Inria, Evaluation of Theme Modeling, Optimization, and Control of Dynamic Systems

Project-team Non-A

March 26 – 27, 2013

Project-team title: Non-Asymptotic estimation for online systems

Scientific leader: Jean-Pierre Richard

Permanent head: Wilfrid Perruquetti

Research center: Lille Nord Europe

Common project-team with: École Centrale de Lille, CNRS, Université de Lille 1

1 Personnel

Personnel (March 2009 - ALIEN)

	Misc.	Inria	CNRS	University	**Total**
DR (1) / Professors			1	4	**5**
CR (2) / Assistant Professors			2	4	**6**
Permanent Engineers (3)					
Temporary Engineers (4)					
PhD Students	2	1		3	**6**
Post-Doc.		1			**1**
Total	**2**	**2**	**3**	**11**	**18**
External Collaborators	1		1	2	**4**
Visitors (> 1 month)					

(1) Senior Research Scientist (Directeur de Recherche)
(2) Junior Research Scientist (Chargé de Recherche)
(3) Civil servant (CNRS, Inria, ...)
(4) Associated with a contract (Ingénieur Expert or Ingénieur Associé)

Personnel (March 26 – 27, 2013)

	Misc.	Inria	CNRS	University	**Total**
DR (1) / Professors				6	**6**
CR (2) / Assistant Professors		2	1	3	**6**
Permanent Engineer					**0**
Temporary Engineer		1		2	**3**
PhD Students		1		5	**6**
Post-Doc.(including 1 Inria Secondment)		2		2	**4**
Total		**6**	**1**	**18**	**25**
External Collaborators	1		1	2	**4**
Visitors (> 1 month)					

Changes in staff

DR / Professors CR / Assistant Professors	Misc.	Inria	CNRS	Univ.	total
Arrival	1	2		1	4
Leaving			2	1	3

Comments: Misc. = +1 Inria secondment (from U.Bourgogne). **Inria** = +2 CR recruited. **CNRS** = −1 DR retired, −1 CR leaving. **Univ.** = −1 As.Pr. leaving (Lille 1), +1 As.Pr. associated (ENSAM). **Not mentioned:** 1 promotion As.Pr. to Pr. (Lille1).

Current composition of the project-team (March 26 – 27, 2013):

Members

- Belkoura Lotfi, Prof. Lille 1, LAGIS
- Efimov Denis, CR1 Inria, LAGIS
- Floquet Thierry, CR1 CNRS, LAGIS
- Perruquetti Wilfrid, Prof. EC Lille, LAGIS, *Permanent head*
- Richard Jean-Pierre, Prof. EC Lille, LAGIS, *Scientific leader*
- Zheng Gang, CR1 Inria, LAGIS

Associate Members (with the year of their arrival)

- Barbot Jean-Pierre, Prof. ENSEA Cergy, ECS-lab (2006)
- Gibaru Olivier, Prof. ENSAM Lille (2007)
- Join Cédric, Assist. Prof. Univ. Nancy, CRAN (2005), Manager AL.I.E.N.–SAS
- Mboup Mamadou, Prof. Univ. Reims, CReSTIC (2005)
- Riachy Samer, Assist. Prof. ENSEA Cergy, ECS-lab (2008)
- Thiery Stéphane, Assist. Prof. ENSAM Lille (2009)

PhD students

- Bernuau Emmanuel, PhD std. EC Lille (Sept. 2010 – 2013)
- El Afou Youssef, PhD std. Lille 1/Univ. Meknes (Morocco) (Oct. 2009 – 2013)
- Guerra Matteo, PhD std. EC Lille (Sept. 2012 – 2015)
- Maalej Sonia, PhD std. Lille 1 (Sept.2011 – 2014)
- Mincarelli Diego, PhD std. Inria (Sept.2010 – 2013)
- Oueslati Marouene, PhD std. ENSAM (Sept.2009 – 2013)

Post-Doc and Non Permanent Fellows

- Delpoux Romain, PhD 2012, ATER Lille1 (01/09/12 – 31/08/12)
- Estrada Antonio, Post-Doc Inria (15/10/12 – 14/02/14)
- Polyakov Andrey, Post-Doc Inria (01/05/12 – 01/05/13)
- Ushirobira Rosane, Assist. Prof. U. Bourgogne, Inria Secondment. 2010 – 2013

Engineers

- Palos Ladeiro Jorge, Engineer, Inria ADT *SLIM* (02/01/2013 – 31/12/2013)
- Jin Xin, Engineer, EC Lille-Sysiass project (02/01/2013 – 31/12/2013)
- Qiu Zhaopeng, Engineer, EC Lille-Sysiass project (02/01/2013 – 31/12/2013)

External Collaborators

- Hetel Laurentiu, CR1 CNRS, LAGIS
- Kökösy Annemarie, Assist. Prof. ISEN Lille, LAGIS
- Kruszewski Alexandre, Assist. Prof. EC Lille, LAGIS

Current position of former project-team members (including PhD students) during the March 2009 - March 2013 period:

NB: The former position and corresponding period are given in *italics*

- Bejarano-Rodriguez Francisco, *Post-Doc 01/10/10 to 30/09/11*:
  Assist. Prof. SGSR, National Polytechnic Institute (IPN), Mexico City
- Briat Corentin, *Post-Doc 01/10/10 to 30/09/11*:
  Post-Doc Fellow, Dept. of Biosyst. Sc.& Eng., Swiss Fed. Inst. of Technol. Zürich
- Delpoux Romain, *PhD std, 01/10/09 to 22/11/12*:
  ATER Post-Doc U. Lille 1, LAGIS & *Non-A*
- Fliess Michel, *DR CNRS, LIX, Scientific leader of ALIEN*:
  Retired (DR Emeritus), Manager of the AL.I.E.N-SAS spin-off (http://alien-sas.com)
- Ibn-Taarit Kaouther, *PhD std 15/11/08 to 31/12/10*:
  Assist. Prof., Ecole Nat. d'Ing. de Monastir, Tunisia
- Jacquelin Lucie, *shared Engineer −Inria FUN−, 15/10/2010 to 14/10/2012*:
  Engineer at SOPRA Rennes
- Liu Dayan, *PhD std 01/09/08 to 17/10/11*:
  Post-Doc Fellow, KAUST, Saudi Arabia
- Ollivier François, *CR CNRS, LIX, Member of ALIEN*:
  CR CNRS, LIX
- Rios-Barajas Hector, *PhD Internship 01/09/12 to 30/11/12*:
  PhD std UNAM, The National Autonomous University of Mexico
- Sauter Pierre, *Post-Doc 01/01/08 to 31/07/09*:
  Unknown, no more contact
- Sédoglavic Alexandre, *Assist.Prof. Lille 1, Member of ALIEN*:
  Assist. Prof. Lille 1, LIFL
- Sert Hugues, *PhD std, 01/10/09 to 11/01/13*:
  Engineer, EOS Innovation, 7 rue Montespan, 91000 Evry, France
- Tiganj Zoran, *PhD std, 01/09/08 to 08/11/11*:
  Post-Doc Fellow, Dept. of Neuroscience, Brown Univ., Providence, Boston, USA
- Yangui Rahma, *Engineer, 01/09/09 to 31/08/11*:
  PhD std, centre IFSTTAR Lille, Villeneuve d'Ascq

Last Inria enlistments

- Efimov Denis, recruitment Inria CR1 01/09/11, today CR1 (HDR 28/11/2012)
- Zheng Gang, recruitment Inria CR2 01/09/09, today CR1

Other comments

The researches of *Non-A* have been partly initiated in the framework of *ALIEN* and we shortly recall the story here.

- *From ALIEN to Non-A*

After being initiated by Michel Fliess as a team in 2005 (Inria-Futurs in Saclay), *ALIEN* jumped from 5[1] to 10 members in 2006 by integrating colleagues from Lille. It became a project-team on July 1st, 2007, the scientific leader of which was Michel Fliess, while Jean-Pierre Richard was the "permanent head" in charge of the Lille's side[2]. *ALIEN*

[1] Cédric Join and Mamadou Mboup are two of the scientific founders of the *ALIEN*/*Non-A*'s ideas. The other associated members joined *ALIEN* between 2007 and 2009.

[2] Note that *ALIEN* was bi-localized, Mamadou Mboup being in charge of the Saclay's side.

met his first evaluation committee in March 2009, recruited its first Inria researcher in September 2009 (Lille), and was reconducted for 4 years in January 2010.

Because of Michel's retirement, *ALIEN* gave rise to the new Inria research team *Non-A* on January 1st 2011, which became an Inria project-team on July 1st 2012.

The researches developed by *Non-A* are within the continuity of *ALIEN* in what concerns the *algebraic tools* that are developed for finite-time estimation purposes. However, *Non-A* also aims at developing complementary estimation techniques, still aiming at the finite-time performance but based on the concept of *homogeneity* and giving rise, for instance, to higher-order sliding mode algorithms.

Last, let us mention that *Non-A* is localized in Lille but there was no question of removing the scientific founders who initiated many of the ideas developed in *ALIEN* and, now, in *Non-A*. Besides, some other colleagues also closely contribute to our activities. For these reasons, *Non-A* includes several *associated members*, the arrival year of which are mentioned in the above lists.

• *About the evaluation period of* Non-A

Considering the above administrative and scientific arguments, it was decided to evaluate our activities over a 'classical' 4-year period. This is why we have described our activities starting from the *ALIEN*'s evaluation of March 2009.

2 Work progress

2.1 Keywords

• automatic control, signal processing,
• numerical differentiation, identification, estimation, observer, control,
• non-asymptotic techniques, finite-time convergence,
• algebra, operational calculus, homogeneity, higher-order sliding-modes,
• delay systems, impulsive/switched systems, nonlinear systems, model-free control,
• networked robots, nano/macro machining, multicell chopper, $i-$PID for industry.

2.2 Context and overall goal of the project

2.2.1 Motivations

For engineers, a wide variety of information is not directly obtained through measurement. Some parameters (constants of an electrical actuator, delay in a transmission...) or internal variables (robot's posture or torques, localization of a mobile...) are unknown or are not measured. Similarly, more often than not, signals from sensors are distorted and tainted by measurement noises. In order to simulate, to control or to supervise processes, and to extract information conveyed by the signals, one often 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 that cannot be summarized here. However, from a general point of view, the performance of an estimation algorithm can be characterized by three indicators:

• *Indicator 1: The computation time.* Here, we mean the time needed for obtaining the (accurate-enough) estimation. Indeed, estimation algorithms should have an as small as possible computation time in order to provide fast, real-time, online estimation for processes with fast dynamics (for example, a challenging problem is to make an Atomic Force Microscope work at GHz rates).

• *Indicator 2: The algorithm complexity.* Here, we mean the easiness of design and implementation. Estimation algorithms should have as low as possible algorithm complexity, in order to allow embedded real-time estimation (for example, in networked robotics, the embedded computation power is limited and can be even more limited for small sensors/actuators devices). Another question about complexity is: can the engineer appropriate and apply the algorithms? For instance, this is easier if the parameters have a physical meaning w.r.t. the process under study.

• *Indicator 3: The robustness.* Estimation algorithms should exhibit as much as possible robustness with respect to a large class of measurement noises, to parameter uncertainties and to discretization and numerical implementation. A complementary point of view on robustness is to manage the compromise between existence of theoretical proofs versus universalism of the algorithm. In the first case, the performance is guaranteed in a particular case (a particular control designed for a particular model). In the second case, a same algorithm can be directly applied in 'most of the cases', but may fail in few situations.

Within the very wide area of estimation, *Non-A* addresses **3 particular theoretical challenges** (see the upper block "Theory" of Figure 1):

1. Design annihilators for some general class of perturbations;
2. Estimate online the derivatives of a signal;
3. Control without sophisticated models.

All of them are connected with the central idea of designing or exploiting algorithms with the finite-time convergence property. In particular, the *non-asymptotic* estimation techniques (numerical differentiation, finite-time differentiators or observers) constitute a central objective of the project, explaining the name *Non-Asymptotic estimation for online systems*. Below, these 3 challenges will be shortly described in relation to the above indicators.

Non-A also wants to confront these theoretical challenges with some **application fields** (shown on the bottom of Figure 1): Networked robots, Nano/macro machining, Multicell chopper, *i*-PID for industry. Today, most of our effort (*i.e.*, engineering staff) is devoted to the first item, according to the theme 'Internet of Things' promoted by Inria in its Strategic Plan for the Lille North-Europe research center. Indeed, WSNR (Wireless Sensor and Robot Networks) integrate mobile nodes (robots) that extends various aspects of the sensor network.

2.3 Objectives for the evaluation period

Non-A was created as a project-team 9 months ago, with the objectives we reproduce below.

• **General annihilators**

Estimation is quite easy in the absence of perturbations. It becomes challenging in more realistic situations, faced to measurement noises or other unknown inputs. In our works, as well as in the founding text of *Non-A*, we have shown how our estimation techniques can successfully get rid of perturbations of the so-called *structured* type, which means the ones that can be annihilated by some linear differential operator (called the annihilator). *ALIEN* already defined such operators by integral operators, but using more general convolution operators is an alternative to be analyzed, as well as defining the "best way to kill" perturbations. 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 parameters be

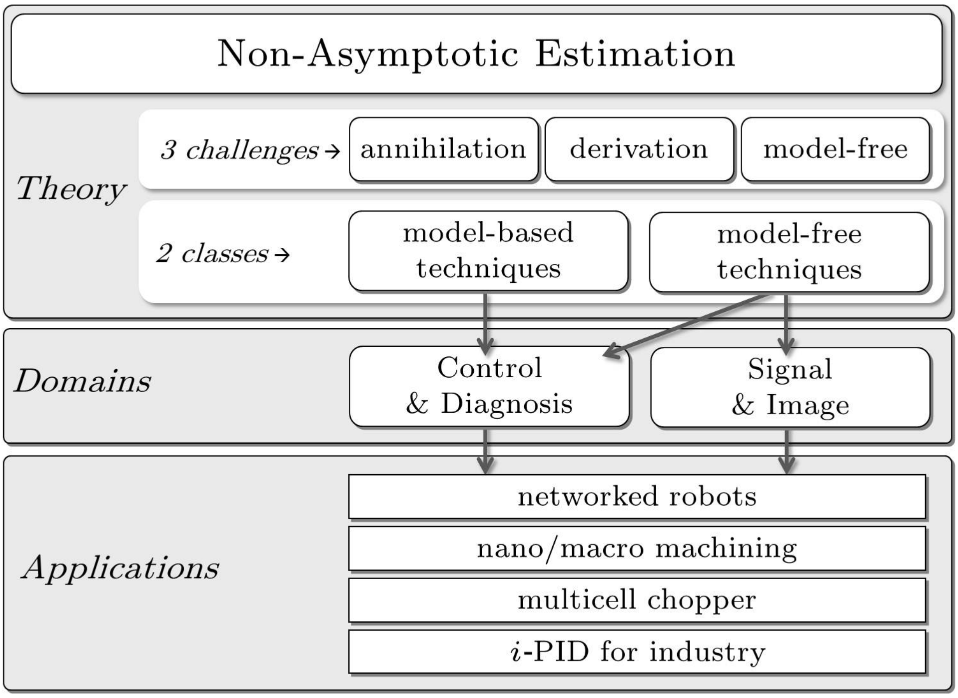

Figure 1: *Non-A* is a method-driven project, centered around non-asymptotic estimation techniques (*i.e.* providing estimates in finite-time), and connected to applications.

derived from efficient tuning rules? *The two first questions will directly impact Indicators 1 (time) and 2 (complexity), whereas the last one will impact indicator 3 (robustness).*

• **Numerical differentiation**

Estimating the derivative of a (noisy) signal with a sufficient accuracy can be seen as a key for numerous problems in control and diagnosis, as well as signal and image processing. At the present stage of our research, the estimation of the n-th order time derivatives of noisy signals (including noise filtering for $n = 0$) appears as a common area for the whole project, either as a research field, or as a tool that is used both for model-based and model-free techniques. *One of the open questions is about the robustness issues (Indicator 3) with respect to the annihilator, the parameters and the numerical implementation choices.*

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, which means the software-based reconstruction of unmeasured variables and, more generally, a left inversion problem[3]. This involves linear/nonlinear state models, including ordinary equations, systems with delays, hybrid systems with impulses or switches which still have to be exploited in the algebraic context. Power electronics is already one of the possible applications. *Model-free techniques* concerns the works initiated by *ALIEN*, which rely on the only information contained in the output signal and its derivatives. The corresponding algorithms rely on our algebraic annihilation viewpoint. *One open question is: How to provide an objective comparison analysis between Model-based and Model-free estimation techniques? For this, we will only concentrate on Non-Asymptotic ones. This comparison will have to be based on the three Indicators 1 (time), 2 (complexity) and 3 (robustness).*

[3]Left invertibility deals with the question of recovering the full state of a system ("observation") together with some of its inputs ("unknown input observers"), and also refers to algebraic structural conditions.

• **Model-free control**

Industry is keen of simple and powerful controllers: The tuning simplicity of the classical PID controller explains its omnipresence in industrial control, although its performances drop when working conditions change. The last challenge we consider is to define control techniques which, instead of using sophisticated models (the development of which may be expensive), use the information contained in the output signal and its estimated derivatives, which can be regarded as "signal-based" controllers. *Such design should take into account the Indicators 1 (time), 2 (complexity) and 3 (robustness).*

• **Applications**

Keeping in mind that we will remain focused at developing and applying fundamental methods for non-asymptotic estimation, we intend to deal with 4 main domains of application (see the lower part of Figure 1). The Lille context offers interesting opportunities in WSAN (wireless sensor and actuator networks and, more particularly, networked robots) at Inria, as well as nano/macro machining at ENSAM. A power electronics platform will be developed in ENSEA Cergy. Last, in contact with companies, several grants, patents and collaborations are expected from the applications of $i-$PID. Each of these four application domains was presented in the *Non-A* proposal:

- Networked robots, WSAN [Lille]
- Nano/macro machining [Lille]
- Multicell chopper [Lille and Cergy]
- i-PID for industry

In the present evaluation report, we choose to give a *particular focus on the first item* (Networked robots) which already received some development. It will be developed as the objective 4.

The results concerning the other 3 applications fields will be dispatched into the 3 sections of theoretical objectives, where they will be briefly presented.

• **Resulting objectives of the period**

In conclusion, the present report will successively present 4 objectives:

1. **More general annihilators**
2. **Non-asymptotic derivation and estimation**
3. **Model-free control**
4. **Focus on Networked robots**

2.4 Objective 1: General annihilators - Executive summary

2.4.1 Personnel - Objective 1

Members and Associate Members

- Mboup Mamadou, Prof. Univ. Reims, CReSTIC
- Perruquetti Wilfrid, Prof. EC Lille, LAGIS
- Ushirobira Rosane, Assist. Prof. U. Bourgogne, Inria secondment

Post-Doc Fellow:

- Estrada Antonio, Post-Doc. Inria

No Engineer, PhD student, nor External Collaborator on the objective.

2.4.2 Project-team positioning - Objective 1

One of the main achievements of our estimation approach is to provide closed form expressions for the desired parameters. These expressions follow from differential algebraic elimination. As originally introduced in the context of linear identifiability by M. Fliess and H. Sira-Ramírez in 2003[4], the corresponding annihilators where taking the form of linear differential operators. During the last five years, some specific forms of annihilators have been considered further, leading to interesting results for numerical differentiation [MJF09, LGP11b] and more generally, to new tools in the control and the signal communities. The robustness properties of the estimators built within this algebraic framework are directly determined by the choice of the annihilators. Despite its importance, the underlying algebraic structure was however not investigated.

