeria, October 2013*, [hal:hal-00923629].

[227] T. Kharkovskaya, D. Efimov, A. Polyakov, J.-P. Richard, *Interval observers for PDEs: approximation approach*, in: Proc. 10th IFAC Symposium on Nonlinear Control Systems (NOLCOS), *Monterey, United States, August 2016*, [hal:hal-01371283]. 2.5.3

[228] S. Kolyubin, D. Efimov, V. O. Nikiforov, A. Bobtsov, *Control of Nonlinear Systems Using Multiple Model Black-Box Identification*, in: IFAC Nolcos 2013, *Toulouse, France, September 2013*, [hal:hal-00844410].

[229] M. Kryachkov, A. Polyakov, *Graph-based field automata for modeling of sliding mode systems*, in: 13th IEEE Workshop on Variable Structure Systems, *p. 1 – 6, Nantes, France, June 2014*, [doi:10.1109/VSS.2014.6881110], [hal:hal-01088569].

[230] K. A. Langueh, O. Datcu, J.-P. Barbot, G. Zheng, K. Busawon, *Outputs analysis and dual immersion method for chaotic systems*, in: International Conference on Computing, Communication and Security, ICCCS 2015, *PROF. SUBRAMANIAM GANESAN, Pointe Aux Piments, Mauritius, December 2015*, [hal:hal-01240249].

[231] K. A. Langueh, G. Zheng, T. Floquet, *Finite-time observer for linear system with time delay*, in: IEEE Chinese Control Conference, *IEEE, Chengdu, China, July 2016*, [hal:hal-01410852].

[232] K. A. Langueh, G. Zheng, T. Floquet, *Finite-time unknown input observer for linear time-delay systems*, in: CDC2016, *IEEE, Las Vegas, United States, December 2016*, [hal:hal-01410876].

[233] A. Levant, D. Efimov, A. Polyakov, W. Perruquetti, *Stability and Robustness of Homogeneous Differential Inclusions*, in: Proc. 55th IEEE Conference on Decision and Control (CDC), *Las Vegas, United States, December 2016*, [hal:hal-01371280]. 2.5.3

[234] D.-Y. Liu, O. Gibaru, W. Perruquetti, *Synthesis on a class of algebraic differentiators and application to nonlinear observation*, in: The 33rd Chinese Control Conference (CCC), *Nanjing, China, July 2014*, [hal:hal-00986345].

[235] D.-Y. Liu, T.-M. Laleg-Kirati, O. Gibaru, W. Perruquetti, *Identification of fractional order systems using modulating functions method*, in: 2013 American Control Conference, 2013, *Washington, DC, United States, June 2013*, [hal:hal-00801425].

[236] F. Lopez-Ramirez, D. Efimov, A. Polyakov, W. Perruquetti, *Fixed-Time Output Stabilization of a Chain of Integrators*, in: Proc. 55th IEEE Conference on Decision and Control (CDC), *Las Vegas, United States, December 2016*, [hal:hal-01371278]. 2.4.3

[237] F. Lopez-Ramirez, A. Polyakov, D. Efimov, W. Perruquetti, *Finite-Time and Fixed-Time Observers Design via Implicit Lyapunov Function*, in: European Control Conference 2016, *Aalborg, Denmark, June 2016*, [hal:hal-01298162].

[238] E. Lucien, S. Di Gennaro, J.-P. Barbot, *Event-triggered observers and observer-based controllers for a class of nonlinear systems*, in: American Control Conference, *Chicago, United States, July 2015*, [doi:10.1109/ACC.2015.7172072], [hal:hal-01195569].

[239] Y. Ma, G. Zheng, W. Perruquetti, Z. Qiu, *Control of nonholonomic wheeled mobile robots via i-PID controller*, in: IEEE/RSJ International Conference on Intelligent Robots and Systems, *IEEE, Tokyo, Japan, November 2013*, [hal:hal-00910218].

[240] Y. Ma, G. Zheng, W. Perruquetti, Z. Qiu, *Motion planning for non-holonomic mobile robots using the i-PID controller and potential field*, in: IEEE/RSJ Conference on Intelligent Robots and Systems (IROS), 2014, *Chicago, United States, September 2014*, [hal:hal-01071506].