Note that 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 some particular properties, such an annihilator can be nicely characterized. However, in the parameter estimation problem, for instance, 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. A few research groups using an algebraic estimation approach can be mentioned: H. Sira-Ramírez (Mexico), J. Rudolph (Germany), V.F. Batlle (Spain), G. Fedele (Italy) and in France: E. Delaleau (Brest), B. D'Andrea-Novel (Mines de Paris).

Our task is to investigate algebraic properties of the systems − more precisely to answer the above presented open questions *OQ1* (Does a normal form exist for such annihilators?), *OQ2* (Does there exist an adequate basis representation of the annihilator in some adequate algebra?) and *OQ3* (Can the annihilator parameters be derived from efficient tuning rules?), in order to obtain general differential annihilators as explained in Objective 1. To illustrate this idea, let us start with an extremely simple example:

$$\frac{dy(t)}{dt} = ay(t) + u(t) + \gamma_0, \qquad (1)$$

where a is an unknown parameter to be identified and y_0 is an unknown, constant perturbation. Using the operational calculus (s is the Laplace variable), we get:

$$sY(s) = aY(s) + U(s) + y_0 + \frac{\gamma_0}{s}$$

[4] *An algebraic framework for linear identification*, ESAIM Contrl.Optim.Calc.Variat., 9, 2003, 151-168.

where y_0 is the initial condition and $Y(s)$ and $U(s)$ are the Laplace transform of the signals $y(t)$, $u(t)$. Using the particular operator:

$$s - 3\frac{d}{ds}s \in \mathbb{R}(s)[\frac{d}{ds}], \tag{2}$$

then, back to the time domain, one obtains:

$$a = \frac{2\int_0^T d\lambda \int_0^\lambda y(t)dt - \int_0^T ty(t)dt + \int_0^T d\lambda \int_0^\lambda tu(t)dt - \int_0^T d\lambda \int_0^\lambda d\sigma \int_0^\sigma u(t)dt}{\int_0^T d\lambda \int_0^\lambda d\sigma \int_0^\sigma y(t)dt - \int_0^T d\lambda \int_0^\lambda ty(t)dt}. \tag{3}$$

The proposed methods involve integral operators, but using more general convolution operators is an alternative to be analyzed (which is equivalent in our algebraic framework to look at more general sets with appropriate algebraic structure, for example the set of hyperfunctions introduced by Mikuzinski). It can be shown that such an annihilator is not unique and a natural question arises about the tuning of its parameters. Note that these operators are linear and, thus, are limited to linear objects (Linear ODE for example).

2.4.3 Scientific achievements - Objective 1

The annihilators considered so far belong to the ring $\mathbb{R}(s)[\frac{d}{ds}]$ which can also be seen as a Weyl algebra. This has allowed us to give clear-cut answers to some of the questions raised above and a better understanding of the properties of the estimators. In particular, there exists a normal form for the annihilators (open question *OQ1*), there exists an adequate basis representation of the annihilator in the Weyl algebra (open question *OQ2*) and the annihilator parameters can be derived from efficient tuning rules [UPMF11, UPMF12]. As a consequence, for a given set of undesired parameters in a linear ODE, we think we are about to find the minimal annihilator which generates all possible annihilators that remove the undesired parameters *via* some differential algebraic manipulations on the original ODE. These results made it possible to successfully apply our methods to two practical engineering situations:

- algebraic parameter estimation of a biased sinusoidal waveform signal from noisy data: it was considered the cases of one sinusoidal waveform signal [UPMF12] and of three sinusoidal waveform signals [UPMF11];
- application of our algebraic method for human posture estimation in the sagittal plane using the noisy signal coming from an accelerometer has been presented at the CDC'2012 [PVM+12]. Antonio Estrada is presently working on this topic of potentially high technological impact.

2.4.4 Collaborations - Objective 1

- Vincent Bonnet and Philippe Fraisse, Inria *DEMAR* and LIRMM Montpellier 2: we look at the estimation of the human posture in the sagittal plane using accelerometers [PVM+12].
- Michel Fliess, CNRS Ecole polytechnique and AL.I.E.N. SAS, on algebraic annihilation ideas [UPMF12];
- Alban Quadrat, *DISCO* (Inria Saclay-Île de France): our new algorithmic design of annihilators leads to some possible implementation in Maple: preliminary contacts with Alban started in 2012 in order to look at these aspects of formal computation, in relation to their `Maple` packages:
  - `OreModules`: A symbolic package for the study of linear (functional/control) systems over Ore algebras (by F. Chyzak, A. Quadrat and D. Robertz);

  - `Sttaford`: An `OreModules` package concerning Stafford's theorems on Weyl algebras and their applications in systems theory (by A. Quadrat, D. Robertz).

- Hebertt Sira-Ramírez, CINVESTAV IPN Mexico City (Mx), about acceleration-based position sensor and other algebraic techniques.

2.4.5 External support - Objective 1

The main result during this period is a theoretical step and has mainly been supported by Rosane Ushirobira's leave from October 2010 to September 2012: her salary was paid by U. Bourgogne, while Inria Lille paid U. Bourgogne for the teaching hours not carried out. From September 2012, she is on secondment at our team (remunerated by Inria Lille).

Since 15/10/12 this objective also benefits from the support of Inria with the post-doc of Antonio Estrada (Inria competitive funding).

2.4.6 Self assessment - Objective 1

[**Strengths:**] New exciting ideas that may lead to promising results. This part is very new, since the working plan for further development about the Weyl Algebra structure used to handle the annihilator was mentioned for the first time at the *Non-A* proposal submission (end of 2011).

[**Weakness:**] Too young activity, not much human power on this topic.

[**Opportunities:**]

1. The Inria secondment of Rosane Ushirobira, Assistant Professor in Mathematics (algebra) from Université de Bourgogne (Dijon).
2. Possible connection with Alban Quadrat from *DISCO* for the future aspects of formal computation. We already discussed about using their `Maple` packages, in relation with our annihilation point of view.
3. Our "accelerometer-based position sensor" is developed in relation with a leader team in human robotics (*DEMAR*-LIRMM). Its success may open various technological issues.

[**Threats:**] Rosane's departure would deprive us of her knowledge of Weyl's algebras.

2.5 Objective 2: Non-asymptotic derivation and estimation - Executive summary

2.5.1 Personnel - Objective 2

Members and Associate Members (including *former ones*)

- Barbot Jean-Pierre, Prof. ENSEA Cergy, ECS-lab (2006)
- Belkoura Lotfi, Prof. Lille 1 LAGIS
- Efimov Denis, CR1 Inria, LAGIS
- *Fliess Michel, DR CNRS, LIX, Scientific leader of ALIEN*
- Floquet Thierry, CR1 CNRS, LAGIS
- Gibaru Olivier, Prof. ENSAM Lille
- Join Cédric, Assist.Prof. UHP Nancy, CRAN
- Mboup Mamadou, Prof. Univ. Reims, CReSTIC
- Perruquetti Wilfrid, Prof. EC Lille, LAGIS
- Richard Jean-Pierre, Prof. EC Lille, LAGIS
- Riachy Samer, Assist.Prof. ENSEA Cergy, ECS-lab
- *Sédoglavic Alexandre, Assist.Prof. Lille 1, Member of ALIEN*
- Thiery Stéphane, Assist.Prof. ENSAM Lille
- Zheng Gang, CR1 Inria, LAGIS

PhD students (including *former ones*)

- Delpoux Romain *PhD std, 01/10/09 to 22/11/12*, now Post-Doc ATER Lille 1
- Guerra Matteo, PhD std. EC Lille
- *Ibn-Taarit Kaouther, PhD std 15/11/08 to 31/12/10*
- *Liu Dayan, PhD std 01/09/08 to 17/10/11*
- Mincarelli Diego, PhD std. Inria
- *Tiganj Zoran, PhD std, 01/09/08 to 08/11/11*

Post-Doc Fellows and Engineers (including *former ones*)

- *Bejarano-Rodriguez Francisco, Post-Doc 01/10/10 to 30/09/11*
- Estrada Antonio, Post-Doc. Inria
- Polyakov Andrey, Post-Doc. Inria

External Collaborators on the objective

- Hetel Laurentiu, CR1 CNRS, LAGIS
- Kökösy Annemarie, Assist.Prof. ISEN Lille, LAGIS
- Kruszewski Alexandre, Assist.Prof. EC Lille, LAGIS

2.5.2 Project-team positioning - Objective 2

Let us recall that the estimation is related to identifiability/observability properties, which means that the quantities to be estimated (parameters or state variables) are functions of some known quantities (measurements and controls) and of a finite number of their successive time derivatives. Moreover, concerning observation, in many practical situations the quantity to be reconstructed is simply some derivative of the output (for example the velocity when the position is measured). Such problems can be efficiently solved using numerical differentiation, which should be robust with respect to measurement noise. 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 approximated derivatives. Therefore, various numerical methods have been developed to obtain stable algorithms of estimation, variously sensitive to noise and uncertainties. They can be classified in two main groups:

[**Model-free approaches**] It is the group of methods, which do not use information about the model of a system in order to estimate its internal variables or parameters. Among them, it is worth mentioning:

- The finite difference methods (I.R. Khan, R. Qu, A.G. Ramm...), Fourier transform methods (F.F. Dou, Z. Qian...), mollification methods (D.N. Hao, D.A. Murio...), regularization methods (G. Nakamura, T. Wei, Y. Wang...), differentiation by integration methods (C. Lanczos, S.K. Rangarajana, Z. Wang...). These techniques deal with numerical differentiation, but not with the noise measurement problem.
- Digital filtering in signal processing for numerical differentiation. In France: S. Diop, F. Chaplais... Abroad, again we can only mention a few: J. Grizzle, M.A. Al-Alaoui, C.K. Chen, J.H. Lee, C.M. Rader, L.B Jackson, R.A. Roberts, C.T. Mullis...

[**Model-based approaches**] This branch of methods uses a-priori available information about a system structure in order to estimate the system state and the model parameters. Mainly, this group deals with the design of various observers:

- Observer design in the control literature: In France: G. Besançon, Y. Chitour, A. Glumineau, C. Moog and F. Plestan, P. Rouchon and Ph. Martin, H. Hamouri, S. Ibrir, J.P. Gauthier, L. Praly... Abroad, researchers are too numerous to be all mentioned, but let us mention a few: A. Astofli, H.K. Khalil, S.V. Drakunov, A. Krener, N. Kazantsis and C. Kravaris, J. Li, C. Qian, F. Allgöwer, I.A.K. Kupka, M. Zeitz...
- Finite-time observers have been introduced by team members in 2008 and developed for more general classes in [MMP10]. Some intermediate and new results were obtained by other teams in particular by Y. Shen (China), X. Xia (South Africa).
- Continuous-time parameter adaptation laws which are, in fact, strongly related with the nonlinear observer theory (A. Astolfi, R. Ortega, R. Marino and P. Tomei...).

Each group of these methods has its own advantages and disadvantages, and the choice of a method for estimation in a concrete application depends on available information and restrictions.

Non-A is the host of an original method for derivative estimation, which is based on the algebraic annihilators [Mbo09, FJM10, Liu11, LGP12]. These techniques require few hypotheses (the main constraint is to assume structured perturbations, which can result from a realistic approximation, or that the noise is a fast-enough fluctuating signal).

In addition, the members of the group have developed various innovative solutions for finite-time estimation and derivation (model-based and model-free algorithms). Despite of the fact that there exists a strong worldwide competition in the field of estimation theory (in which *Non-A* actively competes), it is probably the only team of Inria[5] which is oriented on a group of *theoretical* methods for estimation/derivation with applications to various domains of science and technology.

2.5.3 Scientific achievements - Objective 2

The team is focused on Non-Asymptotic derivation/estimation techniques in order to answer on the fixed time response constraints. In many applications, the time convergence has to be well specified and achieved (for security reasons, for example, or simply to improve the productivity: *e.g.*, robot catching a ball in full flight, control of a walking robot between two impacts, finite-time chaos synchronization in order to reconstruct the transmitted encrypted message, etc. It is also worth highlighting that such finite-time techniques are a possible way to extend in some cases the well known separation principle, which holds for linear systems but fails in some situations for nonlinear ones: in many cases, the finite-time stability framework facilitates the proof of convergence of observer based feedback control algorithms. In addition to that, this finite-time property is a way to provide some certification of the real-time control algorithm: for this, a detailed discretization effect study should be carried on.

The results obtained by *Non-A* belong to both groups of derivation and estimation approaches introduced above:

[**Algebraic differentiation for mono- or multi-variate signal, applications to detection, diagnosis and observation**] The PhD of Dayan Liu [Liu11] has achieved an important analysis of algebraic differentiators [LGP11a, LGP11b, LGP12] with a *comparison* of various other differentiation techniques (higher-order sliding mode differentiators and high gain observer-based differentiators). There, differentiation was considered with regard to the time variable ($1-$D signal [MJF09]), but our algorithms were also considered for *multivariate* numerical differentiation [RMR11], *i.e.* the estimation of partial derivatives of multidimensional ($n-$D) noisy signals (such as image, video...). Applications to *neural spiking detection* (on EEG signals) have been considered in the PhD thesis of Zoran Tiganj [TM12, TM11] as well as *change-point detection* in [FJM10]. *Fault detection and isolation* have been considered in [MAJH12]. Algebraic (on-line) differentiation has also been shown to be a tool for *state and unknown inputs estimation* in [BFPZ13] as well as *tire-road forces* [VDNFM11].

[**Algebraic approach to parametric estimation**] Algebraic differentiators/observers have been applied to the *estimation of parameters or internal variables* [Mbo09, MJF09, RMR11]. The PhD of Romain Delpoux [Del12] included the algebraic identification for an *active magnetic shaft*. Considerable efforts have also been undertaken on open problems linked with the specific structure of the underlying models. Particularly, the two issues of 1) the *delay estimation* of continuous-time systems, and 2) the knowledge of the *active mode of a switched system* at any moment, have been tackled in a unified, algebraic framework in [BRF09], where a simultaneous delay and parameter identification of continuous-time systems with structured entries is proposed, followed by various works including the PhD [Ibn10] of Kaouther Ibn Taarit [ITBKR11, BFIT+11]. Note that we also developed robust control laws for *systems with estimated delays* in [HDRJ11]. The estimation of *switching times* was further developed in [TFBP11], as well as extensions to *impulsive systems* [BFIT+11].

[5]Note that *TROPICS* (Laurent Hascoët, Inria Sophia Antipolis - Méditerranée) develops Automatic Differentiation tools, but from the point of view of software analysis. This differs from *Non-A* since our input is a signal coming from a process.

[**Model-based approaches, observers**] Many of our works have concerned the design of observers for complex systems: nonlinear, chaotic, delayed, hybrid, oscillatory systems, systems with unknown inputs... Our works on *observability forms* [ZBB09, BBBB09, YBBB11] contribute to the preliminary question of the observability. *Finite-time observers* are more particularly considered in [MMP10, DDFP11]. We also dealt with nonlinear observers with *unknown inputs* [BBF09, BFPZ13, BF10, RLGF12, MGGZ09], *interval observers* [EFR$^+$12, ERCZ13, ERZ13, REZ12, SRZE13, ERZ12], observers for *chaotic systems* [ZB11, FBL12, ZBFB09] (with applications to synchronization), as well as hybrid systems [BGB10] (with application to multicell choppers). The PhD of Romain Delpoux [Del12] developed observer-based solutions for an efficient *sensorless control of the stepper motor* (i.e. without mechanical sensor, for the moment presented in ACC'12 [DBF12b] and SysId'12 [DBF12a]). Concerning observers for time-delay systems, we obtained general results for *nonlinear time-delay systems* [GdLB13, ZBB$^+$11] and more particular ones for linear remote, *networked-controlled systems* with communication delays [KJF$^+$12][6]. The recruitment of Denis Efimov drastically strengthened our skills in the area of *oscillatory systems*, with estimation of sinusoid signals [BEPZ12b, BEPZ12a], fault detection and isolation [EZ12]. Such questions also appear for vibrational control of industrial robots, with the *machining applications* considered in [OBG10]. Several finite-time solutions for estimation applying *sliding-mode* techniques have been obtained in [DFKP09b, DFPD09, DNFP09, FES11, GSF11].

[**Model-based *vs* Model-free**] Two classes of techniques are considered here. In what we call *model-based techniques*, the derivative estimation is regarded as an observation problem, which means the software-based reconstruction of unmeasured variables and, more generally, a left inversion problem. This involves various classes of state models (linear, nonlinear, delayed, switched, impulsive, chaotic, oscillatory...). *Model-free techniques* rely on the only information contained in the output signal and its derivatives. The corresponding algorithms rely on our algebraic annihilation viewpoint. As shown by our list of publications, both approaches lead to tractable estimators. The founding text of *Non-A* mentioned: "One open question is: How to provide an objective comparison analysis between Model-based and Model-free [Non-Asymptotic] estimation techniques? This comparison will have to be based on the three Indicators 1 (time), 2 (complexity) and 3 (robustness)". We have mentioned the comparisons, achieved by Dayan Liu during his PhD [LGP11a, LGP11b, LGP12], among high-gain observer, sliding modes differentiator and Jacobi estimators. For a high-gain observer with well tuned parameters, the estimation errors in noise-free case are small. But large values for these parameters can produce large errors in the noisy case. Thus there should be some optimal tuning. The same was also observed for the two other approaches. We also noted that both algebraic differentiation and finite-time sliding mode differentiators constitute nice tools for improving state and unknown inputs estimation, as preliminary results show [BFPZ13]. However, a full comparative work has to be done, which is time and man power consuming (this may be a possible ADT subject for an engineer to implement and compare these techniques).

2.5.4 Collaborations - Objective 2

- Marc Bodson (Univ. of UTAH, Salt Lake City, USA), in the framework of the PhD of Romain Delpoux [Del12] on the observer-based control of stepper motors without mechanical sensor [DBF12b, DBF12a];

[6] Note that this last application also corresponds to the framework of Wireless Sensor and Robot Networks to be presented as the Objective 4.

- Bernhard Beckermann, from Lille 1 University (lab. of Mathematics Paul Painlevé) for the co-supervision of the PhD thesis of Dayan Liu [Liu11] on numerical differentiation algorithms, including the comparison of the existing approaches;
- Alexy Bobtsov from Nat. Research Univ. LITMO, St Petersburg (Ru), on frequency estimation [BEPZ12b, BEPZ12a];
- Bernard Brogliato (BIPOP Inria Rhône-Alpes), Alain Glumineau (IRCCyN Nantes) and their teams, in the framework of ANR ChasLim (sliding modes);
- Emmanuel Brousseau of Cardiff University on application of new algebraic methods in tapping mode for AFM, collaboration with the National Laboratory of Metrology (LNE) located at Trappes [BKC+10];
- Mekki Ksouri, ENIT Tunis, Tunisia, on delay identification, with co-supervision of the PhD thesis of Kaouther Ibn Taarit [Ibn10];
- Ratko Magjarević, Univ. of Zagreb (Croatia) within the PHC Cogito, in relation with the PhD thesis of Zoran Tiganj [Tig11];
- Emmanuel Moulay from CNRS XLim Poitiers on finite-time estimation [MMP10];
- Yuri Orlov from CICESE, Ensenada, Mexico, on finite-time estimation of impulsive systems [BFIT+11, ZOPR11a, ZOPR11b];
- Alessandro Pisano, Univ. of Cagliari (It) in relation with the PhD thesis of Diego Mincarelli (PHC Galileo);
- Joachim Rudolph, from Saarland University (Germany) on algebraic techniques applied to magnetic devices: fault diagnosis [KMR12] and fast identification for closed-loop control [FFR10] (with co-supervision of a Master student in 2009);
- Sarah Spurgeon, Univ. of Kent (UK), on sliding mode observers [FES11, GSF11];
- Ali Zolghadri and his ARIA team of CNRS IMS, University Bordeaux I, on frequency estimation [BEPZ12b, BEPZ12a], interval state observers [EFR+12, ERZ13, REZ12] and fault-detection/diagnosis [EZ12, SRZE13].

2.5.5 External support - Objective 2

[PhD supports] These results where partially developed in the framework of various PhD theses supported by Ecole Centrale de Lille (Emmanuel Bernuau, Romain Delpoux), University of Lille 1 (Dayan Liu) and ENSAM (Marouenne Oueslati). Kaouther Ibn Taarit was partly supported by Tunisia and LAGIS-Lille 1. Zoran Tiganj was supported by Inria.

[CIFRE grants (at ENSEA)] Two PhD students with J.P. Barbot are working on finite-time estimation in the framework of CIFRE grants (PhD within industry, see http://www.anrt.asso.fr/fr/espace_cifre/accueil.jsp), which shows the industry interest for these techniques: Leonardo Amet is with GS Maintenance (Champagne sur Seine) for power converter applications [AGB12]; Essaid Edjekouan started on February 2013 with SDI (Taverny) for mechatronics.

[ANR ChasLim] Jointly with *BIPOP* (Inria Rhône-Alpes), CNRS IRCCyN (Nantes), this ANR project runs from 1 Oct. 2011 until 30 Sept. 2015 and aims at developing a toolbox for synthesizing controllers and adequately simulating the obtained closed-loop systems. Andrey Polyakov is supported by ChasLim. More information at http://chaslim.gforge.inria.fr/

[FP7 NoE HYCON2] The work was partly supported by the FP7 Network of Excellence HYCON2.http://www.hycon2.eu/ and all our PhD students (whatever the objective) attend several modules of the associated EECI Graduate School on Control (European Embedded Control Institute) http://www.eeci-institute.eu/.

[PHC] Hubert Curien Partnership GALILEO 26076ZJ (2011-2012) "Estimation techniques for embedded switching systems with applications to the security of embedded systems", Thierry Floquet and Alessandro Pisano - Univ. of Cagliari (in relation with the PhD thesis of Diego Mincarelli).

[PHC] COGITO 2011-2012: Mamadou Mboup won an Hubert Curien Partnership with Univ. of Zagreb, Croatia (Prof. Ratko Magjarević) for works on biomedical signal algebraic detection (in relation with the PhD thesis of Zoran Tiganj).

2.5.6 Self assessment - Objective 2

[Strengths:]

1. [Model-free] The obtained algebraic differentiators, according to our internal intensive testing / simulation campaigns and practical implementation experience demonstrate a rather good trade-off between the 3 above-defined indicators. The number of applications fields of these differentiators keeps enlarging.
2. [Model-based] The spreading of model-based control advances by the members of our group is confirmed by our production in the major journals, our participation to numerous TC/ IPC as well as national research networks.

[Weaknesses:]

1. [Model-free] It is still necessary to disseminate our approach on algebraic differentiators among a wider audience. In theoretical development a particular attention should be paid on the choice of structure of an algebraic differentiator (in relation with annihilation – Objective 1) and its tuning parameters, which play a central role in the numerical implementation and the noise error reduction. New differentiation schemes have to be developed taking into account various practical requirements and trade-offs.
2. [Model-based] The finite-time observers (emerged in [MMP10]) already attracted a lot of attention of scientific community the last years. New globally convergent finite-time and fixed-time observers have to be designed for uniformly observable nonlinear systems while relaxing the Lipschitz condition (on the nonlinear terms). A particular attention has to be paid to noise level reduction and parameter tuning.

[Opportunities:] Beyond finite-time, the *fixed-time* design aims at providing a required observation/control observation precision in a prescribed time (selected *a priori*) and independently of the initial state (fixed-time observation/control). *Non-A* is presently hosting a Post-Doc fellow, Andrey Polyakov, whose project is oriented towards this emerging research [Pol12]. Ongoing collaboration is already fruitful[7] and we are convinced there is a real opportunity for us to stabilize him at Lille... in finite or fixed time.
[Threats:] Theoretical research may lose its importance and become less supported by scientific institutions and state funding organizations (like ANR or NSF). A common focus on application-oriented investigations seems to be a right direction, since even a pure theoretical research may gain in its value by taking into account the real world constraints and requirements. However, *"There is nothing more practical than a good theory"* (Kurt Lewin, 1951).

[7] A. Polyakov, D. Efimov, and W. Perruquetti. A Constructive Method for Finite Time and Fixed Time Stabilization with Application to Chattering-free Sliding Mode Control. *provisionally accepted as a regular paper* in the IEEE Transactions on Automatic Control.

2.6 Objective 3: Model-free control - Executive summary

2.6.1 Personnel - Objective 3

Members and Associate Members (including *former ones*)

- Belkoura Lotfi, Prof. Lille 1 LAGIS
- *Fliess Michel, DR CNRS, LIX, Scientific leader of ALIEN*
- Join Cédric, Assist.Prof. UHP Nancy, CRAN
- Riachy Samer, Assist.Prof. ENSEA Cergy, ECS-lab
- Thiery Stéphane, Assist.Prof. ENSAM Lille
- Zheng Gang, CR1 Inria, LAGIS

PhD students (including *former ones*)

- El Afou Youssef, PhD std. Lille 1/Univ. Meknes-Morocco
- Maalej Sonia, PhD std. Lille 1

External Collaborator on the objective

- Kruszewski Alexandre, Assist.Prof. EC Lille, LAGIS

2.6.2 Project-team positioning - Objective 3

Introduced by M. Fliess and C. Join (for good summarizes, see [FJ09b, FJR11]), the so-called Model-Free Control (MFC) has now a quite impressive list of successful, concrete applications in most diverse fields such as electronics, mechanics, automobile, hydroelectricity, traffic, finance...

MFC offers various advantages:

- it does not need any precise mathematical model,
- it presents a great conceptual simplicity and so, simplified parametrization,
- it exhibits a great robustness with respect to most various disturbances,
- and, very recently, MFC has been implemented on microchip, which makes it become a real alternative to the PID controller block.

Concept

Let us recall that the concept of MFC is to replace the model of the system, generally unknown, with the *ultra-local model*:

$$y^{(\nu)} = F + \alpha u, \tag{4}$$

where

- the order $\nu \geq 0$ of derivation is a non-negative integer which is selected by the practitioner[8];
- $\alpha \in \mathbb{R}$ is chosen by the practitioner such that αu and $y^{(\nu)}$ are of the same magnitude.

Some comments on F are in order:

- F is estimated *via* the measurements of u and y;
- F subsumes not only the unknown structure of the system, but any perturbation;
- F is re-actualized in real-time, which means that what we call the 'utra-local' model (4) depicts the system's behavior over a very short interval of time.

[8]The existing examples show that ν may always be chosen quite low, *i.e.*, 0, 1, or 2.

Intelligent controllers

Denote $e = y^* - y$, where y^* is the desired output. Now, we close the loop with respect to Equation (4) via the *intelligent controller*:

$$u = -\frac{F - y^{*(\nu)} + \mathfrak{C}(e)}{\alpha}. \tag{5}$$

Combining Equations (4) and (5) yields the functional equation:

$$e^{(\nu)} + \mathfrak{C}(e) = 0.$$

$\mathfrak{C}$ should be selected so to impose the tracking error dynamic and to ensure the stability. Replacing $\mathfrak{C}$ by usual proportional-integral-derivative controller $K_P e + K_I \int e + K_D \dot{e}$, we obtain the following *intelligent proportional-integral-derivative controller*, or *i*-PID:

$$u = -\frac{F - \ddot{y}^* + K_P e + K_I \int e + K_D \dot{e}}{\alpha}, \tag{6}$$

where K_P, K_I, K_D are the tuning gains. As explained in the *Non-A* founding text, estimation of F is provided according to:

$$[F]_e = [y^{(\nu)}]_e - \alpha u,$$

where the derivative estimation $[y^{(\nu)}]_e$ is needed.

Using the results of Objective 2, we are able to estimate F without differentiating the signal, according to our algebraic method for numerical differentiation [MJF09].

2.6.3 Scientific achievements - Objective 3

Results on the period

Besides the creation of AL.I.E.N. SAS (end 2011, see below), our results have been published in various domains, always associated to real-world experiments:

- control of shape-memory actuators (active spring) [GDB+11],
- car control: tire-road forces and maximum friction estimation [VDNFM11],
- control of DC/DC converters [MJF+10],
- power control of cascaded hydroelectrical dams, with EDF (Electricité de France) [JRF10, JRF10],
- control of a magnetic bearing [DMRF+12],
- traffic control, with DIRIF (Direction des Routes Île de France) [AFIJ12, AFIJ11, AFIJ11, FAIJ12].
- bank: risk management [FJ09c], option pricing and dynamic hedging [FJ09a], existence of trends in financial time series [FJ12].

International patents have been filed:

- with EDF [RLFJ10] on hydroelectrical dams, which was awarded the *Innovation Prize 2010 from Ecole Polytechnique*, in the "Patents" category;
- with DIRIF [AFJ11] on traffic control.

Latest results

- Based on usual stability margins, MFC has been analyzed and a new interpretation of its robustness is ready. A conference paper on this analysis has been submitted.
- According to its great simplicity and to its nature of a recursive algorithm, *MFC is now implemented on microchip* (like dsPIC, MFC clock rate 0.1ms). It makes it become a real alternative to PID controller block, this last still constituting the reference industrial controller. A conference paper on this subject is submitted.

2.6.4 Collaborations - Objective 3

Many people are interested by our concept, see below effective academic collaborations :

- Hassane Abouaissa, Univ. d'Artois, on traffic control,
- Brigitte d'Andréa-Novel, Ecole des Mines de Paris and Hugues Mounier, Univ. Paris Sud, on vehicle control [VDNFM11],
- Benachir Bouchikhi, Univ. of Meknes, Morocco,
- Emmanuel Delaleau, ISEN Brest, on shape-memory actuators [GDB+11],
- Jérôme De Miras, Univ. Technol. Compiègne, on magnetic actuators [DMRF+12],
- Frédéric Lafont, Université du Sud, Toulon, on greenhouse control
- Pierre Sicard and Ahmed Chériti, Université du Québec à Trois-Rivières, on DC/DC converters [MJF+10],
- and various other colleagues working on MFC in Spain (V.F. Batlle), Italy (G. Fedele), Germany (J. Rudolph), Mexico (H. Sira-Ramírez)...

Most of activities on MFC are led in the framework of the AL.I.E.N.-SAS start-up (see below), but some works are also carried out in Lille:

- The PhD of Youssef El Afou, jointly prepared[9] with the Meknes University and supported by a PHC Volubilis partnership, aims at showing how MFC applies to a greenhouse temperature control. Experimental results are encouraging and a paper is under preparation.
- The PhD of Sonia Maalej is concerned with the theoretical analysis of the robustness. It considers controller/estimator pairs, the stability and performances of which are guaranteed for the largest set of systems, with as less knowledge as possible.
- We are currently working on MFC for non-honolomic mobile robots (see page 23).

2.6.5 External support - Objective 3

[**Start-up AL.I.E.N. SAS**] Founded by Michel Fliess and Cédric Join, AL.I.E.N.-SAS exists from the end of 2011 and is domiciled at Nancy. It is helped by the "Incubateur Lorrain" and was awarded the *"Prix OSEO, catégorie émergence"* to support its creation.
[**Contracts**] Industrial contracts have been successfully concluded, where MFC plays a crucial rôle:

- EdF (Bourget-du-Lac): "Commande en puissance de barrages hydroélectriques en cascade" (power control of cascaded hydroelectrical dams) [JRF10],
- DIRIF `http://www.enroute.ile-de-france.developpement-durable.gouv.fr/`: "commande des cycles de feux de 4 rampes d'accès de l'autoroute A4" (cycle control for the traffic lights of the 4 public ramps to the A4 highway),
- EdF (Bourget-du-Lac): "Commande en puissance d'un groupe du Curbans" (power control of a group of the Curbans dam).

International patents [RLFJ10] and [AFJ11] now protect two solutions of those. The patent [RLFJ10] has received the *Innovation Prize 2010 from École Polytechnique*, in the "Patents" category.

Other contracts dealing with the problem of estimation have also been accomplished:

- EdF (Bourget-du-Lac): "Séparation des sources de puissance",
- EdF (Bourget-du-Lac): "Estimation de débits entrants",
- EdF (Mulhouse): "Modélisation de l'écoulement du Doubs".

[**PHC**] Hubert Curien Partnership VOLUBILIS MA/09/211, Lotfi Belkoura and Benachir Bouchikhi (Univ.Meknes, Morocco) in relation with the PhD of Youssef El Afou.

[9] PhD co-supervised by Lotfi Belkoura, Cédric Join and Benachir Bouchikhi.

2.6.6 Self assessment - Objective 3

[**Strengths:**] As previously explained and shown according to many industrial applications, the practical experimentation of MFC should be continued. It will be the case through start-up AL.I.E.N.-SAS which already received two awards.
[**Weaknesses:**] From a theoretical point of view, the MFC of delayed systems is a key case and needs some effort.
[**Opportunities:**] AL.I.E.N.-SAS has realized, thanks to VieDoc, an important market study and conclusions are clear: AL.I.E.N.-SAS is the only society to hold and control a such know-how. Through this society, *Non-A* has the opportunity to develop an important industrial activity.
[**Threats**]: Until now MFC met only industrial successes.

2.7 Focus on an applied Objective: Networked robots - Executive summary

2.7.1 Personnel - Objective 4

Members and Associate Members

- Floquet Thierry, CR1 CNRS, LAGIS
- Perruquetti Wilfrid, Prof. EC Lille, LAGIS
- Richard Jean-Pierre, Prof. EC Lille, LAGIS
- Zheng Gang, CR1 Inria, LAGIS

PhD students (including *former ones*)

- Guerra Matteo, PhD std. EC Lille
- Sert Hugues, *PhD std, 01/10/09 to 11/01/13*

Post-Doc Fellows and Engineers (including *former ones*)

- *Lucie Jacquelin, Engineer, Inria ADT Sensas 15/10/2010 au 14/10/2012*
- Palos Ladeiro Jorge, Engineer, Inria
- Jin Xin, Engineer, EC Lille-Sysiass project
- Qiu Zhaopeng, Engineer, EC Lille-Sysiass project
- *Yangui Rahma, Engineer, 01/09/09 to 31/08/11*

External Collaborators on the objective

- Hetel Laurentiu, CR1 CNRS, LAGIS
- Kökösy Annemarie, Assist.Prof. ISEN Lille, LAGIS
- Kruszewski Alexandre, Assist.Prof. EC Lille, LAGIS

2.7.2 Project-team positioning - Objective 4

• Global positioning

Integrating wireless sensor networks and multi-robot systems increases the potential of the sensors: Robots, in comparison, are resource-rich and can be involved in taking decisions and performing appropriate actions on themselves on sensors and/or the environment. In this area, our positioning can be done by reference to the FP7-ECO4 European project SEAL "Smart Efficient Component-based Cognitive sensor, Actuator and robot systems for everyday Life" that has been submitted on January, 15th 2013. This project concerns 3 teams in Inria Lille - Nord Europe (*FUN*, *SequeL*, *Non-A*) as well as partners from Greece, Serbia, Spain, Sweden and UK. It gathers wireless sensors networks, robotics, collaboration and cognition. To the best of our knowledge, SEAL is unique in addressing the main objective of developing a cognitive framework for artificial, heterogeneous, complex and multi-degree-of-freedom systems by exploiting the principles of control, optimization, component-based design, wireless networking, information processing, learning and distributed decision-making, to provide robotics systems able to evolve in an autonomous fashion and to dynamically adapt to dynamic environments.

Collaborative robotics has experienced a little over ten years a considerable development in the world and particularly in the US, partly under the DARPA management. Most of these US projects can be classified into two categories, dealing with: 1) a collaboration of robots[10]; 2) or deployment of networks / sensors[11]. At the European Research Area, approximately 85 projects were performed in robotics during subsequent calls of ICT, only 15 of them involve collaboration robot / robot[12] and the nearest 7 ones do not consider the network deployment (sensors are fixed with known positions, which simplifies the robot/sensor interaction). Note also that, concerning the global point of view of SEAL, it is aimed at considering cognition aspects. Among the few European actions gathering robotics and cognition, most are centered around the single robot[13] and *not* on the emerging global behavior of a fleet of robots and sensors. Only 4 projects[14] analyze cognitive *collaborative* models but without considering communication and relocation issues.

Recently two projects have been launched dealing with the intersection of these two areas: 1) At EPFL (Laboratory of Intelligent Systems), the SMAVNET Project (Swarming Micro Air Vehicle Network) aims at developing swarms of flying robots that can be deployed in disaster areas to rapidly create communication networks for rescuers. 2) At MIT (Distributed Robotics Laboratory), the project "Deployment and Optimization of Wireless ad-hoc Communication Networks" develops a platform for autonomous deployment of a mobile communication backbone, which can provide networking capability to other robotic agents, sensor networks, or people). In comparison with these projects, SEAL is

[10]Univ. of Pennsylvania; Univ. Southern California; Advanced Robotics System (ARS) - JRP / ARFL; Basic UXO Gathering System (BUGS) - AFRL; Distributed Robotics (DR) - DARPA / MTO; Software for Distributed Robotics (SDR) - DARPA / IPTO; MOBOTS (Rodney Brooks).

[11]Man-Portable Networked Sensor System (MPNSS) - SPAWAR; Autonomous Mobile Communication Relays (CDMA) - DARPA / IPTO.

[12]2 projects deal with micro robots (REPLICATOR and MICRON), 4 concern underwater UAVs (MORPH, Co3 AUVs, CoCoRo and NOPTILUS), 2 are devoted to flying robots (sFLY and COMETS), the rest 7 project investigate various research/application problems for ground mobile robots. Among them, 5 projects (ARCAS, MARTHA, IWARD, DustBot and ROBOSWARM) deal with a fixed asset of sensors for transportation, area cleaning, construction or patrolling. Finally, only 2 addressed the aspects of sensor placing and adaptation (URUS and GUARDIANS).

[13]COGX http://cogx.eu/, ROBOT-CUB http://www.robotcub.org/, PACO-PLUS, in which cognitive approaches are used to make the robot self-understand and self-extend its abilities

[14]SPARK2 http://www.spark2.diees.unict.it/, IWARD http://www.iward.eu/cms/index.php, ROBOSWARM http://roboswarm.eu/ and SENSOPAC http://www.sensopac.org/. RUBICON http://www.fp7rubicon.eu/ is devoted to smart houses.

more fundamental and it is oriented on a combined investigation of cognitive networks of sensors, data knowledge processing and mobile robots, while the latter two projects were considering only the robotics.