[241] Y. Ma, G. Zheng, W. Perruquetti, *Cooperative path planning for mobile robots based on visibility graph*, in: IEEE 32nd Chinese Control Conference, *IEEE, Xi'an, China, July 2013*, [hal:hal-00910186].

[242] Y. Ma, G. Zheng, W. Perruquetti, *Real-time Identification of different types of non-holonomic mobile robots*, in: 9th IFAC Symposium on Nonlinear Control Systems, *Toulouse, France, September 2013*, [hal:hal-00910210].

[243] Y. Ma, G. Zheng, W. Perruquetti, *Real-time local path planning for mobile robots*, in : IEEE 9th International Workshop on Robot Motion and Control, *IEEE, Wasowo, Poland, July 2013*, [hal:hal-00910182].

[244] S. Maalej, A. Kruszewki, L. Belkoura, *Derivative Based Control For LTV System With Unknown Parameters*, in : European Control Conference, *Zurich, Switzerland, July 2013*, [hal:hal-01248967].

[245] S. Maalej, A. Kruszewski, R. Delpoux, L. Belkoura, *Derivative based control for LPV system with unknown parameters: An application on a Permanent Magnet Synchronous Motors*, in : 11th International Multi-Conference on Systems, Signals & Devices, *Castelldefels-Barcelona, Spain, February 2014*, [doi:10.1109/SSD.2014.6808870], [hal:hal-01248969].

[246] M. Mbaye, M. Diallo, M. Mboup, *Unimodular-Upper polynomial matrix decomposition for MIMO Spatial Multiplexing*, in : 15th IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC14), *Toronto, Canada, June 2014*, [hal:hal-00995923].

[247] M. Mera, A. Polyakov, W. Perruquetti, G. Zheng, *Finite-time Attractive Ellipsoid Method Using Implicit Lyapunov Functions*, in : 54th conference on Decision and Control, *IEEE, Osaka, Japan, December 2015*, [hal:hal-01212602].

[248] T. Mohammad Ridha, C. Moog, E. Delaleau, M. Fliess, C. Join, *A variable reference trajectory for model-free glycemia regulation*, in : SIAM Conference on Control & its Applications (SIAM CT15), *Paris, France, July 2015*, [hal:hal-01141268].

[249] H. Omran, L. Hetel, J.-P. Richard, F. Lamnabhi-Lagarrigue, *On the stability of input-affine nonlinear systems with sampled-data control*, in : ECC'2013, *p. NC, Zurich, Switzerland, July 2013*, [hal:hal-00830881].

[250] S. Parsegov, A. Polyakov, P. Shcherbakov, *Fixed-time consensus algorithm for multi-agent systems with integrator dynamics*, in : 4th IFAC Workshop on Distributed Estimation and Control in Networked Systems, *IFAC, p. 110–115, Koblenz, Germany, September 2013*, [doi:10.3182/20130925-2-DE-4044.00055], [hal:hal-00920078].

[251] A. Polyakov, I. Chairez, *A New Homogeneous Quasi-Continuous Second Order Sliding Mode Control*, in : XVI Congreso Latinoamericano de Control Automático, *Cancun, Mexico, October 2014*, [hal:hal-01090716].

[252] A. Polyakov, J.-M. Coron, L. Rosier, *On Finite-Time Stabilization of Evolution Equations: A Homogeneous Approach*, in : IEEE Conference on Decision and Control 2016, *Las Vegas, United States, December 2016*, [hal:hal-01371089].

[253] A. Polyakov, D. Efimov, E. Fridman, W. Perruquetti, *On Homogeneous Evolution Equation in a Banach Space*, in : European Control Conference 2015, *Linz, Austria, July 2015*, [hal:hal-01160068].

[254] A. Polyakov, D. Efimov, W. Perruquetti, J.-P. Richard, *Interval Observer Approach to Output Stabilization of Time-Varying Input Delay System*, in : European Control Conference 2013, *Zurich, Switzerland, July 2013*, [hal:hal-00801821].