- **Autonomous groups of mobile robots**

The self deployment of autonomous groups of mobile robots in an unknown environment (including different kinds of static or moving obstacles, as other moving vehicles or robots) involves localization, path planning and robust control problems. Both the control and signal aspects of our researches are expected to solve some problems coming from – or taking advantage of – such collaboration frameworks, which includes the following aspects:

1. *Path planning based on optimal collaborative control problem;*
2. *Localization using as few as possible landmarks and exteroceptive information by means of derivative estimates;*
3. *Robust, autonomous, energy-aware controllers based on either model-free or model-based techniques.*

2.7.3 Scientific achievements - Objective 4

1) Path planning based on optimal collaborative control problem:
Our preliminary works on coordinated control of non-honolomic robot swarms[15] [DPK+09, DFKP09a] have opened new feasible ways of optimizing, on-line, a collaborative path planning as well as their local control[16].

During the period, these algorithms have been applied to the coordinated control of groups of mobile robots: An illustrative platform exhibited at EuraTechnologie(plateau Inria in Lille city) `http://www.inria.fr/centre/lille/innovation/plateau-inria` has been designed within the framework of *Non-A*. They are now being extended to medical devices (such as wheelchairs) within the European project *SYSIASS*, in collaboration with partners from hospital settings (`http://www.sysiass.eu`).

Moreover, our pool of engineers is currently regrouping all our published results as a package of the open source ROS, see presentation of the *SLIM* software page 26).

2) Localization using as few as possible landmarks and exteroceptive information by means of derivative estimates:
In the framework of the PhD of Hugues Sert [Ser13], we applied the differential algebra to two main issues of wheeled mobile robotics, localization and navigation [SPK+12]. Our localization algorithm presented at ICRA 2011 [SKP11] can be worked out with one single landmark instead of 3, usually.

The first issue was to be able to tell where the robot is in its environment. We assume that we have a number of landmarks in space whose coordinates are known in this area. Depending on the number of landmarks, it is possible or not to localize the robot. This notion of localizability has been defined and studied in the algebraic framework. We show that this framework is more interesting than the geometric one in the sense that it does not only allow for studying localizability, but also for designing state estimators which reconstruct the posture of the robot. This study was conducted in a five-case study concerning four of the five classes of wheeled mobile robots. The second problem studied is that of a robot decentralized swarm navigation in a complex environment. This work presents an architecture that can be used in a wide class of problems and enjoying the

[15] PhD of M. Defoort, 2007, `http://tel.archives-ouvertes.fr/tel-00196529`

[16] For instance, the following paper has has been cited 65 times: Defoort, Floquet, Kökösy, Perruquetti: Sliding-mode formation control for cooperative autonomous mobile robots, IEEE Trans. on Industrial Electronics, 55(11), 3944-3953, 2008

benefits of both discrete and continuous approaches. Indeed, high-level block strategy specifies the goal, constraints and parameters as well as the cost function; A low-level block computes a trajectory which minimizes the cost function in accordance with the objective and the problem constraints. This minimization is done on a sliding window, so it is possible to take into account changes in the environment or mission during navigation.

3) Robust, autonomous, energy-aware controllers based on either model-free or model-based techniques:
[Model-based techniques:] WSAN are composed of embedded systems interconnected through unreliable communications networks. Robustness and optimization issues are to be considered in relation to usual control performance (see above), but also w.r.t. the perturbations created by this additional dynamics coming from the communication medium. We have addressed various networked situations: network-in-the-loop control (how to face the unreliability of the network?), sparse sampling control (how to reduce the number of output-data packets sent by the sensors?). These advances were achieved with 'external colleagues' from our LAGIS team SyNeR and use Lyapunov-based approaches (ensuring asymptotic convergence). Our main two results were: 1) to ensure the robustness w.r.t. asynchronously sampled data, packets dropouts, transmission delays... [HKPR11, KJF+12] and 2) to actively control the sampling interval so to enlarge it and avoid too frequent sensor transmissions [FHPR12].
*[Model-free control:]*Another ongoing study concerns the adaptation of our model-free control techniques to general non-honolomic mobile robots. For such models, one parameter of the local model has to switch according to the information from the system.

2.7.4 Collaborations - Objective 4

- *FUN*, Inria Project-Team at Lille (Future Ubiquitous Networks, Nathalie Mitton).
- and more generally in the framework of the *CIA*, *FIT* and *SENSAS* programs (see below).
- ISEN Lille (A. Kökösy is also a member of our LAGIS team), the Kent Univ., Essex Univ. as members of the Interreg IV A 2 Mers Seas Zeeën - *SYSIASS*.

2.7.5 External support - Objective 4

2010-2012 RobotCity] was exhibited for the first time during the opening ceremony held on April 6th, 2011, see http://team.inria.fr/non-a/RobotCity
(other video at http://chercheurs.lille.inria.fr/~jrichard/manips.htm)

2010-2013 SYSIASS InterReg IV-A Two Seas 6-020-FR: Autonomous and Intelligent Healthcare System. *SYSIASS* aims at assisting patient's mobility and securing the provision of communication services. An exemplar of the corresponding technology would be an intelligent wheelchair that is able to provide mobility to the patient and allows healthcare providers to transport patients to desired locations in a clinical or domestic environment. See http://www.sysiass.eu

2010-2014 CPER CIA, "Campus Intelligence Ambiante", is a program supported by the Government, Regional Council and European FEDER, which our collaboration with the team *FUN* belongs to. We also start a collaboration on the Equipex platform *FIT* (see 'opportunities' at the end of this part).

2010-2014 ADT SENSAS: Our developments on WSRN take place in this national network *SENSAS (SENSor network ApplicationS)*, which proposes robotic applications (package *SENSROB*) based on wireless sensor and actuator network nodes provided from the work done around *SENSLAB* and *SENSTOOLS* projects. It involves 8 Inria project-teams, see http://sensas.gforge.inria.fr/.

2012-2014 ADT *SLIM*, *Software LIbrary for cooperative Multi-robots* is one of the "Actions de Développement Technologique" that Inria supports in Lille, see p.26.

2.7.6 Self assessment - Objective 4

[**Strengths:**] Networked robots is one key application of *Non-A*. We have successfully applied our theoretical results to the localization and control of non-honolomic mobile robots. By estimating velocities (for which other techniques do not apply), our non-asymptotical estimation techniques offer a comparable localization result with respect to conventional localization method, with less landmarks or sensors. The algebraic differentiator has also been used to identify the different types of those robots. As well, the MFC technique (model-free control) is being applied to control non-honolomic mobile robots. Moreover, there was 5 projects on this topic during the last 4 years. Those two aspects (theoretical research and implementation project) are to be highlighted and continued.

[**Weaknesses:**]

1. Beyond the success of our academic activities, now we feel ready for wider collaborations with industries which, despite preliminary contacts, still need to be created.
2. Even if 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 conferences ICRA [SKP11] and IROS [SPK+12].

[**Opportunities:**]

1. This activity is a part of the challenge *Internet of Things* of the Inria strategic plan at Lille Nord Europe. It benefits from the construction of the EQUIPEX platform FIT (http://www.inria.fr/en/centre/lille/news/equipex, Future Internet of Things) won by the team *FUN* and planning the collaboration between thousands of sensors and hundreds of robots. Indeed, future ubiquitous services require to conjugate information and action, such as in wireless sensor and actuator networks. In what concerns the many informatics aspects of wireless sensors and networks, various skills are present at Inria Lille. Fewer control/estimation skills are present[17]. We think we can be the necessary "control and robotics ingredient" for the success of this strategic challenge.
2. Another opportunity comes from the fact that our former PhD student working in collaborative robotics, Hugues Sert, is now in charge of R&D for a small company, *EOS innovation* (Evry) http://www.eos-innovation.eu/eos. Depending on the success of this company, a promising collaboration in may start with our group on this topic.

[**Threats:**] No identified threat.

[17](except *SequeL* by Philippe Preux that considers complementary components in sequential learning and sensor fusion, and *Orchestron* by Rodolphe Sepulchre, devoted to brain rythms).

3 Knowledge dissemination

3.1 Publications

	2009	2010	2011	2012+13	total
PhD Thesis (†)	0	2	2	1+1	5
H.D.R (*)	1	1	0	2+0	4
Journal	19	11	23	18+5	76
Conference proceedings (**)	32	25	22	43+1	123
Book chapter	1	1	0	4+0	6
Book (written)					
Book (edited)					
Patent		1	1		
General audience papers					
Technical report					
Deliverable					

(*) HDR Habilitation à diriger des Recherches

(**) Conference with a program committee

(†) Note that three other PhD co-supervised by members of Non-A *have been defended in the framework of the LAGIS team: W.J. Jiang 2009, Z. Bo 2012, C. Fiter 2012.*

Two major journals in the field and, for each, the number of papers coauthored by members of *Non-A* that have been accepted during the evaluation period:

- 6 Automatica (2.829)
- 9 IEEE Transactions on Automatic Control (2.110)

Other journals:

- 1 SIAM Journal on Control and Optimization (1.518)
- 2 Systems & Control Letters (1.222)
- 3 International Journal of Robust and Nonlinear Control (1.554)
- 2 IEEE Transactions on Control Systems Technology (1.766)
- 2 IEEE Transactions on Industrial Electronics (5.160)
- 1 IEEE Signal Processing Letters (1.388)
- 3 Control Engineering Practice (1.481)
- 4 International Journal of Control (0.977)
- 1 Chaos, Solitons & Fractals (1.222)
- 3 IET Control Theory & Applications (0.990)
- 6 Nonlinear Analysis: Hybrid Systems (new journal, no impact index by ISI yet)
- 1 Applied and Computational Harmonic Analysis (3.452)
- 2 Numerical Algorithms (1.042)
- 1 Robotics and Autonomous Systems (1.056)
- 1 Robotica (1.032)
- ...

Major conferences in the field and, for each, the number of papers coauthored by members of *Non-A* that have been accepted during the evaluation period:

- 21 CDC, IEEE Conference on Decision and Control
- 5 SYSID, IFAC Conference on Systems Identification [18]
- 1 ICRA, IEEE International Conference on Robotics and Automation

[18](SYSID is organized every three years, here 2009 and 2012)

3.2 Software

- *SLIM: Software LIbrary for cooperative Multi-robots* (more details in the next section page 26): Within *SLIM*, our pool of engineers is currently regrouping all our published results as a package of the open source ROS. It is targeted at all potential users (experienced or not, scientific or not).
- *Neural Spike Sorting*: Matlab program implementing the spike sorting method presented in J. Neural Eng. 9 (2012) Z. Tiganj and M. Mboup [TM12].
- In the general annihilators context, `Maple` programs are implemented for computations in the Weyl algebra, using the package `Ore algebra`.

NB: Today, it is not planned to circulate the last two softwares but we keep it for internal use.

3.3 Valorization and technology transfer (Socio-economic impact and transfer)

- *Collaborative robots in Lille:* The ADT *SLIM*: 'Software LIbrary for cooperative Multi-robots' is one of the ADTs [19] Inria supports in Lille (2 years, 2013-2014). *SLIM* aims at combining all algorithms developed by *Non-A* (localization, path planning and robust control) and offering a simple and complete software library for the cooperation of multi-robots. The targeted software library will allow *all users* (experienced or not, scientific or not) to easily reuse and establish their own scenario of application. It is developed under the open-source ROS (Robotic Operation System[20]) `http://www.ros.org/wiki/`. Among several other open-source systems (Robotics Developper Studio by Microsoft, NAOQi by Aldebaran Robotics, URBI by Gostai), ROS was chosen mainly for two reasons: ROS can integrate code from other project (Player/Stage, OpenCV...), contrarily to its above competitors; ROS is a *de facto* standard in robotics and Inria teams use this architecture (*e-Motion, FUN, PRIMA*...) as well as the national Equipex *FIT*, the ADT *SENSAS*...

- *Model-Free Control in Nancy:* By the end of 2011, Michel Fliess and Cédric Join created the start-up AL.I.E.N.-SAS, domiciled at Nancy. This start-up is helped by the "Incubateur Lorrain" and was awarded the *"Prix OSEO, catégorie émergence"* to support its creation (see below).

- *CIFRE grants at ENSEA:* Two PhD students with J.P. Barbot are working on finite-time estimation in the framework of CIFRE grants (PhD within industry, see `http://www.anrt.asso.fr/fr/espace_cifre/accueil.jsp`), which shows the industry interest for these techniques: Leonardo Amet is with GS Maintenance (Champagne sur Seine) for power converter applications [AGB12]; Essaid Edjekouan started on February 2013 with SDI (Taverny) for mechatronics.

- *GM R&D Center:* since 2002, Denis Efimov is in charge of control projects for General Motors R&D Center in Warren, USA (hybrid systems and IC engines).

- *Nanotechnologies at ENSAM:* we expect to improve the speed performances of AFMs (Atomic Force Microscopes) and apply it to nano-machining (collaboration of O. Gibaru and S. Thiery with Cardiff Univ. [BKC+10]).

[19] ADT: 'Actions de Développement Technologique'

[20] Licensed under an open source, BSD license, ROS provides libraries and tools to help software developers create robot applications: hardware abstraction, device drivers, libraries, visualizers, message-passing, package management, and more.

3.4 Teaching

All members of the team teach at various levels in universities (Lille, Nancy, Reims) and engineering schools (EC Lille, ENSAM Lille, ENSEA Cergy, ISEN Lille):

- 192h/y - Barbot Jean-Pierre, Prof. ENSEA Cergy
- 192h/y - Belkoura Lotfi, Prof. Lille 1
- 25h/y - Efimov Denis, CR1 Inria
- 18h/y - Floquet Thierry, CR1 CNRS
- 192h/y - Gibaru Olivier, Prof. ENSAM Lille
- 192h/y - Join Cédric, Ass.Prof. Univ. Nancy
- 192h/y - Mboup Mamadou, Prof. Univ. Reims
- 86h/y - Perruquetti Wilfrid, Prof. EC Lille
- 192h/y - Riachy Samer, Ass.Prof. ENSEA Cergy
- 192h/y - Richard Jean-Pierre, Prof. EC Lille
- 192h/y - Thiery Stéphane, Ass.Prof. ENSAM Lille
- 25h/y - Zheng Gang, CR1 Inria

In particular, *at Master Thesis level*:

- Lotfi Belkoura is in charge of the Master Thesis training in control 'SMaRT' (autonomous systems and field busses) of Université Lille 1 and Ecole Centrale de Lille. This Master has been awarded as one of the *"Pépites 2013 de la Fac"* (Top 400 French University training, over 11000) by *Le Nouvel Observateur* (31 January 2013). *Non-A* is quite invested in this training since L. Belkoura, T. Floquet, W. Perruquetti and J.P. Richard are all carrying out teaching activites there.
- Jean-Pierre Richard is in charge of the 'Filière Recherche', École Centrale de Lille, which is a dedicated training for the last year students preparing a Master 2.
- Jean-Pierre Barbot has been in charge (until 2011) of the Master Thesis training in control of the University of Tlemcen, Algeria.

Name	*Course title*	*Institution*
Barbot (–2011)	Advanced control and communications	Univ. Cergy-Pontoise
Barbot	Process Control	Univ. Tlemcen, Algeria
Floquet	Robotics	MR SMaRT Lille 1 - EC Lille
Gibaru	Applied Mathematics	Lille 1-UVHC-ULCO
Mboup (–2011)	Advanced Signal Processing	Univ.Paris 5, ENIT-Tunis
Perruquetti	Nonlinear control	MR SMaRT Lille 1 - EC Lille
Richard	Nonlinear and Delay Systems	MR SMaRT Lille 1 - EC Lille
Richard	Dynamical systems	EC Lille
Belkoura	An introduction to distributions	MR SMaRT Lille 1 - EC Lille

Book: With Tunisian, French and German colleagues, we also organized a series of two Schools 'Mathematics for R&D' in Djerba, Tunisia (2008 and 2009) ending with the edition of a dedicated book[21]

[21]'Mathématiques pour l'Ingénieur', 2009 - ISBN 978-9973-0-0852-7, 385 pages, available on-line at http://hal.archives-ouvertes.fr/docs/00/51/95/55/PDF/livreMathsIng_09.pdf

3.5 General audience actions

SYSIASS, Press Releases at http://www.sysiass.eu/?page_id=518, in particular:

http://www.inria.fr/centre/lille/actualites/un-fauteuil-roulant-plus-intelligent

RobotCity, launched on 2011 together with an interview of Wilfrid Perruquetti https://team.inria.fr/non-a/RobotCity/, see also:
http://www.youtube.com/watch?v=U2Y1eGpMi2k
http://www.inria.fr/centre/lille/innovation/plateau-inria

Control applications, various videos at
http://researchers.lille.inria.fr/jrichard/Mes_sites_Web_English/manips.htm

in particular: 'smartuator' (shape-memory actuator), 'robotcity2' and 'inverted pendulum'.

3.6 Visibility

Editorial Boards of Journals

- Editor-in-Chief of the *African Diaspora Journal of Mathematics* (M. Mboup, since 2013 - Managing Edt. 2005-2012) http://math-res-pub.org/adjm
- Associate Editor of *Nonlinear Analysis: Hybrid Systems* (Elsevier) (T. Floquet, 2012-present) http://www.journals.elsevier.com/nonlinear-analysis-hybrid-systems/
- Associate Editor of the *Eurasip Journal on Advances in Signal Processing* (Springer) (M. Mboup, 2009-present)

  http://www.springer.com/engineering/signals/journal/13634
- Associate Editor of *International Journal of Systems Science* (Taylor & Francis) (J.P. Richard, 2007-2012) http://www.tandfonline.com/toc/tsys20/current

Plenary Talks:

- (2009) SysId'2009, 15th IFAC Symp. on Systems Identification (St Malo, France) [FJ09b] (M. Fliess, C. Join)
- (2009) ICST'2009, Int. Conf. on Systems Theory - Modeling, Analysis and Control (Fes, Morocco) [FJ09a](M. Fliess, C. Join)
- (2009) 6th CNRS workshop RECAP (Grenoble, France)
  http://evariste.org/mail/recap.7Nov09.txt.html) (W. Perruquetti)
- (2010) 'InnoLecture' Univ. of Saarland, Germany (with Guest Professor Program) (M. Mboup) http://www.uni-saarland.de/fileadmin/user_upload/Professoren/fr74_ProfRudolph/annonce_alien.pdf
- (2010) CNRS internat. school of GDR 2984 DYCOEC (Besançon, France)
  http://www.coria.fr/dycoec/spip.php?article114 (J.P. Richard)
- (2010) TDS'2010, 9th IFAC Workshop on Time Delay Systems (Prague, Czech Rep.) [Bel10] (L. Belkoura)
- (2010) VSS'2010, 12th IFAC Workshop on Variable Structure Systems (Mexico) [DFKP10] (W. Perruquetti)
- (2011) CNRS Journées Nat. de Recherche en Robotique JNRR'2011 (La Rochelle, France) http://jnrr2011.irccyn.ec-nantes.fr/ (W. Perruquetti)
- (2011) CNRS internat. school of GDR 2984 DYCOEC (Batz-s/-Mer, France)
  http://www.coria.fr/dycoec/spip.php?article124 (J.P. Richard)
- (2011) (Semi-plenary) Workshop in honor of G. Bartolini (25 Aug.2011, Cagliari, Italy) (W. Perruquetti)

- (2011) (Semi-plenary) Workshop “Toward a Society of Robots”, Centro Piaggio (21-22 June 2011, Pisa, Italy) (W. Perruquetti)
- (2011) (Semi-plenary) Summer School on Robotics and Automation (26-30 June 2011, Algiers) (W. Perruquetti)

Awards & Highlights:

- (2010) AL.I.E.N.-SAS was awarded the *“Prix OSEO, catégorie émergence”*
- (2010) A patent with EDF [RLFJ10] was awarded the *Innovation Prize 2010 from Ecole Polytechnique*
- (2011) The paper [FHPR11] was awarded the *‘Meilleur article jeune chercheur’* at the French conference 8e MSR http://www.lifl.fr/msr11/
- (2011) The program ‘Agregation’ of ECS Lab was awarded the *Prix du partenariat Technologique 2011 du Val d’Oise* http://www.vonews.fr/article_13725
- (2013) The Master SMaRT was awarded one of the French *“Pépites 2013 de la Fac”* (Top 400 French University training, over 11000) by *Le Nouvel Observateur* (31 January 2013)
- (2009-2013) Since 2009, our survey paper on time delay systems[22] is ranked as the ScienceDirect TOP 1 hottest article of Automatica http://top25.sciencedirect.com/subject/engineering/12/journal/automatica/00051098/archive/40/

Miscellaneous:

- IPC Chair (and organization) of ICSCS’12 (IEEE), Lille, France, Aug. 2012, 1st Int. Conf. on Systems & Computer Science (L. Belkoura, J.P. Richard) http://www-lagis.univ-lille1.fr/ICSCS2012/
- CIFA: Deep investment in the biennial, international, French-speaking conference of automatic control CIFA, co-organized with IEEE and CNRS: Governing Board since its creation in 2000, IPC Chair of CIFA 2010 (Nancy, France, 2-4 June 2010) (J.P. Richard), IPCs of CIFA Nancy 2000 and Grenoble 2012 (J.P. Barbot, L. Belkoura, C. Join, M. Mboup, W. Perruquetti, J.P. Richard), see http://cifa2010.cran.uhp-nancy.fr/ and www.gipsa-lab.fr/CIFA2012/
- IPC Associate Editorship for 9 IFAC/IEEE conferences[23] (D. Efimov,J.P. Richard)
- IPC Membership: over 35 other participations to IPCs of IFAC or IEEE international conferences (J.P. Barbot, L. Belkoura, M. Mboup, W. Perruquetti, J.P. Richard)
- IFAC TCs: participation to 6 IFAC Technical Committees: TC 1.2, Adaptive and Learning Systems; TC-1.3 Discrete and Hybrid Systems; TC1.5 Networked Systems; TC2.2 Linear Systems; TC-2.3 Nonlinear Control Systems; TC-2.5 Robust Control (J.P. Barbot, T. Floquet, M. Mboup, W. Perruquetti, J.P. Richard))
- Invitations: various invitations in France and abroad: Czech Rep. (T.U. Prague), Italy (Calgiari Univ.), Japan (Keio Univ.), US (General Motors), Saudi Arabia (KAUST), Tunisia (ENIT Tunis)
- PhD committees: participation to various PhD committees in France, India, Italy, Mexico, Russia, South Africa, Spain, Tunisia

[22] J.P. Richard, Time Delay Systems: An overview of some recent advances and open problems, Automatica 39 (10), 1667-1694, 2003.

[23] **IEEE-EUCA ECC’13** Zürich, Switzerland, http://www.ecc13.ch/; **IFAC SSC-TDS-FDIA’13** Grenoble, France,http://www.gipsa-lab.fr/SSSC2013; **IEEE MED’2012** Barcelona, Spain, http://med12.esaii.upc.edu/; **IFAC 10th TDS’2012** Boston, USA, http://www.coe.neu.edu/IFACTDS2012/main.htm; **18th World IFAC’11** Milano, Italy, http://www.ifac2011.org/, **19th IEEE MED’2011** Corfu, Greece, http://www.med2011.org/; **18th IEEE MED’2010** Marrakech, Morocco, http://www.med10.org/; **4th IFAC Symp.SSC’2010** Ancona, Italy, http://leibniz.diiga.univpm.it/SSSC10/; **IEEE MSC’09**, Saint-Petersburg, Russia http://conf.physcon.ru/msc09/

- Expert activities: various other expertise activities appointed by French institutions (ANR, CNRS, DGRI/MEI, DGESIP...) and abroad: Australia (Australian Research Council), Israel (Tel Aviv Univ.), Romania (Nat. Council for Research & Devel.), USA (General Motors, Southern Illinois Univ.)
- National Council of the French University (CNU): Section 61 - Control & Signal (T. Floquet, G. Zheng) and Section 25 - Mathematics (R. Ushirobira, also vice-president in the permanent committee (CP-CNU) for the Group 5, gathering sections 25 - Maths, 26 - Applied Maths. and 27 - Informatics)
- J.P. Barbot was the Director of the laboratory ECS-Lab (EA3649, Electronics and Control Systems Lab) until Feb.2013

- W. Perruquetti held, over the period, various national (AERES, ANR, DGRI...) and Regional (Doctoral School, GRRT[24], Inria...) responsibilities and, in particular, for the ANR (French Agency fir Research): since 2012, he is the Scientific head of the Maths-STIC division the R2E department[25] and, since 2010, Scientific officer for the ANR - SIMI 3 committee[26]
- J.P. Richard held, over the period, various national responsibilities (expert AERES, DGRI/MEI, DGESIP, Gov. board of CNRS GDR 717 MACS[27]...) and, in particular, he was the President of the *GRAISyHM*, Regional Federation of Control and Man-Machine systems (about 200 people, 11 Institutes from North of France) http://www.univ-valenciennes.fr/graisyhm/ and served in several other regional/local committees.

[24] Group for Research in Transport, Regional Council
[25] Recherches exploratoires et émergentes : "département Blanc" (annual budget 25 MEuros)
[26] Automatique - Productique - Robotique - Signal Image - Micro Nano (annual budget 8MEuros)
[27] http://www.univ-valenciennes.fr/gdr-macs/

4 Funding

4.1 Funding external to Inria

(k euros)	year1	year2	year3	year4
National initiatives				
ANR CHASLIM (Inria)[28]				14.544
CPER CIA (Inria)[29]				16.375
PHC [a] Volubilis MA/09/211 (Lille 1)	5.485	7.962	7.420	5.636
PHC [a] Galileo 26076ZJ 4EC Lille			2.000	1.800
European projects				
FP7 HYCON2 (CNRS)			2.000	2.000
InterReg SYSIASS (EC Lille)				4.482
Industrial contracts (note: contracts are with AL.I.E.N. SAS)				
Scholarships				
PhD EC Lille (EC Lille)	12.000	48.000	72.000	72.000
PhD Lille 1 (Lille 1)	36.000	36.000	36.000	36.000
PhD ISEN and ENSAM	24.000	72.000	72.000	72.000
Post-Doc ANR CHASLIM (Inria)				36.000
Post-Doc/Eng. InterReg SYSIASS (EC Lille)			11.722	41.696
Post-Doc CPER CIA (Inria)	40.728			
Other external funding				
Total	112.728	156.000	203.142	302.533

[a] *competitive programs by the Ministries of Foreign Affairs and of Higher Education & Research.*

NB: the above table only concerns the supports managed by the partners institutes (EC Lille, Lille 1, CNRS and Inria Lille.

4.2 Inria competitive funding

(k euros)	year1	year2	year3	year4
Inria Research Initiatives				
ARC [1]				
AE [2]				
Associated teams				
Scholarships				
Internship		2.731		3.164
PhD[3]	33.946	42.040	59.777	42.296
Post Doc[4]	3.898	42.466	35.098	9.817
Technological development				
AI [5]				
ADT [6] (AI)	2.110	52.559	45.395	81.262
ODL [7]				
Other Inria competitive funding				
Total	39.954	139.976	140.270	136.539

[1] *Inria Cooperative Research Initiative (ARC = Action de Recherche Cooperative).*

[2] *Large-scale Initiative Action (AE = Action d'Envergure nationale).*

[3] *Inria doctoral research contract (CORDI-S, doctorat Inria sur subvention).*

[4] *Inria postdoctoral research contract ('post-doc Inria sur subvention').*
[5] *Junior engineer supported by Inria.*
[6] *Technological Development Action (ADT = Action de Développement Technologique).*
[7] *Software Development Operation (ODL = Opération Développement Logiciel). Last ones ended in 2010.*

National initiatives

- **[ANR ChasLim 2011-2015]** Jointly with *BIPOP* (Inria Rhône-Alpes), CNRS IRCCyN (Nantes), this ANR project runs from 1 Oct. 2011 until 30 Sept. 2015 and aims at developing a toolbox for synthesizing controllers and adequately simulating the obtained closed-loop systems. Andrey Polyakov is supported by ChasLim. More information at http://chaslim.gforge.inria.fr/
- **[CPER CIA 2010-2014]** The "Campus Intelligence Ambiante" is a program supported by the Government, Regional Council and European FEDER, which our collaboration with the team *FUN* belongs to. We also start a collaboration on the Equipex platform *FIT* (see 'opportunities' at the end of this part).
- **[PHC Volubilis 2010-2013]** VOLUBILIS MA/09/211 is a Hubert Curien Partnership dealing with MFC applied to a greenhouse temperature control, jointly with Univ. of Meknes, Morocco (in relation with the PhD of Youssef El Afou).
- **[PHC Galileo 2011-2012]** This Hubert Curien Partnership GALILEO 26076ZJ deals with estimation techniques for embedded switching systems with applications to the security of embedded systems, jointly with Univ. of Cagliari, Italy (in relation with the PhD thesis of Diego Mincarelli).
- **[PHC Cogito 2010-2012]** Mamadou Mboup won this Hubert Curien Partnership with Univ. of Zagreb, Croatia (Prof. Ratko Magjarević) for works on neurophysiologic signal detection (in relation with the PhD thesis of Zoran Tiganj). Support: 2.5k euros/y, not mentioned above because not in Lille.

European projects

- **[FP7 NoE HYCON2 2010-2013]** This FP7 Network of Excellence, started in September 2010, is a four-year project coordinated by the CNRS (F. Lamnabhi-Lagarrigue) with the partnership of Inria and many European institutes. It aims at establishing a long-term integration in the strategic field of control of complex, large-scale, and networked dynamical systems. Its associated EECI Graduate School on Control is regularly attended by our PhD students. HYCON2.http://www.hycon2.eu/

- **[InterReg SYSIASS 2010-2013]** This InterReg IV-A Two Seas 6-020-FR on Autonomous and Intelligent Healthcare System, aims at assisting patient's mobility and securing the provision of communication services. It was worked on an intelligent powered wheelchair for clinical or domestic environment. It involves ISEN Lille, EC Lille, Kent Univ., Essex Univ. and several partners from hospital settings. http://www.sysiass.eu

Industrial contracts

Contracts of AL.I.E.N. SAS on model-free control:

- EdF (Bourget-du-Lac): "Commande en puissance de barrages hydroélectriques en cascade" (power control of cascaded hydroelectrical dams),
- DIRIF: "Commande des cycles de feux de 4 rampes d'accès de l'autoroute A4" (cycle control for the traffic lights of the 4 public ramps to the A4 highway),

- EdF (Bourget-du-Lac): "Commande en puissance d'un groupe du Curbans" (power control of a group of the Curbans dam).

Contracts of AL.I.E.N. SAS on algebraic estimation:

- EdF (Bourget-du-Lac): "Séparation des sources de puissance",
- EdF (Bourget-du-Lac): "Estimation de débits entrants",
- EdF (Mulhouse): "Modélisation de l'écoulement du Doubs".

No ARCs, no AE, no other funding

Associated teams and other international projects

We contribute (no funding) to a GDRi *DELSYS* (CNRS internat. group on Delay Systems) https://dri-dae.cnrs-dir.fr/IMG/pdf/GDRI_DELSYS_2012-2.pdf, associated with the IFAC Workshop on Time-Delay Systems and, now, with a new book series 'Advances in Delays and Dynamics at Springer' coordinated by S.I. Niculescu from CNRS and *DISCO*.

5 Objectives for the next four years

Non-A has been created in July 2012, so our objectives remain unchanged:

Theory:

- More general annihilators
- Non-asymptotic derivation and estimation
- Model-free control

Applications:

- Networked robots, WSAN [Lille]
- Nano/macro machining [Lille]
- Multicell chopper [Lille and Cergy]
- *i*-PID for industry [Nancy, AL.I.E.N. SAS]

6 Bibliography of the project-team

Abstract of selected publications (downloadable from the evaluation website)

1. Objective 1 – Annihilators and Weyl Algebra [UPMF12]
Rosane Ushirobira, Wilfrid Perruquetti, Mamadou Mboup and Michel Fliess: Algebraic parameter estimation of a biased sinusoidal waveform signal from noisy data. *in Proc. SYSID'2012, 16th IFAC Symp. on System Identification*, Brussels, 2012.
http://hal.inria.fr/hal-00685067
Weyl algebra applied to robust estimation of the amplitude, frequency and phase of a biased and noisy sum of two complex exponential sinusoidal signals. The estimation is obtained within a fraction of the signal period. The methods that are popular today do not seem able to achieve such performances. The approach is illustrated by several computer simulations.

2. Objective 2 – Algebraic Differentiation [MJF09]
Mamadou Mboup, Cédric Join and Michel Fliess: Numerical differentiation with annihilators in noisy environment, *Numerical Algorithms*, 50 (4), pp.439-467, 2009.
http://hal.inria.fr/inria-00319240
Numerical differentiation in noisy environment is revised through our algebraic approach. Elementary differential-algebraic operations yield explicit formulas of the point-wise derivatives of chosen orders. These expressions are composed of iterated integrals filtering the noisy observation signal. The introduction of delayed estimates affords significant improvement. An implementation in terms of a classical FIR digital filter is given.

3. Objective 2 – Algebraic Differentiation for $n-$D Signal [RMR11]
Samer Riachy, Mamadou Mboup and Jean-Pierre Richard: Multivariate numerical differentiation. *Journal of Computational and Applied Mathematics*, 236 (6), pp.1069-1089, 2011. http://hal.inria.fr/inria-00637164/en
A generalization of the above $1-D$ result for $n-D$ signals. Multivariate numerical differentiation concerns the estimation of partial derivatives of multidimensional noisy signals. Again, the desired partial derivative is expressed as a function of iterated integrals of the signal. A family of estimators for each partial derivative of any order is given. Numerical implementation can be achieved via FIR digital filters.

4. Objective 2 – Algebraic identification of Delay (or Switched) Systems [BRF09]
Lotfi Belkoura, Jean-Pierre Richard and Michel Fliess: Parameters estimation of systems with delayed and structured entries. *Automatica*, 45 (5), pp.1117-1125.
http://hal.inria.fr/inria-00343801
On-line identification of continuous-time systems with structured entries, which may consist in inputs, perturbations or piecewise polynomial (time varying) parameters. Such signals can be easily annihilated, yielding a non asymptotic estimation of the unknown coefficients. Application to delayed and switching hybrid systems are proposed, with numerical simulations and experimental results on a delay process.

5. Objective 2 – Algebraic Estimation of Impulsive Systems [BFIT+11]:
Lotfi Belkoura, Thierry Floquet, Kaouther Ibn Taarit, Wilfrid Perruquetti and Yuri Orlov: Estimation problems for a class of impulsive systems. *Int. Journal of Robust and Nonlinear Control*, 21, pp.1066-1079. http://hal.inria.fr/inria-00504941
On-line identification of continuous-time systems subject to impulsive terms. Using a distribution framework, we annihilate singular terms corresponding to the impulses. An on-line estimation of unknown parameters is provided, regardless of the switching times nor impulse rules, followed by numerical simulations of physical processes.

6. Objective 2 – Model-based, Finite-Time observers [MMP10]
Thomas Menard, Emmanuel Moulay and Wilfrid Perruquetti: A global high-gain finite-time observer, *IEEE Trans. on Automatic Control*, 55 (6), pp.1500-1506, 2010.
http://hal.inria.fr/hal-00455790
A global finite-time observer is designed for nonlinear systems which are uniformly observable and globally Lipschitz. This result is based on a high-gain approach combined with recent advances on finite-time stability using Lyapunov function and homogeneity concepts.

7. Objective 2 – Model-based, Finite-Time estimation [BEPZ12b]
Alexy Bobstov, Denis Efimov, Anton Pyrkin and Ali Zolghadri: Switched algorithm for frequency estimation with noise rejection, *IEEE Trans. on Automatic Control*, 57 (9), pp.2400-2404, 2012
http://hal.inria.fr/hal-00664105
Parametric estimation of harmonic signals is achieved in the presence of noise and computational constraints, via an algorithm for frequency and bias estimation. A switching algorithm is able to filter the measurement high-frequency noise and to ensure the required minimal accuracy in a finite time.

8. Objective 2 – Use of Non-Asymptotic differentiation techniques [BFPZ13]
Francisco Javier Bejarano, Thierry Floquet, Wilfrid Perruquetti and Gang Zheng: Observability and detectability of singular linear systems with Unknown Inputs, *Automatica*, 49 (2), pp.-, 2013.
http://hal.inria.fr/hal-00753706
The strong observability/detectability of a general class of singular linear systems with unknown inputs are tackled. Algebraic NSC of observability/detectability are given. A formula expresses the state as high order derivative of a function of the output. Finite-time differentiation techniques are applied to solve it concretely.

9. Objective 3 – Model-Free Control [RLFJ10]
Gérard Robert (EDF), Antoine Libaux (EDF), Michel Fliess and Cédric Join: Procédé de régulation d'un niveau dans un aménagement hydraulique. *European Patent EP 2 196 886 A1*, EDF and École Polytechnique, 20 pages, 16 June 2010.
This is the legal text (written in French) of a patent concerning the water level control for an hydroelectric dam, with several Figures describing the process. A scientific presentation can also be found in [JRF10].

10. Objective 4 – Robots localization: algebra *vs* EKF [SPK+12]
Hugues Sert, Wilfrid Perruquetti, Annemarie Kokosy, Xin Jin and Jorge Palos: Localizability of unicycle mobiles robots: an algebraic point of view. *In Proc. IROS'2012, Int. Conf. on Intelligent Robots & Systems*, Vilamoura, Portugal, 2012.
http://hal.inria.fr/hal-00720198
Our ICRA'2011 paper [SKP11] described a single-landmark-based localization algorithm for mobile robots of the unicycle type. Here, a sensibility study leads to a new fusion algorithm in the multi-landmark case. Simulations and experimentations compare our algebra-based techniques with the well known EKF method.

6.1 Doctoral dissertations and "Habilitation" theses

[Del12] Romain Delpoux. *Contribution à l'identification, l'estimation et la commande de Moteurs Synchrones à Aimants Permanents*. PhD thesis, Ecole centrale de Lille, 22, Nov 2012.

[Efi12] Denis Efimov. *Analysis, control and estimation of nonlinear oscillations*. Hdr, LIlle 1, November 2012.

[Flo09] Thierry Floquet. *Commande et observation à structure variable des systèmes non linéaires*. Hdr, Lille 1 Université de Sciences et Technologies, 29, Oct 2009.

[Ibn10] Kaouther Ibn Taarit. *Contribution à l'identification des systèmes à retards ou à commutations*. PhD thesis, Ecole centrale de Lille, 17, Dec 2010.

[Joi12] Cédric Join. *Une approche algébrique pour la pratique de l'estimation, du diagnostic, de la commande et de la finance*. Hdr, Université de Lorraine, June 2012.

[Liu11] Dayan Liu. *Analyse d'Erreurs d'Estimateurs des Dérivées de Signaux Bruités et Applications*. PhD thesis, Université des Sciences et Technologie de Lille - Lille I, October 2011.

[Ser13] Hugues Sert. *De l'utilisation de l'algèbre differ'entielle pour la localisation et la navigation de robots mobiles autonomes*. PhD thesis, Ecole centrale de Lille, 11, Jan 2013.

[Tia10] Yang Tian. *Une contribution à l'observation et à l'estimation des systèmes linéaires*. PhD thesis, Ecole centrale de Lille, 8, Dec 2010.