[255] A. Polyakov, D. Efimov, W. Perruquetti, J.-P. Richard, *Implicit Lyapunov-Krasovski Functionals for Time Delay Systems*, in : Conference on Decision and Control, *IEEE, Los Angeles, United States, December 2014*, [hal:hal-01071227].

[256] A. Polyakov, D. Efimov, W. Perruquetti, *Finite-time Stabilization Using Implicit Lyapunov Function Technique*, in : IFAC Nolcos 2013, *Toulouse, France, September 2013*, [hal:hal-00844386].

[257] A. Polyakov, D. Efimov, W. Perruquetti, *Homogeneous Differentiator Design using Implicit Lyapunov Function Method*, in : European Control Conference, *IEEE, IFAC, Strasbourg, France, June 2014*, [hal:hal-01003992]. 2.4.2

[258] A. Polyakov, D. Efimov, W. Perruquetti, *Sliding Mode Control Design for MIMO Systems: Implicit Lyapunov Function Approach*, in : European Control Conference, *IEEE, IFAC, Strasbourg, France, June 2014*, [hal:hal-01003984].

[259] A. Polyakov, L. Hetel, *On Finite-time Stabilization via Relay Feedback Control*, in: Conference on Decision and Control 2015, *IEEE, Osaka, Japan, December 2015*, [hal:hal-01212598].

[260] A. Polyakov, Y. Orlov, H. Oza, S. Spurgeon, *Robust Finite-time Stabilization and Observation of a Planar System Revisited*, in: 54th conference on Decision and Control 2015, *IEEE, Osaka, Japan, December 2015*, [hal:hal-01212582].

[261] A. Polyakov, A. Poznyak, J.-P. Richard, *Robust Output Stabilization of Time-Varying Input Delay Systems using Attractive Ellipsoid Method*, in: IEEE Conference on Decision and Control, *IEEE, p. 934–939, Florence, Italy, December 2013*, [hal:hal-00920047].

[262] A. Polyakov, J.-P. Richard, *Suboptimal LMI-based Solution of Minimum Time Control Problem*, in: IFAC World Congress, *Cape Town, South Africa, August 2014*, [hal:hal-00977875].

[263] A. Polyakov, *Discontinuous Lyapunov Functions for Nonasymptotic Stability Analysis*, in: IFAC World Congress, *Cape Town, South Africa, August 2014*, [hal:hal-00977869].

[264] A. Quadrat, R. Ushirobira, *Algebraic analysis for the Ore extension ring of differential time-varying delay operators*, in: 22nd International Symposium on Mathematical Theory of Networks and Systems (MTNS), *p. 8, Minneapolis, United States, July 2016*, [hal:hal-01415256]. 2.3.3

[265] G. Rance, Y. Bouzidi, A. Quadrat, A. Quadrat, *A symbolic-numeric method for the parametric H∞ loop-shaping design problem*, in: 22nd International Symposium on Mathematical Theory of Networks and Systems (MTNS), *p. 8, Minneapolis, United States, July 2016*, [hal:hal-01415294]. 2.6

[266] H. Ríos, D. Efimov, L. Fridman, J. Moreno, W. Perruquetti, *Uniform Stability Analysis for Time-Varying Systems Applying Homogeneity*, in: IEEE CDC 2014, *Los Angeles, United States, December 2014*, [hal:hal-01082173].

[267] H. Ríos, D. Efimov, J. Moreno, W. Perruquetti, *Finite-Time Identification Algorithm based on Time-Varying Homogeneity and Lyapunov Approach*, in: Proc. 10th IFAC Symposium on Nonlinear Control Systems (NOLCOS), *Monterey, United States, August 2016*, [hal:hal-01372047].

[268] H. Ríos, D. Efimov, A. Polyakov, W. Perruquetti, *Robustness of Homogeneous Systems with Respect to Time-Varying Perturbations*, in: European Control Conference (ECC16), *Aalborg, Denmark, June 2016*, [hal:hal-01295721].