[Tig11] Zoran Tiganj. *On the pertinence of a numerical transmission model for neural information*. PhD thesis, Université des Sciences et Technologie de Lille - Lille I, November 2011.

[Ush10] Rosane Ushirobira. *Autour des algèbres et super-algèbres de Lie et de l'algèbre de Weyl*. Hdr, Université de Bourgogne, December 2010.

6.2 Patents

[AFJ11] Hassane Abouaissa, Michel Fliess, and Cédric Join. Procédé de régulation du trafic routier, 28 february 2011. French Patent, École Polytechnique.

[RLFJ10] Gérard Robert, Antoine Libaux, Michel Fliess, and Cédric Join. Procédé de régulation d'un niveau dans un aménagement hydraulique, système et produit programme d'ordinateur correspondant, 16 June 2010. European Patent, Electricité de France and École Polytechnique.

6.3 Articles in referred journals

[AM09] Daniel Alpay and Mamadou Mboup. Transformée en échelle de signaux stationnaires. *Comptes Rendus de l'Académie des Sciences - Series I - Mathematics*, 347(11-12):603–608, 2009.

[AM10] Daniel Alpay and Mamadou Mboup. Discrete-time multi-scale systems. *Integral Equations and Operator Theory*, 68(2):163–191, 2010.

[BB09] Djamila Benmerzouk and Jean-Pierre Barbot. Chaotic behavior analysis based on corner bifurcations. *Nonlinear Analysis: Hybrid Systems*, 3:543–550, 2009.

[BB10] Djamila Benmerzouk and Jean-Pierre Barbot. Chaotic behavior analysis based on sliding bifurcations. *Nonlinear Analysis: Hybrid Systems*, 4(3):503–512, 2010.

[BBBB09] Latifa Boutat-Baddas, Driss Boutat, and Jean-Pierre Barbot. Observability analysis by poincaré normal forms. *Mathematics of Control Signals and Systems*, 21(2):147–170, 2009.

[BBF09] Jean-Pierre Barbot, Driss Boutat, and Thierry Floquet. An observation algorithm for nonlinear systems with unknown inputs. *Automatica*, 45(8):1970–1974, 2009.

[BBZ+11] S. Bououden, Driss Boutat, Gang Zheng, Jean-Pierre Barbot, and Frédéric Kratz. A triangular canonical form for a class of 0-flat nonlinear systems. *International Journal of Control*, 84(1-3):261–269, 2011.

[BEPZ12a] Alexy Bobstov, Denis Efimov, Anton Pyrkin, and Ali Zolghadri. Adaptive Algorithm of Frequency Estimation for Bias Periodical Signal with Additive Nonregular Component. *Mechatronics, Automatization, Control*, (2):16–21, October 2012.

[BEPZ12b] Alexy Bobstov, Denis Efimov, Anton Pyrkin, and Ali Zolghadri. Switched Algorithm for Frequency Estimation with Noise Rejection. *IEEE Transactions on Automatic Control*, 57(9):2400–2404, 2012.

[BF10] Jean-Pierre Barbot and Thierry Floquet. Iterative higher order sliding mode observer for nonlinear systems with unknown inputs. *Dynamics of Continuous, Discrete and Impulsive Systems*, 17(6):1019–1033, 2010.

[BFIT+11] Lotfi Belkoura, Thierry Floquet, Kaouther Ibn Taarit, Wilfrid Perruquetti, and Yuri Orlov. Estimation problems for a class of impulsive systems. *International Journal of Robust and Nonlinear Control*, 21:1066–1079, 2011.

[BFPZ13] Francisco Javier Bejarano, Thierry Floquet, Wilfrid Perruquetti, and Gang Zheng. Observability and Detectability of Singular Linear Systems with Unknown Inputs. *Automatica*, 49(2), 2013.

[BGB10] Francisco Javier Bejarano, Malek Ghanes, and Jean-Pierre Barbot. Observability and observer design for hybrid multicell choppers. *International Journal of Control*, vol 83(3), March 2010.

[BKC+10] E.B. Brousseau, F. Krohs, E. Cailleaud, S. Dimov, O. Gibaru, and S. Fatikow. Development of a novel process chain based on atomic force microscopy scratching for small and medium series production of polymer nanostructured components. *Journal of Manufacturing Science and Engineering*, 132(3), 2010.

[BRF09] Lotfi Belkoura, Jean-Pierre Richard, and Michel Fliess. Parameters estimation of systems with delayed and structured entries. *Automatica*, 45(5):1117–1125, 2009.

[DBB09] Mohamed Djemai, Jean-Pierre Barbot, and Inâm Belmouhoub. Discrete-time normal form for left invertibility problem. *European Journal of Control*, 15(2):194–204, 2009.

[DDFP11] Michael Defoort, Mohamed Djemai, Thierry Floquet, and Wilfrid Perruquetti. Robust finite time observer design for multicellular converters. *International Journal of Systems Science*, 42(11):1859–1868, 2011.

[DFKP09a] Michael Defoort, Thierry Floquet, Annemarie Kökösy, and Wilfrid Perruquetti. Motion planning for cooperative unicycle-type mobile robots with limited sensing ranges: A distributed receding horizon approach. *Robotics and Autonomous Systems*, 57(11):1094–1106, 2009.

[DFKP09b] Michael Defoort, Thierry Floquet, Annemarie Kökösy, and Wilfrid Perruquetti. A novel higher order sliding mode control scheme. *Systems & Control Letters*, 58(2):102–108, 2009.

[DFPD09] Michael Defoort, Thierry Floquet, Wilfrid Perruquetti, and Serguey Drakunov. Integral sliding mode control of an extended heisenberg system. *IET Control Theory and Applications*, 3(10):1409–1424, 2009.

[DNFP09] Michael Defoort, F Nollet, Thierry Floquet, and Wilfrid Perruquetti. A third order sliding mode controller for a stepper motor. *IEEE Transactions on Industrial Electronics*, 56(9):3337–3346, 2009.

[DPK+09] Michael Defoort, Jorge Palos, Annemarie Kökösy, Thierry Floquet, and Wilfrid Perruquetti. Performance-Based Reactive Navigation for Nonholonomic Mobile Robots. *Robotica*, 27(2):281–290, 2009.

[EF12] Denis Efimov and Alexander Fradkov. Natural Wave Control in Lattices of Linear Oscillators. *Systems&Control Letters*, 61:887–893, July 2012.

[Efi12] Denis Efimov. Global Lyapunov analysis of multi-stable nonlinear systems. *SIAM Journal on Control and Optimization*, 50(5):3132–3154, November 2012.

[EFR+12] Denis Efimov, Leonid Fridman, Tarek Raissi, Ali Zolghadri, and Ramatou Seydou. Interval Estimation for LPV Systems Applying High Order Sliding Mode Techniques. *Automatica*, 48:2365–2371, November 2012.

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

[ERZ13] Denis Efimov, Tarek Raissi, and Ali Zolghadri. Control of nonlinear and LPV systems: interval observer-based framework. *IEEE Transactions on Automatic Control*, 2013.

[EZ12] Denis Efimov and Ali Zolghadri. Optimization of Fault Detection Performance for a Class of Nonlinear Systems. *International Journal of Robust and Nonlinear Control*, 22(17):1969–1982, October 2012.

[FAIJ12] Michel Fliess, Hassane Abouaissa, Violina Iordanova, and Cédric Join. La commande *sans modèle* du trafic autoroutier. *FLASH X – La revue scientifique de l'Ecole polytechnique*, (14):25–28, 2012.

[FBL12] Madalin Frunzete, Jean-Pierre Barbot, and Christophe Letellier. Influence of the singular manifold of non observable states in reconstructing chaotic attractors. *Physical Review E*, 86(2), August 2012.

[FES11] Thierry Floquet, Chris Edwards, and Sarah Spurgeon, K. An output feedback sliding mode control strategy for MIMO systems of arbitrary relative degree. *International Journal of Robust and Nonlinear Control*, 21(2):119–236, 2011.

[FHPR12] Christophe Fiter, Laurentiu Hetel, Wilfrid Perruquetti, and Jean-Pierre Richard. A State Dependent Sampling for Linear State Feedback. *Automatica*, 48(8):1860–1867, August 2012.

[FJM10] Michel Fliess, Cédric Join, and Mamadou Mboup. Algebraic change-point detection. *Applicable Algebra in Engineering, Communication and Computing*, 21(2):131–143, 2010.

[GBGdL10] Malek Ghanes, Jean-Pierre Barbot, Alain Glumineau, and Jesus de Leon. A robust sensorless output feedback controller of the induction motor drives: New design and experimental validation. *International Journal of Control*, 83:484–497, 2010.

[GDB+11] Pierre-Antoine Gédouin, Emmanuel Delaleau, Jean-Matthieu Bourgeot, Cédric Join, Shabnam Arbab-Chirani, and Sylvain Calloch. Experimental comparison of classical pid and model-free control: position control of a shape memory alloy active spring. *Control Engineering Practice*, 19(5):433–441, May 2011. WOS.

[GdLB13] Malek Ghanes, Jesus de Leon, and Jean-Pierre Barbot. Observer design for nonlinear systems under unknown time-varying delays. *IEEE Transactions on Automatic Control*, June 2013.

[GDSSFR11] Joâo Manoel Gomes Da Silva, Alexandre Seuret, Emilia Fridman, and Jean-Pierre Richard. Stabilization of neutral systems with saturating control inputs. *International Journal of Systems Science*, 42(7):1093 – 1103, 2011.

[GSF11] Srinath Govindaswamy, Sarah Spurgeon, K., and Thierry Floquet. Discrete-time output feedback sliding-mode control design for uncertain systems using linear matrix inequalities. *International Journal of Control*, 84(5):916–930, 2011.

[GZ12] Antoine Girard and Gang Zheng. Verification of Safety and Liveness Properties of Metric Transition Systems. *ACM Transactions on Embedded Computing Systems*, 11(S2), 2012.

[HDRJ11] Laurentiu Hetel, Jamal Daafouz, Jean-Pierre Richard, and Marc Jungers. Delay-dependent sampled-data control based on delay estimates. *Systems & Control Letters*, 60(2):146–150, January 2011.

[HKPR11] Laurentiu Hetel, Alexandre Kruszewski, Wilfrid Perruquetti, and Jean-Pierre Richard. Discrete and intersample analysis of systems with aperiodic sampling. *IEEE Transactions on Automatic Control*, PP(99):1, 2011.

[ITBKR11] Kaouther Ibn Taarit, Lotfi Belkoura, Mekki Ksouri, and Jean-Pierre Richard. A fast identification algorithm for systems with delayed inputs. *International Journal of Systems Science*, 42(3):449–456, 2011.

[KBP11] Alexandre Kruszewski, Romain Bourdais, and Wilfrid Perruquetti. Converging algorithm for a class of BMI applied on state dependant stabilization of switched systems. *Nonlinear Analysis: Hybrid Systems*, 5(4):647–654, November 2011.

[KEBN12] Sergey Kolyubin, Denis Efimov, Alexey Bobtsov, and Vladimir Nikiforov, O. Two-channel adaptive hybrid control of the air-to-fuel ratio and torque of automobile engines. *Automation and Remote Control / Avtomatika i Telemekhanika*, 73(11):1794–1807, November 2012.

[KJF$^+$12] Alexandre Kruszewski, Wenjuan Jiang, Emilia Fridman, Jean-Pierre Richard, and Armand Toguyeni. A switched system approach to exponential stabilization through communication network. *IEEE Transactions on Control Systems Technology*, 20(4):887–900, 2012.

[LGP11a] Dayan Liu, Olivier Gibaru, and Wilfrid Perruquetti. Differentiation by integration with Jacobi polynomials. *Journal of Computational and Applied Mathematics*, 235(9):3015 – 3032, 2011.

[LGP11b] Dayan Liu, Olivier Gibaru, and Wilfrid Perruquetti. Error analysis of Jacobi derivative estimators for noisy signals. *Numerical Algorithms*, 58(1):53–83, March 2011.

[MA11] Mamadou Mboup and Tülay Adali. A Generalization of the Fourier Transform and its Application to Spectral Analysis of Chirp-like Signals. *Applied and Computational Harmonic Analysis*, 2011.

[MAJH12] Abdouramane Moussa Ali, Cédric Join, and Frédéric Hamelin. Fault diagnosis without a priori model. *Systems & Control Letters*, 61(2):316–321, February 2012.

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

[MGGZ09] Malek Ghanes and Gang Zheng. On Sensorless Induction Motor Drives: Sliding-Mode Observer and Output Feedback Controller. *IEEE Transactions on Industrial Electronics*, 56(9):3404–3413, 2009.

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

[MMP10] Tomas Menard, Emmanuel Moulay, and Wilfrid Perruquetti. A global high-gain finite-time observer. *IEEE Transactions on Automatic Control*, 55(6):1500–1506, 2010.

[NGA11] E Nyiri, Olivier Gibaru, and P Auquiert. Fast $l_1^k c^k$ polynomial spline interpolation algorithm with shape-preserving propertiesstar. *Computer Aided Geometric Design*, 28(1):65–74, 2011.

[OBG10] A Olabi, R Béarée, and Olivier Gibaru. Feedrate planning for machining with industrial six-axis robot. *Control Engineering Practice*, 18(5):471–482, 2010.

[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, 2012.

[RLGF12] Sandy Rahme, Yann Labit, Frédéric Gouaisbaut, and Thierry Floquet. Sliding Modes for Anomaly Observation in TCP Networks: From Theory to Practice. *IEEE Transactions on Control Systems Technology*, PP(99):16p., September 2012. (IEEE early access article).

[RMR11] Samer Riachy, Mamadou Mboup, and Jean-Pierre Richard. Multivariate numerical differentiation. *Journal of Computational and Applied Mathematics*, 236(6):1069 – 1089, October 2011.

[SRZE13] Ramatou Seydou, Tarek Raissi, Ali Zolghadri, and Denis Efimov. Actuator fault diagnosis for flat systems: A constraint satisfaction approach. *International Journal of Applied Mathematics & Computer Science*, Vol 23(N° 1), January 2013.

[TFBP11] Yang Tian, Thierry Floquet, Lotfi Belkoura, and Wilfrid Perruquetti. Algebraic switching time identification for a class of linear hybrid systems. *Journal of Nonlinear Analysis: Hybrid Systems*, 5, 2011.

[TM11] Zoran Tiganj and Mamadou Mboup. A non-parametric method for automatic neural spikes clustering based on the non-uniform distribution of the data. *Journal of Neural Engineering*, 8(6):066014, November 2011.

[TM12] Zoran Tiganj and Mamadou Mboup. Neural spike sorting using iterative ICA and deflation based approach. *Journal of Neural Engineering*, 9:066002, October 2012.

[VDNC+09] Jorge Villagra, Brigitte D'Andréa Novel, Sungwoo Choi, Michel Fliess, and Hugues Mounier. Robust stop-and-go control strategy: an algebraic approach for nonlinear estimation and control. *International Journal of Vehicle Autonomous Systems*, 7:270–291, 2009.

[VDNFM11] Jorge Villagra, Brigitte D'Andrea Novel, Michel Fliess, and Hugues Mounier. A diagnosis-based approach for tire-road forces and maximum friction estimation. *Control Engineering Practice*, 19(2):174–184, 2011.

[YBBB11] Lei Yu, Jean-Pierre Barbot, Driss Boutat, and Djamila Benmerzouk. Observability forms for switched systems with Zeno phenomenon or high switching frequency. *IEEE Transactions on Automatic Control*, 56(2):436–441, Feb. 2011.

[YBZS10] Lei Yu, Jean-Pierre Barbot, Gang Zheng, and Hong Sun. Compressive sensing with chaotic sequence. *IEEE Signal Processing Letters*, 17(8):731 – 734, 2010.

[YSBZ12] Lei Yu, Hong Sun, Jean-Pierre Barbot, and Gang Zheng. Bayesian Compressive Sensing for Cluster Structured Sparse Signals. *Signal Processing*, 92(1):259–269, January 2012.

[YZBB11] Lei Yu, Gang Zheng, Driss Boutat, and Jean-Pierre Barbot. Observability and observer design for a class of switched systems. *IET Control Theory and Applications*, 5(9):1113 – 1119, June 2011.

[ZB11] Gang Zheng and Driss Boutat. Synchronization of chaotic systems via reduced observers. *IET Control Theory & Applications*, 5(2):308–314, 2011.

[ZBB09] Gang Zheng, Driss Boutat, and Jean-Pierre Barbot. Multi-output dependent observability normal form. *Journal of Nonlinear Analysis Series A: Theory, Methods & Applications*, 70(1):404–418, 2009.

[ZBB10] Gang Zheng, Driss Boutat, and Jean-Pierre Barbot. On uniform controller design for linear switched systems. *Nonlinear Analysis: Hybrid Systems*, 40(1):189–198, 2010.

[ZBB+11] Gang Zheng, Jean-Pierre Barbot, Driss Boutat, Thierry Floquet, and Jean-Pierre Richard. On observation of time-delay systems with unknown inputs. *IEEE Transactions on Automatic Control*, 56(8):1973–1978, 2011.

[ZBFB09] Gang Zheng, Driss Boutat, Thierry Floquet, and Jean-Pierre Barbot. Secure Communication Based on Multi-input Multi-output Chaotic System with Large Message Amplitude. *Chaos, Solitons and Fractals*, 41(3):1510–1517, 2009.

[ZT09] Gang Zheng and Arnaud Tonnelier. Chaotic solutions in the quadratic integrate-and-fire neuron with adaptation. *Cognitive Neurodynamics*, 3:197–204, 2009.

[ZTM09] Gang Zheng, Arnaud Tonnelier, and Dominique Martinez. Voltage-stepping schemes for the simulation of spiking neural networks. *Journal of Computational Neuroscience*, 26(3):409–423, 2009.

6.4 Book chapters

[Bel12] Lotfi Belkoura. *Identifiability and algebraic identification of time delay systems*, volume 423 of *Lecture Notes in Control and Information Sciences*, chapter 8, pages 103–117. Springer, 2012.

[HKR12] Laurentiu Hetel, Alexandre Kruszewski, and Jean-Pierre Richard. A hybrid method for the analysis of non-uniformly sampled systems. In Sipahi R.; Vyhlidal T.; Niculescu S.-I.; Pepe P., editor, *Time Delay Systems: Methods, Applications and New Trends*, Lecture Notes in Control and Information Sciences, pages 253–264. Springer Verlag, 2012.

[KBX10] W. Kang, Jean-Pierre Barbot, and L. Xu. On the observability of nonlinear and switched system. In *Emergent Problems in Nonlinear Systems and Control*. Springer, 2010.

[LGP12] Da-Yan Liu, Olivier Gibaru, and Wilfrid Perruquetti. Convergence Rate of the Causal Jacobi Derivative Estimator. *Lecture Notes in Computer Science*, 6920:445 – 455, 2012.

[YBB+12] Lei Yu, Jean-Pierre Barbot, Djamila Benmerzouk, Driss Boutat, Thierry Floquet, and Gang Zheng. Discussion about sliding mode algorithms, Zeno phenomena and observability. In Fridman Leonid; Moreno Jaime; Iriarte Rafael (Eds.), editor, *Lecture Notes in Control and Information Sciences, 2012, Volume 412*. Springer, February 2012.

6.5 Publications in conferences and workshops

[ADBG12] Bilal Amghar, Moumen Darcherif, Jean-Pierre Barbot, and Patrick Gauthier. Modeling and control of parallel multicell chopper using Petri nets. In *8th Power Plant and Power System Control Symposium - PPPSC 2012*, Toulouse, France, September 2012.