[269] H. Ríos, L. Hetel, D. Efimov, *Vector Lyapunov Function based Stability for a Class of Impulsive Systems*, in: 54th IEEE Conference on Decision and Control (CDC), 2015, *Osaka, Japan, December 2015*, [hal:hal-01218955].

[270] H. Ríos, L. Hetel, D. Efimov, *Observer-based Control for Linear Sampled-Data Systems: An Impulsive System Approach*, in: Proc. 55th IEEE Conference on Decision and Control (CDC), *Las Vegas, United States, December 2016*, [hal:hal-01371272].

[271] W. Saadi, D. Boutat, G. Zheng, L. Sbita, *Multi-Output Partial Nonlinear Observer Normal Form*, in: 54th IEEE Conference on Decision and Control (CDC), *Osaka, Japan, December 2015*, [hal:hal-01252365].

[272] Z. Shao, G. Zheng, D. Efimov, W. Perruquetti, *Modelling and control for position-controlled modular robot manipulators*, in: Proc. IEEE/RSJ Int. Conf. Intelligent Robots and Systems (IROS), *Hamburg, Germany, September 2015*, [hal:hal-01185120].

[273] Z. Shao, G. Zheng, D. Efimov, W. Perruquetti, *Modelling and control of actuators with built-in position controller*, in: IFAC MICNON 2015, *Saint-Petersburg, Russia, June 2015*, [hal:hal-01162683].

[274] Z. Shao, G. Zheng, D. Efimov, W. Perruquetti, *Robust and adaptive control using measurements of higher order derivatives*, in: ECC 2016, *IFAC, Aalborg, Denmark, June 2016*, [hal:hal-01410855].

[275] R. Tami, D. Boutat, G. Zheng, F. Kratz, *Parameters and states estimation for Dengue epidemic model*, in: 13th European Control Conference, *Strasbourg, France, June 2014*, [hal:hal-01094912].

[276] R. Tami, D. Boutat, G. Zheng, *Nonlinear observer normal form with output injection and extended dynamic*, in: 9th IFAC Symposium on Nonlinear Control Systems, *IFAC, Toulouse, Ethiopia, September 2013*, [hal:hal-00910212].

[277] R. Tami, D. Boutat, G. Zheng, *Nonlinear observer for the PM synchronous motor*, in: ACC, *p. 4133 – 4138, Portland, United States, June 2014*, [doi:10.1109/ACC.2014.6859080], [hal:hal-01094915].

[278] R. Tami, G. Zheng, D. Boutat, D. Aubry, *Partial observability normal form for nonlinear functional observers design*, in: CCC 2013 - IEEE 32nd Chinese Control Conference, *IEEE, p. 95 – 100, Xi'an, China, July 2013*, [hal:hal-00910190].

[279] S. Tebbani, M. Titica, C. Join, M. Fliess, D. Dumur, *Model-based versus model-free control designs for improving microalgae growth in a closed photobioreactor: Some preliminary comparisons*, in: The 24th Mediterranean Conference on Control and Automation (MED'16), The 24th Mediterranean Conference on Control and Automation, *Athens, Greece, June 2016*, [hal:hal-01312251].

[280] R. Ushirobira, D. Efimov, G. Casiez, N. Roussel, W. Perruquetti, *A forecasting algorithm for latency compensation in indirect interaction*, in: In proceedings of ECC'16, the 15th annual European Control Conference, *p. 6, Aalborg, Denmark, June 2016*, [hal:hal-01420653]. 2.4.3, 2.6

[281] R. Ushirobira, A. Korporal, W. Perruquetti, *On an algebraic method for derivatives estimation and parameter estimation for partial derivatives systems*, in: Mathematical Theory of Networks and Systems, *Groningen, Netherlands, July 2014*, [hal:hal-01116890]. 2.3.3

[282] R. Ushirobira, W. Perruquetti, M. Mboup, M. Fliess, *Algebraic parameter estimation of a multi-sinusoidal waveform signal from noisy data*, in: European Control Conference, *Zurich, Switzerland, July 2013*, [hal:hal-00819048]. 2.3.3

[283] R. Ushirobira, A. Quadrat, *Algebraic estimation of a biased and noisy continuous signal via orthogonal polynomials*, in: CDC 2016 - 55th IEEE Conference on Decision and Control, *Las Vegas, United States, December 2016*, [hal:hal-01380320]. 2.3.3

[284] C. Voyant, C. Join, M. Fliess, M.-L. Nivet, M. Muselli, C. Paoli, *On meteorological forecasts for energy management and large historical data: A first look*, in: International Conference on Renewable Energies and Power Quality (ICREPQ'15), 13 – April 2015, *La Coruña, Spain, March 2015. Published in Renewable Energy and Power Quality Journal, n°13, mars 2015*, [hal:hal-01093635].

[285] L. Yu, C. Wei, G. Zheng, *Group sparse LMS for multiple system identification*, in: 23rd European Signal Processing Conference, *Nice, France, August 2015*, [doi:10.1109/EUSIPCO.2015.7362672], [hal:hal-01252391].

[286] L. Yu, G. Zheng, F. J. Bejarano, *Observer design for linear systems with commensurate delays*, in: IEEE CCC, *Hangzhou, China, July 2015*, [doi:10.1109/ChiCC.2015.7259616], [hal:hal-01252385].

[287] J. Zerad, S. Riachy, P. Toussaint, J.-P. Barbot, *A Nonlinear Controller for Parallel Induction Heating Systems*, in: IFAC World Congress 2014, 19, *1, p. 11617–11622, Cap Town, South Africa, August 2014*, [doi:10.3182/20140824-6-ZA-1003.00311], [hal:hal-01195543].

[288] G. Zheng, D. Boutat, H. Wang, *Observer design for a class of nonlinear singular systems*, in: CDC2016, *IEEE, Las Vegas, United States, December 2016*, [hal:hal-01410882].

[289] G. Zheng, D. Boutat, *Adaptive observer for simultaneous estimation of state and parameter for a class of nonlinear systems*, in: The 33rd IEEE CCC, *Nanjing, China, July 2014*, [hal:hal-01094908].

[290] G. Zheng, D. Efimov, F. J. Bejarano, W. Perruquetti, *On the interval estimation for nonlinear singular system*, in: 54th IEEE Conference on Decision and Control (CDC), *Osaka, Japan, December 2015*, [hal:hal-01252374]. 2.5.3

[291] G. Zheng, D. Efimov, W. Perruquetti, *Interval state estimation for uncertain nonlinear systems*, in : IFAC Nolcos 2013, *Toulouse, France, September 2013*, [hal:hal-00844397]. 2.5.3

[292] G. Zheng, D. Efimov, W. Perruquetti, *Finite-time observer for the output depending observer form*, in : IEEE CDC, *Los Angeles, United States, December 2014*, [hal:hal-01094919].

[293] G. Zheng, A. Polyakov, A. Levant, *Delay estimation for nonlinear time-delay systems*, in : International Workshop on Variable Structure Systems, *IFAC, Nanjing, China, March 2016*, [hal:hal-01410851].

[294] G. Zheng, H. Wang, *A simple finite-time observer for linear time-delay systems*, in : International Workshop on Variable Structure Systems, *IFAC, Nanjing, China, March 2016*, [hal:hal-01410836].

[295] S. Zhuk, A. Polyakov, *On Output-based Sliding Mode Control Design Using Minimax Observer*, in : International Workshop on Variable Structure Systems, *Nantes, France, June 2014*, [hal:hal-01071233].

[296] S. Zhuk, A. Polyakov, *Output-based Sliding Mode Control Design for Linear Plants with Multiplicative Disturbances: the minimax approach*, in : European Control Conference 2015, *Linz, Austria, July 2015*, [hal:hal-01160062].

[297] K. Zimenko, D. Efimov, A. Polyakov, W. Perruquetti, *Time-delay Robustness Analysis for Systems with Negative Degree of Homogeneity*, in : Proc. 10th IFAC Symposium on Nonlinear Control Systems (NOLCOS), *Monterey, United States, August 2016*, [hal:hal-01371370].