[AFIJ11] Hassane Abouaissa, Michel Fliess, Violina Iordanova, and Cédric Join. First steps towards a model-free control of a freeway traffic flow. In *Conférence Méditerranéenne sur l'Ingénierie Sûre des Systèmes Complexes, MISC 2011*, Agadir, Morocco, May 2011.

[AFIJ12] Hassane Abouaissa, Michel Fliess, Violina Iordanova, and Cédric Join. Freeway ramp metering control made easy and efficient. In *13th IFAC Symposium on Control in Transportation Systems (CTS 2012)*, Sofia, Bulgaria, 2012.

[AGB12] Leonardo Amet, Malek Ghanes, and Jean-Pierre Barbot. HOSM control under quantization and saturation constraints: Zig-Zag design solutions. In *CDC'12, 51st IEEE Conference on Decision and Control*, Maui, Hawaii, USA, December 2012.

[AM09] Daniel Alpay and Mamadou Mboup. A natural transfer function space for linear discrete time-invariant and scale-invariant systems. In *International Workshop on Multidimensional (nD) Systems*, 2009.

[AM10] D. Alpay and M. Mboup. Discrete multiscale systems: stability results. In *Int. Symp. on Mathematical Theory of Networks and Systems*, 2010.

[BB09a] D Benmerzouk and Jean-Pierre Barbot. Chaotification of piecewise smooth systems. In *IFAC Conference on Analysis and Control of Chaotic Systems*, 2009.

[BB09b] Driss Boutat and Jean-Pierre Barbot. Observavility Brunovsky Normal Form: Multi-Output Linear Dynamical Systems. In *ACC'2009, IEEE American Control Conference*, St Louis, USA, 2009.

[BBBK09] S. Bououden, Driss Boutat, Jean-Pierre Barbot, and F. Kratz. A geometrical characterization of a class of 0-flat affine dynamical systems. In *ACC'2009, IEEE American Control Conference*, St Louis, USA, 2009.

[Bel09] Lotfi Belkoura. Change point detection with application to the identification of a switching process. In *International conference on systems theory : Modelling, Analysis and Control*, 2009.

[Bel10] Lotfi Belkoura. Identifiability and algebraic identification of time delay systems. In *IFAC Workshop on Time delay Systems*, Prague, Czech Rep., 2010. Plenary Lecture.

[BFPZ11] Francisco Javier Bejarano, Thierry Floquet, Wilfrid Perruquetti, and Gang Zheng. Observability and Detectability Analysis of Singular Linear Systems with Unknown Inputs. In *CDC-ECC'11, 50th IEEE Conference on Decision and Control and European Control Conference*, Orlando, Florida, United States, September 2011.

[BPEM12] Emmanuel Bernuau, Wilfrid Perruquetti, Denis Efimov, and Emmanuel Moulay. Finite-time output stabilization of the double integrator. In *CDC'12, 51st IEEE Conference on Decision and Control*, Maui, Hawaii, USA, December 2012.

[BPEP13] Emmanuel Bernuau, Andrey Polyakov, Denis Efimov, and Wilfrid Perruquetti. Robustness of finite-time stability property for sliding modes. In *Joint SSSC, TDS, FDA 2013*, Grenoble, France, February 2013.

[BPFZ12] Francisco Javier Bejarano, Wilfrid Perruquetti, Thierry Floquet, and Gang Zheng. State Reconstruction of Nonlinear Differential-Algebraic Systems with Unknown Inputs. In *IEEE Conf. on Decision and Control*, Hawai, United States, 2012.

[BZBBD12] Driss Boutat, Gang Zheng, Latifa Boutat-Baddas, and Mohamed Darouach. Observers design for a class of nonlinear singular systems. In *CDC'12, 51st IEEE Conference on Decision and Control*, Maui, Hawaii, USA, December 2012.

[BZF+12] Jean-Pierre Barbot, Gang Zheng, Thierry Floquet, Driss Boutat, and Jean-Pierre Richard. Delay estimation algorithm for nonlinear time-delay systems with unknown inputs. In *IFAC TDS*, Boston, United States, July 2012. IFAC.

[BZH10] Driss Boutat, Gang Zheng, and Hassan Hammouri. A nonlinear canonical form for reduced order observer design. In *IFAC Symposium on Nonlinear Control Systems*, 2010.

[CDNF+09] Sungwoo Choi, Brigitte D'Andréa Novel, Michel Fliess, Hugues Mounier, and Jorge Villagra. Model-free control of automotive engine and brake for stop-and-go scenarios. In *European Control Conference*, 2009.

[CJT09] Abbas Chamseddine, Cédric Join, and Didier Theilliol. Actuator fault-tolerant control for satellites in rendez-vous mission. In *Diagnosis of Processes and Systems*, 2009.

[DBF12a] Romain Delpoux, Marc Bodson, and Thierry Floquet. Joint Identification of Stepper Motor Parameters and of Initial Encoder Offset. In *SysId'12, 16th IFAC Symposium on System Identification*, Brussels, Belgium, 2012.

[DBF12b] Romain Delpoux, Marc Bodson, and Thierry Floquet. Parameter estimation of permanent magnet stepper motors without position or velocity sensors. In *American Control Conference*, Montreal, Canada, 2012.

[DBV10] O Datcu, Jean-Pierre Barbot, and A. Vlad. New enciphering algorithm based on chaotic generalized hénnon map. In *Chaotic Modeling and Simulation International Conference*, 2010.

[DDFP10] Michael Defoort, Mohamed Djemai, Thierry Floquet, and Wilfrid Perruquetti. On finite time observer design for multicellular converter. In *VSS'2010, IFAC International Workshop on Variable Structure Systems*, 2010.

[DF11] Romain Delpoux and Thierry Floquet. On-line parameter estimation of a magnetic bearing. In *Med11*, Corfu, Greece, June 2011.

[DFB12] Octaviana Datcu, Leonid Fridman, and Jean-Pierre Barbot. A third-order sliding-mode observer for a continuous delay chaotic system. In *IFAC Conference on analysis and control of chaotic systems CHAOS 2012*, Cancun, Mexico, June 2012.

[DFKP10] Michael Defoort, Thierry Floquet, Annemarie Kokosy, and Wilfrid Perruquetti. Higher order sliding modes in collaborative robotics. In *VSS'2010, IFAC International Workshop on Variable Structure Systems*, Mexico, 2010. Plenary Lecture.

[DGDB11] Nadia Djeghali, Malek Ghanes, Said Djennoune, and Jean-Pierre Barbot. Backstepping Fault Tolerant Control Based on Second Order Sliding Mode Observer : Application to Induction Motors. In *IEEE CDC-ECC'11, 50th IEEE Conference on Decision and Control and European Control Conference*, Orlando, USA, December 2011.

[DGT+10] N Djeghali, M Ghanes, M. Tadjine, S. Djennoune, and Jean-Pierre Barbot. Fault tolerant control for induction motors using sliding mode observers. In *VSS'2010, IFAC International Workshop on Variable Structure Systems*, 2010.

[DKMEA12] Nehla Debbabi, Marie Kratz, Mamadou Mboup, and Sadok El Asmi. Combining Algebraic Approach with Extreme Value Theory for Spike Detection. In *IEEE EUSIPCO 2012*, Buccarest, Romania, June 2012.

[DNFJ+10] Brigitte D'Andrea Novel, Michel Fliess, Cédric Join, Hugues Mounier, and Bruno Steux. A mathematical explanation via "intelligent" pid controllers of the strange ubiquity of pids. In *Mediterranean Conference on Control and Automation*, 2010.

[EFI12] Denis Efimov, Alexander Fradkov, and Tetsuya Iwasaki. On finite time resonance entrainment in multi-DOF systems. In *ACC'2012, IEEE American Control Conference*, Montreal, Canada, June 2012.

[EFR+12] Denis Efimov, Leonid Fridman, Tarek Raissi, Ali Zolghadri, and Ramatou Seydou. Application of Interval Observers and HOSM Differentiators for Fault Detection. In *SafeProcess-2012, 8th IFAC Symposium on Fault Detection, Supervision and Safety for Technical Processes*, Mexico City, August 2012.

[EFRZ12] Denis Efimov, Leonid Fridman, Tarek Raissi, and Ali Zolghadri. Set-Membership Estimation Improvement Applying HOSM Differentiators. In *ACC'2012, IEEE American Control Conference*, Montreal, Canada, June 2012.

[EP11a] Denis Efimov and Wilfrid Perruquetti. Homogeneity for time-delay systems. In *IFAC WC 2011*, pages 1–6, Milano, Italy, August 2011.

[EP11b] Denis Efimov and Wilfrid Perruquetti. Oscillating system design applying universal formula for control. In *IEEE CDC-ECC'11, 50th IEEE Conference on Decision and Control and European Control Conference* , pages 1–6, Orlando, USA, December 2011.

[ERCZ12] Denis Efimov, Tarek Raissi, Stanislav Chebotarev, and Ali Zolghadri. On Set-Membership Observer Design for a Class of Periodical Time-Varying Systems. In *CDC'12, 51st IEEE Conference on Decision and Control*, Maui, Hawaii, USA, December 2012.

[EZCD12] Denis Efimov, Ali Zolghadri, Jérome Cieslak, and Henry David. Input estimation via sliding-mode differentiation for early ofc detection. In *SafeProcess-2012, 8th IFAC Symposium on Fault Detection, Supervision and Safety for Technical Processes*, Mexico, August 2012.

[FCJ09] Giuseppe Fedele, Francesco Chiaravalloti, and Cédric Join. An algebraic derivative-based approach for the zero-crossings estimation. In *European Signal Processing Conference*, 2009.

[FFR10] Christophe Fiter, Thierry Floquet, and Joachim Rudolph. Sensorless control of a stepper motor based on higher order sliding modes. In *IFAC Symposium on Nonlinear Control Systems*, 2010.

[FHP09] Thierry Floquet, Laurentiu Hetel, and Wilfrid Perruquetti. Stabilization of switched linear systems: a sliding mode approach. In *ADHS'09, 3rd IFAC Conference on Analysis and Design of Hybrid Systems*, 2009.

[FHPR11] Christophe Fiter, Laurentiu Hetel, Wilfrid Perruquetti, and Jean-Pierre Richard. State dependent sampling: an LMI based mapping approach. In *IFAC'11, 18th IFAC World Congress*, Milano, Italy, June 2011.

[FHPR12] Christophe Fiter, Laurentiu Hetel, Wilfrid Perruquetti, and Jean-Pierre Richard. State-Dependent Sampling for Perturbed Time-Delay Systems. In *CDC'12, 51st IEEE Conference on Decision and Control*, Maui, Hawaï, USA, September 2012.

[FJ09a] Michel Fliess and Cédric Join. A mathematical proof of the existence of trends in financial time series. In *International Conference on Systems Theory: Modelling, Analysis and Control*. Presses Universitaires de Perpignan, 2009. Plenary Lecture.

[FJ09b] Michel Fliess and Cédric Join. Model-free control and intelligent pid controllers: towards a possible trivialization of nonlinear control? In *SYSID'09, 15th IFAC Symposium on System Identification*, St Malo, France, 2009. Plenary Lecture.

[FJ09c] Michel Fliess and Cédric Join. Towards new technical indicators for trading systems and risk management. In *SYSID'09, 15th IFAC Symposium on System Identification*, St Malo, France, 2009.

[FJ10] Michel Fliess and Cédric Join. Delta hedging in financial engineering: Towards a model-free approach. In *IEEE Mediterranean Conference on Control and Automation*, 2010.

[FJ12] Michel Fliess and Cédric Join. Preliminary remarks on option pricing and dynamic hedging. In *1st International Conference on Systems and Computer Science*, Villeneuve d'Ascq, France, August 2012.

[FJH11a] Michel Fliess, Cédric Join, and Frédéric Hatt. Is a probabilistic modeling really useful in financial engineering? In *Conférence Méditerranéenne sur l'Ingénierie Sûre des Systèmes Complexes, MISC 2011*, Agadir, Morocco, May 2011.

[FJH11b] Michel Fliess, Cédric Join, and Frédéric Hatt. Volatility made observable at last. In *3èmes Journées Identification et Modélisation Expérimentale, JIME'2011*, Douai, France, April 2011.

[FJP09] Michel Fliess, Cédric Join, and Wilfrid Perruquetti. Real-time estimation of the switching signal for perturbed switched linear systems. In *IFAC Conference on Analysis and Design of Hybrid Systems*, 2009.

[FJR11] Michel Fliess, Cédric Join, and Samer Riachy. Revisiting some practical issues in the implementation of model-free control. In *IFAC'11, 18th IFAC World Congress*, Milano, Italy, August 2011.

[FM12] Thierry Floquet and Diego Mincarelli. On Second-Order Sliding Mode Observers with Residuals' Projection for Switched Systems. In *IEEE Conf. on Decision and Control*, Hawai, United States, 2012.

[FMP12] Thierry Floquet, Diego Mincarelli, and Alessandro Pisano. Continuous and Discrete State Estimation in Linear Switched Systems by Sliding Mode Observers with Residuals' Projection. In *ADHS'12, 4th IFAC Conference on Analysis and Design of Hybrid Systems*, Eindhoven, Netherlands, 2012.

[GB09] Malek Ghanes and Jean-Pierre Barbot. On sliding mode and adaptive observers design for multicell converter. In *ACC'2009, IEEE American Control Conference*, St Louis, USA, 2009.

[GBHB12] Malek Ghanes, Olivier Bethoux, Mickaël Hilairet, and Jean-Pierre Barbot. Validation expérimentale d'une commande aux perturbations singulières d'un système pile à combustible/super capacités. In *CIFA*, Grenoble, France, July 2012.

[GFS09] S Govindaswamy, Thierry Floquet, and Sarah Spurgeon. Linear matrix inequality based static output feedback sliding mode control for discrete time systems. In *European Control Conference*, 2009.

[GFS11] Srinath Govindaswamy, Thierry Floquet, and Sarah Spurgeon, K. Discrete time Output Feedback Sliding Mode Control for Uncertain Systems. In *IFAC'11, 18th IFAC World Congress*, Milano, Italy, 2011.

[GJD+09] Pierre-Antoine Gédouin, Cédric Join, Emmanuel Delaleau, Jean-Matthieu Bourgeot, Shabnam Arbab Chirani, and Sylvain Calloch. A new control strategy for shape memory alloys actuators. In *European Symposium on Martensitic Transformations*, 2009.

[HDJR10] Laurentiu Hetel, Jamal Daafouz, Marc Jungers, and Jean-Pierre Richard. Delay-dependent sampled-data control of LTI systems. In *IFAC Workshop on Distributed Estimation and Control in Networked Systems*, 2010.

[HGBD10] Hamid Hamiche, Malek Ghanes, Jean-Pierre Barbot, and Said Djennoune. Secure digital communication based on hybrid dynamical systems. In *IEEE, IET International Symposium on Communication Systems, Networks and Digital Signal Processing*, 2010.

[HKGR09] Laurentiu Hetel, Alexandre Kruszewski, Thierry-Marie Guerra, and Jean-Pierre Richard. Improved stability conditions for sampled data systems with jitter. In *IFAC Symposium on Robust Control Design*, 2009.

[HKPR11] Laurentiu Hetel, Alexandre Kruszewski, Wilfrid Perruquetti, and Jean-Pierre Richard. Discrete-time switched systems, set-theoretic analysis and quasi-quadratic Lyapunov functions. In *19th Mediterranean Conference on Control & Automation (MED)*, page cd, Corfou, Greece, June 2011.

[HKR09] Laurentiu Hetel, Alexandre Kruszewski, and Jean-Pierre Richard. About the lyapunov exponent of sampled-data systems with non-uniform sampling. In *IFAC Workshop on Time Delay Systems*, 2009.

[JFKR09] Wenjuan Jiang, Emilia Fridman, Alexandre Kruszewski, and Jean-Pierre Richard. Switching controller for stabilization of linear systems with switched time-varying delays. In *CDC'09, 48th IEEE Conference on Decision and Control*, Shanghai, China, 2009.

[JKFR10] Wenjuan Jiang, Alexandre Kruszewski, Emilia Fridman, and Jean-Pierre Richard. Delay dependent stability analysis of interval time-delay systems. In *IFAC Workshop on Time Delay Systems*, 2010.

[JKRT09a] Wenjuan Jiang, Alexandre Kruszewski, Jean-Pierre Richard, and Armand Toguyeni. A remote observer and controller with adaptation to the network Quality of Service. In *European Control Conference*, 2009.

[JKRT09b] Wenjuan Jiang, Alexandre Kruszewski, Jean-Pierre Richard, and Armand Toguyeni. Networked control and observation for master-slave systems. In Balakumar Balachandran, Kalmár-Nagy Tamás, and David E Gilsinn, editors, *Topics in Delay Differential Equations: Recent Advances and New Directions*, pages 1–23. Springer Verlag, 2009.

[JRF10] Cédric Join, Gérard Robert, and Michel Fliess. Model-free based water level control for hydroelectric power plants. In *IFAC Conference on Control Methodologies and Technologies for Energy Efficiency*, 2010.

[KBBB12] Yassine Khaled, Jean-Pierre Barbot, Djamila Benmerzouk, and Krishna Busawon. A new type of impulsive observer for hyperchaotic system. In *IFAC Conference on analysis and control of chaotic systems*, Cancún, México, Mexico, June 2012.

[KBX10] W. Kang, Jean-Pierre Barbot, and L. Xu. On the observability of nonlinear and switched system. In *Emergent Problems in Nonlinear Systems and Control*. Springer, 2010.

[KMR12] Lothar Kiltz, Mamadou Mboup, and Joachim Rudolph. Fault diagnosis on a magnetically supported plate. In *1st International Conference Systems and Computer Science*, Lille, France, August 2012.

[LGP09] Dayan Liu, Olivier Gibaru, and Wilfrid Perruquetti. Error analysis for a class of numerical differentiator: Application to state observation. In *CDC'09, 48th IEEE Conference on Decision and Control*, Shanghai, China, 2009.

[LGP11] Dayan Liu, Olivier Gibaru, and Wilfrid Perruquetti. Parameters estimation of a noisy sinusoidal signal with time-varying amplitude. In *19th Mediterranean Conference on Control and Automation (2011)*, Corfou, Greece, June 2011.

[LGP12] Dayan Liu, Olivier Gibaru, and Wilfrid Perruquetti. Non-asymptotic fractional order differentiators via an algebraic parametric method. In *1st International Conference on Systems and Computer Science*, Villeneuve d'ascq, France, August 2012.

[LGPLK12] Dayan Liu, Olivier Gibaru, Wilfrid Perruquetti, and Taous-Meriem Laleg-Kirati. Fractional order differentiation by integration with Jacobi polynomials. In *51st IEEE Conference on Decision and Control*, Hawaii, United States, December 2012.

[MAJH09] Abdouramane Moussa Ali, Cédric Join, and Frédéric Hamelin. Fault diagnosis of uncertain linear system using structural knowledge. In *IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes, Safeprocess 2009*, 2009.

[MJF+10] Loïc Michel, Cédric Join, Michel Fliess, Pierre Sicard, and Ahmed Chériti. Model-free control of dc/dc converters. In *IEEE Workshop on Control and Modeling for Power Electronics*, 2010.

[MMP09] Tomas Menard, Emmanuel Moulay, and Wilfrid Perruquetti. Global finite-time observers for non linear systems. In *CDC'09, 48th IEEE Conference on Decision and Control*, Shanghai, China, 2009.