[298] K. Zimenko, A. Polyakov, D. Efimov, A. Kremlev, *Frequency Domain Analysis of Control System Based on Implicit Lyapunov Function*, in : European Control Conference 2016, *IFAC, Aalborg, Denmark, June 2016*, [hal:hal-01298160].

[299] K. Zimenko, A. Polyakov, D. Efimov, *Stabilization of Chain of Integrators with Arbitrary Order in Finite-time*, in : 54th conference on Decision and Control 2015, *IEEE, Osaka, Japan, December 2015*, [hal:hal-01212600].

[300] A. Zolghadri, J. Cieslak, D. Efimov, D. Henry, G. Philippe, R. Dayre, A. Gheorghe, H. Le Berre, *Signal and model-based fault detection for aircraft systems*, in : Preprints, 9th IFAC Symposium on Fault Detection, Supervision and, *Paris, France, September 2015*, [doi:10.1016/j.ifacol.2015.09.673], [hal:hal-01250782].

Scientific Books or Book Chapters

[301] E. Bernuau, D. Efimov, W. Perruquetti, A. Polyakov, *Homogeneity of differential inclusions*, in : Recent Trends in Sliding Mode Control, *2016*, [hal:hal-01405148]. 2.4.3

[302] D. Efimov, W. Perruquetti, J.-P. Richard, *Global and Local Weighted Homogeneity for Time-Delay Systems*, in : Recent Results on Nonlinear Delay Control Systems, *K. I., M. M., M. F., and P. P. (editors), 4, Springer, August 2015, p. 163–181*, [hal:hal-01185726].

[303] S. C. Olteanu, A. Aitouche, L. Belkoura, *Advances in P.E.M. Fuel Cell stack observer design using Takagi-Sugeno approach with unmeasurable premise variables*, in : Renewable Energy: Generation and Applications, *Springer, 2014, p. 117–130*, [doi:10.1007/978-3-319-05708-8_10], [hal:hal-01248971].

[304] H. Omran, L. Hetel, J.-P. Richard, F. Lamnabhi-Lagarrigue, *Analysis of bilinear systems with sampled-data state feedback*, in : Delays and Networked control systems, *A. Seuret, L. Hetel, J. Daafouz, and K. E. Johansson (editors), Springer Verlag, 2015, p. 79–96*, [hal:hal-01260212].

[305] A. Poznyak, A. Polyakov, V. Azhmyakov, *Attractive Ellipsoids in Robust Control*, *Springer, 2014*, [doi:10.1007/978-3-319-09210-2], [hal:hal-01088632]. 2.5.3

[306] S. D. Solvar, M. Ghanes, L. Amet, J.-P. Barbot, G. Santomenna, *Industrial Application of a Second Order Sliding Mode Observer for Speed and Flux Estimation in Sensorless Induction Motor*, in: Induction Motors - Modelling and Control, *D. R. Araujo (editor), InTech, 2013*, [hal:hal-00749826].

[307] G. Zheng, J.-P. Richard, *Identifiability and observability of nonlinear time-delay system with unknown inputs*, in: Recent Results on Nonlinear Time Delayed Systems, *Springer Verlag, 2015*, [hal:hal-01109157]. 2.3.3

[308] S. Zhuk, A. Polyakov, *Minimax observer for sliding mode control design*, in: Recent Trends in Sliding Mode Control, *2016*, [doi:10.1049/PBCE102E_ch2.2], [hal:hal-01405115].

[309] A. Zolghadri, D. Henry, J. Cieslak, D. Efimov, P. Goupil, *Fault Diagnosis and Fault-Tolerant Control and Guidance for Aerospace Vehicles: From theory to application*, Advances in Industrial Control, *Springer London Ltd, October 2013*, [doi:10.1007/978-1-4471-5313-9], [hal:hal-00869253].

Research Reports

[310] H. Ahmed, R. Ushirobira, D. Efimov, *Robust global synchronization of Brockett oscillators*, Research report, *Inria Lille - Nord Europe ; Clemson University, November 2016*, [hal:hal-01391120].

[311] F. Boulier, F. Lemaire, M. Rosenkranz, R. Ushirobira, N. Verdière, *On Symbolic Approaches to Integro-Differential Equations*, research report, *March 2016, Research Report*, [hal:hal-01367138]. 2.3.3

[312] T. Cluzeau, C. Koutschan, A. Quadrat, M. Tõnso, *Effective algebraic analysis approach to linear systems over Ore algebras*, Research Report number RR-8999, *Inria Lille - Nord Europe ; University of Limoges, France ; RICAM, Austrian Academy of Sciences ; Institute of Cybernetics, Tallinn University of Technology, December 2016*, [hal:hal-01413591].

[313] T. Cluzeau, A. Quadrat, *Equivalences of linear functional systems*, Research Report number RR-9000, *Inria Lille - Nord Europe ; University of Limoges, France, December 2016*, [hal:hal-01413593].

[314] K. H. Degue, D. Efimov, A. Iggidr, *Interval observer for sequestered erythrocytes in malaria*, research report, *November 2015, Research Report*, [hal:hal-01250447].

[315] D. Efimov, J. Schiffer, N. Barabanov, R. Ortega, *A relaxed characterization of ISS for periodic systems with multiple invariant sets*, research report, *March 2016, Research Report*, [hal:hal-01351139].

[316] C. Join, H. Abouaissa, M. Fliess, *A fresh look at ramp metering control: ALINEA without any tedious calibration*, Research report, *Ecole polytechnique, Palaiseau, France, February 2015*, [hal:hal-01117068].

[317] A. Quadrat, G. Regensburger, *Computing Polynomial Solutions and Annihilators of Integro-Differential Operators with Polynomial Coefficients*, Research Report number RR-9002, *Inria Lille - Nord Europe ; Institute for Algebra, Johannes Kepler University Linz, December 2016*, [hal:hal-01413907]. 2.3.3

[318] A. Quadrat, *Towards an effective study of the algebraic parameter estimation problem*, research report, *November 2016, Research Report*, [hal:hal-01415300]. 2.3.3

[319] H. Ríos, L. Hetel, D. Efimov, *Stability Analysis for Impulsive Systems: 2D Vector Lyapunov Function Approach*, Research report, *Inria Lille - Nord Europe, February 2016*, [hal:hal-01280321].

[320] I. D. J. Salgado Ramos, A. Polyakov, *Signal differentiation by means of algebraic techniques and sliding mode techniques*, Research report, *Inria, 2015*, [hal:hal-01413612]. 2.4.3

Patents

[321] S. Aranovskiy, G. Casiez, D. Efimov, N. Roussel, R. Ushirobira, *Dispositif à affichage prédictif, France, 1000365810, September 2016,* [hal:hal-01426069]*. 2.6, 3.3*

[322] P. Goupil, R. Dayre, A. Gheorghe, D. Efimov, J. Cieslak, A. Zolghadri, *Procédé et dispositif de détection d'une anomalie sur un aéronef, France, FR20130055665, June 2013,* [hal:hal-00869250]*. 3.3*

[323] A. Zolghadri, A. Gheorghe, D. Efimov, J. Cieslak, P. Goupil, R. Dayre, *Method and device for detecting a failure on an aircraft, United States, US 06510051, November 2014,* [hal:hal-01016216]*. 3.3*

Additional references

[APA+08] V Andrieu, L Praly, A Astolfi, et al. Homogeneous approximation, recursive observer design, and output feedback. *SIAM Journal on Control and Optimization*, 47(4):1814–1850, 2008.

[BB05] Sanjay P Bhat and Dennis S Bernstein. Geometric homogeneity with applications to finite-time stability. *Mathematics of Control, Signals and Systems*, 17(2):101–127, 2005.

[BM08] Franco Blanchini and Stefano Miani. *Set-Theoretic Methods in Control*. Systems & Control: Foundations & Applications. Birkher, 2008.

[CQR07] Frédéric Chyzak, Alban Quadrat, and Daniel Robertz. OreModules: A symbolic package for the study of multidimensional linear systems. In Chiasson J. and J.J. Loiseau, editors, *Applications of time delay systems*, volume 352, pages 233–264. Springer, 2007.

[ERCZ13] Denis Efimov, Tarek Raissi, Stanislav Chebotarev, and Ali Zolghadri. Interval State Observer for Nonlinear Time Varying Systems. *Automatica*, 49(1):200–205, February 2013.

[FJ09] Michel Fliess and Cédric Join. Model-free control and intelligent PID controllers: towards a possible trivialization of nonlinear control? In *15th IFAC Symposium on System Identification (SYSID 2009)*, Saint-Malo, France, July 2009. IFAC.

[FSR03] Michel Fliess and Hebertt Sira-Ramirez. An algebraic framework for linear identification. *ESAIM: Control, Optimisation and Calculus of Variations*, 9:151–168, 2003.

[Grü00] Lars Grüne. Homogeneous state feedback stabilization of homogenous systems. *SIAM Journal on Control and Optimization*, 38(4):1288–1308, 2000.

[Her91] Henry Hermes. Nilpotent and high-order approximations of vector field systems. *SIAM Review*, 33(2):238–264, 1991.

[Hon01] Yiguang Hong. H8 control, stabilization, and input–output stability of nonlinear systems with homogeneous properties. *Automatica*, 37(6):819–829, 2001.

[Hon02] Yiguang Hong. Finite-time stabilization and stabilizability of a class of controllable systems. *Systems & Control Letters*, 46(4):231–236, 2002.

[Kha00] Hassan K Khalil. Universal integral controllers for minimum-phase nonlinear systems. *IEEE Transactions on automatic control*, 45(3):490–494, 2000.

[LGP11] Da-Yan Liu, Olivier Gibaru, and Wilfrid Perruquetti. Error analysis of Jacobi derivative estimators for noisy signals. *Numerical Algorithms*, 58(1):53–83, February 2011.

[Liu11] Da-Yan Liu. *Error analysis of a class of derivative estimators for noisy signals and applications*. Theses, Université des Sciences et Technologie de Lille - Lille I, October 2011.

[Mbo09] Mamadou Mboup. Parameter estimation for signals described by differential equations. *Applicable Analysis*, 88(1):29–52, 2009.

[MJF09] Mamadou Mboup, Cédric Join, and Michel Fliess. Numerical differentiation with annihilators in noisy environment. *Numerical Algorithms*, 50(4):439–467, 2009.

[MP06] Emmanuel Moulay and Wilfrid Perruquetti. Finite time stability and stabilization of a class of continuous systems. *Journal of Mathematical Analysis and Applications*, 323(2):1430–1443, 2006.

[PFM08] Wilfrid Perruquetti, Thierry Floquet, and Emmanuel Moulay. Finite time observers: application to secure communication. *IEEE Transactions on Automatic Control*, 53(1):356–360, 2008.

[Pol12] Andrey Polyakov. Nonlinear feedback design for fixed-time stabilization of Linear Control Systems. *IEEE Transactions on Automatic Control*, 57(8):2106–2110, August 2012.

[REZ12] Tarek Raissi, Denis Efimov, and Ali Zolghadri. Interval state estimation for a class of nonlinear systems. *IEEE Transactions on Automatic Control*, 57(1):260–265, Jan 2012.

[Ros92] Lionel Rosier. Homogeneous lyapunov function for homogeneous continuous vector field. *Systems & Control Letters*, 19:467–473, 1992.

[Rya95] EP Ryan. Universal stabilization of a class of nonlinear systems with homogeneous vector fields. *Systems & Control Letters*, 26(3):177–184, 1995.

[SA96] Rodolphe Sepulchre and Dirk Aeyels. Stabilizability does not imply homogeneous stabilizability for controllable homogeneous systems. *SIAM journal on control and optimization*, 34(5):1798–1813, 1996.

[Ser13] Hugues Sert. *The use of differential algebra for the localisation and autonomous navigation of wheeled mobile robots*. Theses, Ecole Centrale de Lille, January 2013.

[Zub58] V.I. Zubov. On systems of ordinary differential equations with generalized homogenous right-hand sides. *Izvestia vuzov. Mathematica (in Russian)*, 1:80–88, 1958.