[MMP11] Tomas Menard, Emmanuel Moulay, and Wilfrid Perruquetti. Homogeneous approximations for multi-output systems and local observability. In *IFAC'11, 18th IFAC World Congress*, page 6, Milano, Italy, September 2011.

[OBGM12] Marouene Oueslati, Richard Béarée, Olivier Gibaru, and George Moraru. Improving the Dynamic Accuracy of Elastic Industrial Robot Joint by Algebraic Identification Approach. In *1st International Conference on Systems and Computer Science*, LILLE, France, 2012.

[OHR12] Hassan Omran, Laurentiu Hetel, and Jean-Pierre Richard. Local Stability of Bilinear Systems with Asynchronous Sampling. In *ADHS'12, 4th IFAC Conference on Analysis and Design of Hybrid Systems*, pages 19–24, Eindhoven, Netherlands, June 2012.

[OHRLL12] Hassan Omran, Laurentiu Hetel, Jean-Pierre Richard, and Françoise Lamnabhi-Lagarrigue. Stability of bilinear sampled-data systems with an emulation of static state feedback. In *CDC'12, 51st IEEE Conference on Decision and Control*, Maui, Hawai, USA, December 2012.

[PVM+12] Wilfrid Perruquetti, Bonnet Vincent, Mamadou Mboup, Rosane Ushirobira, and Philippe Fraisse. An algebraic approach for human posture estimation in the sagittal plane using accelerometer noisy signal. In *CDC'12, 51st IEEE Conference on Decision and Control*, Maui, Hawaii, USA, September 2012.

[RDFE12] Héctor Ríos, Jorge Davila, Leonid Fridman, and Denis Efimov. State estimation for linear switched systems with unstable invariant zeros and unknown inputs. In *CDC'12, 51st IEEE Conference on Decision and Control*, Maui, Hawai, USA, December 2012.

[RED+12a] Héctor Ríos, Denis Efimov, Jorge Davila, Tarek Raissi, Leonid Fridman, and Ali Zolghadri. State Estimation and Fault Detection for Linear Switched Systems with Unstable Internal Dynamics. In *SafeProcess-2012, 8th IFAC Symposium on Fault Detection, Supervision and Safety for Technical Processes*, Mexico City, August 2012.

[RED+12b] Héctor Ríos, Denis Efimov, Jorge Davila, Tarek Raissi, Leonid Fridman, and Ali Zolghadri. State Estimation for Linear Switched Systems with Unknown Inputs. In *ADHS'12, 4th IFAC Conference on Analysis and Design of Hybrid Systems*, Eindhoven, Netherlands, June 2012.

[RFJ11] Samer Riachy, Michel Fliess, and Cédric Join. High-order sliding modes and intelligent PID controllers: First steps toward a practical comparison. In *IFAC'11, 18th IFAC World Congress*, Milano, Italy, August 2011.

[RMR11] Samer Riachy, Mamadou Mboup, and Jean-Pierre Richard. Numerical differentiation on irregular grids. In *IFAC'11, 18th IFAC World Congress*, Milano, Italy, August 2011.

[SFRS09] Alexandre Seuret, Thierry Floquet, Jean-Pierre Richard, and Sarah Spurgeon. Observer design for systems with non small and unknown time-varying delay. In Jean-Jacques Loiseau, Wim Michiels, Silviu-Ilian Niculescu, and Rifat Sipahi, editors, *Topics in Time-Delay Systems: Analysis, Algorithms and Control*, volume 388 of *LNCIS, Lecture Notes in Control and Information Sciences*, pages 233–242. Springer Verlag, 2009.

[SKP11] Hugues Sert, Annemarie Kokosy, and Wilfrid Perruquetti. A single landmark based localization algorithm for non-holonomic mobile robots. In *IEEE International Conference on Robotics and Automation*, Shanghai, China, May 2011.

[SLG+10] Sebastien Solvar, Vu Le, Malek Ghanes, Jean-Pierre Barbot, and Gaëtan Santomenna. Sensorless second order sliding mode observer for induction motor. In *IEEE Control Conference Application*, 2010.

[SPK+12] Hugues Sert, Wilfrid Perruquetti, Annemarie Kokosy, Xin Jin, and Jorge Palos. Localizability of unicycle mobiles robots: an algebraic point of view. In *International Conference on Intelligent Robots and Systems*, Vilamoura, Algrave, Portugal, October 2012.

[SRB12] Oscar Salas, Samer Riachy, and Jean-Pierre Barbot. Nonlinear controller for a modified design of the ball & beam system. In *ASME, ESDA 2012*, Nantes, France, February 2012.

[SRZE12] Ramatou Seydou, Tarek Raissi, Ali Zolghadri, and Denis Efimov. Robust Fault Diagnosis with Interval Continuous-time Parity Equations. In *SafeProcess-2012, 8th IFAC Symposium on Fault Detection, Supervision and Safety for Technical Processes*, Mexico City, August 2012.

[TBZH12] Ramdane Tami, Driss Boutat, Gang Zheng, and Hassan Hammouri. Une forme normale pour l'observateur d'ordre réduit. In *CIFA 2012*, Grenoble, France, July 2012.

[TFBP09a] Yang Tian, Thierry Floquet, Lotfi Belkoura, and Wilfrid Perruquetti. Algebraic switching time identification for a class of linear hybrid systems. In *ADHS'09, 3rd IFAC Conference on Analysis and Design of Hybrid Systems*, 2009.

[TFBP09b] Yang Tian, Thierry Floquet, Lotfi Belkoura, and Wilfrid Perruquetti. Switching time estimation for linear switched systems: an algebraic approach. In *CDC'09, 48th IEEE Conference on Decision and Control*, Shanghai, China, 2009.

[TM09] Zoran Tiganj and Mamadou Mboup. Spike detection and sorting: combining algebraic differentiation with ICA. In *ICA'2009, 8th International Conference of Independent Component Analysis and Signal Separation*, Paraty, Brazil, March 2009.

[TMCK12] Zoran Tiganj, Mamadou Mboup, Sylvain Chevallier, and Emmanuel Kalunga. Online frequency band estimation and change-point detection. In *1st International Conference Systems and Computer Science*, Lille, France, August 2012.

[TMPB10] Zoran Tiganj, Mamadou Mboup, Christophe Pouzat, and Lotfi Belkoura. An algebraic method for eye blink artifacts detection in single channel eeg recordings. In *IEEE International Conference on Biomagnetism advances in Biomagnetism*, 2010.

[UPMF12] Rosane Ushirobira, Wilfrid Perruquetti, Mamadou Mboup, and Michel Fliess. Algebraic parameter estimation of a biased sinusoidal waveform signal from noisy data. In *SYSID'12, 16th IFAC Symposium on System Identification*, Brussels, Belgium, 2012.

[VDNFM10] Jorge Villagra, Brigitte D'Andrea Novel, Michel Fliess, and Hugues Mounier. An algebraic approach for maximum friction estimation. In *IFAC Symposium on Nonlinear Control Systems*, 2010.

[YBB+12] Lei Yu, Jean-Pierre Barbot, Djamila Benmerzouk, Driss Boutat, Thierry Floquet, and Gang Zheng. Discussion about sliding mode algorithms, Zeno phenomena and observability. In Fridman Leonid; Moreno Jaime; Iriarte Rafael (Eds.), editor, *Lecture Notes in Control and Information Sciences, 2012, Volume 412*. Springer, February 2012.

[YBBB09] Lei Yu, Jean-Pierre Barbot, Driss Boutat, and D Benmerzouk. Observability Normal Forms for a class of switched systems with Zeno phenomena. In *ACC'2009, IEEE American Control Conference*, St Louis, USA, 2009.

[YBF09] Lei Yu, Jean-Pierre Barbot, and Thierry Floquet. Tire/road contact condition identification using algebraic numerical differentiation. In *SYSID'09, 15th IFAC Symposium on System Identification*, St Malo, France, 2009.

[YBZS10] Lei Yu, Jean-Pierre Barbot, Gang Zheng, and Hong Sun. Toeplitz-structured chaotic sensing matrix for compressive sensing. In *IEEE, IET International*

Symposium on Communication Systems, Netowrks and Digital Signal Processing, 2010.

[YSBZ11] Lei Yu, Hong Sun, Jean-Pierre Barbot, and Gang Zheng. Bayesian Compressive Sensing for Clustered Sparse Signals. In *ICASSP*, Prague, Czech Republic, May 2011.

[YZB+10] L Yu, G. Zheng, D. Boutat, D. Benmerzouk, Jean-Pierre Barbot, and T. Floquet. Discussion about sliding modes algorithms, zeno phenomena and observability of switched systems. In *VSS'2010, IFAC International Workshop on Variable Structure Systems*, 2010.

[ZB10] Gang Zheng and Driss Boutat. Reduced observers and its application to synchronization of chaotic systems. In *IEEE, IET International Symposium on Communication Systems, Networks and Digital Signal Processing*, 2010.

[ZBB+10a] Gang Zheng, Jean-Pierre Barbot, Driss Boutat, Thierry Floquet, and Jean-Pierre Richard. Causal observability of nonlinear time-delay systems with unknown inputs. In *IEEE Conference on Decision & Control*, 2010.

[ZBB+10b] Gang Zheng, Jean-Pierre Barbot, Driss Boutat, Thierry Floquet, and Jean-Pierre Richard. Finite time observation of nonlinear time-delay systems with unknown inputs. In *IFAC Symposium on Nonlinear Control Systems*, 2010.

[ZBB11] Gang Zheng, Jean-Pierre Barbot, and Driss Boutat. Delay identification for nonlinear time-delay systems. In *IEEE CDC-ECC'11, 50th IEEE Conference on Decision and Control and European Control Conference* , Orlando, USA, December 2011.

[ZBB12] Gang Zheng, Driss Boutat, and Jean-Pierre Barbot. Finite time Observer design for linear switched system. In *The 31st IEEE Chinese Control Conference*, Hefei, China, July 2012.

[ZG09] Gang Zheng and Antoine Girard. Bounded and unbounded safety verification using bisimulation metrics. In *12th International Conference on Hybrid Systems: Computation and Control*, 2009.

[ZGBN10] Dalila Zaltni, Malek Ghanes, Jean-Pierre Barbot, and Abdelkrim Naceur. Synchronous motor observability study and an improved zero-speed position estimation design. In *CDC'10, 49th IEEE Conference on Decision and Control*, 2010.

[ZKR11] Bo Zhang, Alexandre Kruszewski, and Jean-Pierre Richard. Tracking improvement based on the Proxy control scheme for bilateral teleoperation system under time-varying delays. In *16th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA)*, Toulouse, France, September 2011.

[ZKR12a] Bo Zhang, Alexandre Kruszewski, and Jean-Pierre Richard. H_∞ Control Design for Novel Teleoperation System Scheme: A Discrete Approach. In *10th IFAC Workshop on Time Delay Systems*, Boston, United States, June 2012.

[ZKR12b] Bo Zhang, Alexandre Kruszewski, and Jean-Pierre Richard. $H_{-}\infty$ Control of Delayed Teleoperation Systems under Polytopic-Type Uncertainties. In *20th Mediterranean Conference on Control and Automation*, Spain, July 2012.

[ZKR12c] Bo Zhang, Alexandre Kruszewski, and Jean-Pierre Richard. $H_{-}\infty$ Robust Control Design for Teleoperation Systems. In *7th IFAC Symposium on Robust Control Design*, Aalborg, Denmark, June 2012.

[ZOPR11a] Gang Zheng, Yuri Orlov, Wilfrid Perruquetti, and Jean-Pierre Richard. Finite-time observer-based control of linear impulsive systems with persistently acting impact. In *IFAC'11, 18th IFAC World Congress*, Milano, Italy, August 2011.

[ZOPR11b] Gang Zheng, Yuri Orlov, Wilfrid Perruquetti, and Jean-Pierre Richard. Finite time observer design for nonlinear impulsive systems with impact perturbation. In *IEEE CCDC'11, 23rd Chinese Control and Decision Conference*, Mianyan, China, May 2011.

[ZWB09] Gang Zheng, Aggoune Woihida, and Jean-Pierre Barbot. Analogue private communication based on hybrid chaotic systems with delays. In *IFAC Conference on Analysis and Control of Chaotic Systems*, 2009.

[ZYBB09] Gang Zheng, Lei Yu, Driss Boutat, and Jean-Pierre Barbot. Algebraic observer for a class of switched systems with zeno phenomenon. In *CDC'09, 48th IEEE Conference on Decision and Control*, Shanghai, China, 2009.

6.6 Publications in French, or in national conferences

[ADB12] Bilal Amghar, Moumen Darcherif, and Jean-Pierre Barbot. Modélisation et commande d'un convertisseur multicellulaire parallèle par réseau de Petri. In *IEEE CIFA 2012, 7ème Conférence Internationale Francophone d'Automatique*, Grenoble, France, July 2012.

[AFIJ11] Hassane Abouaissa, Michel Fliess, Violina Iordanova, and Cédric Join. Towards a nonlinear characterization of a freeway network. In *3èmes Journées Identification et Modélisation Expérimentale, JIME'2011*, Douai, France, April 2011.

[BBBK10] S. Bououden, D. Boutat, Jean-Pierre Barbot, and F. Kratz. Quelques formes normales non linéaires plates. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[BRMR10] Yara Bachalany, Samer Riachy, Mamadou Mboup, and Jean-Pierre Richard. Différenciation numérique multivariable II : Projection orthogonale et filtrage à RIF. In *IEEE Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[BZBBD11] Driss Boutat, Gang Zheng, Latifa Boutat-Baddas, and Mohamed Darouach. Formes normales singulières non linéaires : un nouvel observateur. In *14e Rencontres du non-linéaire*, Paris, France, March 2011.

[BZBBD12] Driss Boutat, Gang Zheng, Latifa Boutat-Baddas, and Mohamed Darouach. Forme normale d'observabilité pour une classe de systèmes non linéaires singuliers. In *IEEE CIFA 2012, 7ème Conférence Internationale Francophone d'Automatique*, Grenoble, France, July 2012.

[DBF12] Romain Delpoux, Marc Bodson, and Thierry Floquet. Estimation des paramètres d'un moteur pas-à-pas sans capteur mécanique. In *IEEE CIFA 2012, 7ème Conférence Internationale Francophone d'Automatique*, Grenoble, France, 2012.

[Del11] Romain Delpoux. Estimation en ligne de paramètres d'un palier magnétique. In *4ieme JD-MACS*, Marseille, France, June 2011.

[DMRF+12] Jérôme De Miras, Samer Riachy, Michel Fliess, Cédric Join, and Stéphane Bonnet. Vers une commande sans modèle d'un palier magnétique – First steps towards a model-free control of a magnetic bearing. In *IEEE CIFA 2012, 7ème Conférence Internationale Francophone d'Automatique*, Grenoble, France, 2012.

[DNBF+10] Brigitte D'Andrea Novel, Clément Boussard, Michel Fliess, Oussama El Hamzaoui, Hugues Mounier, and Bruno Steux. Commande sans modèle de la vitesse longitudinale d'un véhicule électrique. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[ERZ12] Denis Efimov, Tarek Raissi, and Ali Zolghadri. Stabilisation robuste d'une classe de systèmes non linéaires incertains. *Journal Européen des Systèmes Automatisés*, 4–5:335–348, September 2012.

[FFR10] Christophe Fiter, Thierry Floquet, and Joachim Rudolph. Commande sans capteur du moteur pas-à-pas à base de modes glissants d'ordre supérieur. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[FHPR11] Christophe Fiter, Laurentiu Hetel, Wilfrid Perruquetti, and Jean-Pierre Richard. échantillonnage dépendant de l'état pour les systèmes avec perturbations et retards. In *MSR 2011, 8ème Colloque Francophone sur la Modélisation des Systèmes Réactifs*, Lille, France, November 2011.

[FJ09] Michel Fliess and Cédric Join. Systematic risk analysis: first steps towards a new definition of beta. In *COGIS 2009, COGnitive systems with Interactive Sensors Conference*, Paris, France, Nov. 2009.

[FJR11] Michel Fliess, Cédric Join, and Samer Riachy. Nothing is as Practical as a Good Theory: Model-Free Control. In *4èmes Journées Doctorales / Journées Nationales MACS, JD-JN-MACS*, Marseille, France, June 2011.

[GCDNFM09] Francisco De Asís García Collado, Brigitte D'Andréa Novel, Michel Fliess, and Hugues Mounier. Analyse fréquentielle des dérivateurs algébriques. In *XXIIe Colloque GRETSI*, 2009.

[HGB10] Hamid Hamiche, Malek Ghanes, and Jean-Pierre Barbot. Systèmes dynamiques hybrides pour les communications privées. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[ITBK10] Kaouther Ibn Taarit, Lotfi Belkoura, and Mekki Ksouri. Estimation en ligne par approche algébrique : application au cas des frottements secs. In *IEEE Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[JRF10] Cédric Join, Gérard Robert, and Michel Fliess. Vers une commande sans modèle pour aménagements hydroélectriques en cascade. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[KBB12a] Yassine Khaled, Jean-Pierre Barbot, and Djamila Benmerzouk. Un nouveau type d'observateur impulsionnel. In *IEEE CIFA 2012, 7ème Conférence Internationale Francophone d'Automatique*, Grenoble, France, July 2012.

[KBB+12b] Yassine Khaled, Jean-Pierre Barbot, Djamila Benmerzouk, Krishna Busawon, and Malek Ghanes. Strange attractor identification and state observation under sparse measurements. In *Environment-Friendly Energies and Applications*, Newcastle, upon tyne, United Kingdom, June 2012.

[MAJH09] Abdouramane Moussa Ali, Cédric Join, and Frédéric Hamelin. Une méthode algébrique de diagnostic de défauts. In *Journées Doctorales / Journées Nationales MACS*, 2009.

[MAJH11] Abdouramane Moussa Ali, Cédric Join, and Frédéric Hamelin. Diagnostic des systèmes dynamiques linéaires sans modèle explicite. *Journal Européen des Systèmes Automatisés*, (Spécial : Nouvelles tendances en automatique):1, January 2011.

[MFHR12] Sonia Maalej, Christophe Fiter, Laurentiu Hetel, and Jean-Pierre Richard. Echantillonnage dépendant de l'état : une approche discrète. In *IEEE CIFA 2012, 7ème Conférence Internationale Francophone d'Automatique*, Grenoble, France, July 2012.

[OBNG09] A Olabi, R Béarée, E Nyiri, and Olivier Gibaru. L1 parametric interpolation and feedrate planning for machining robots. In *Swedish Production Symposium Göteborg, Sweden*, 2009.

[RBMR10] Samer Riachy, Yara Bachalany, Mamadou Mboup, and Jean-Pierre Richard. Différenciation numérique multivariable I : estimateurs algébriques et structure. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[RFJB10] Samer Riachy, Michel Fliess, Cédric Join, and Jean-Pierre Barbot. Vers une simplification de la commande non linéaire : l'exemple d'un avion à décollage vertical. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[SGBS10] Sebastien Solvar, Malek Ghanes, Jean-Pierre Barbot, and Gaëtan Santomenna. Observateur à mode glissant d'ordre 2 pour la machine asynchrone sans capteur mécanique. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.

[Tia09] Yang Tian. Estimation d'état pour des systèmes linéaires : approche algébrique. In *Journées Doctorales / Journées Nationales MACS*, 2009.

[UPMF11] Rosane Ushirobira, Wilfrid Perruquetti, Mamadou Mboup, and Michel Fliess. Estimation algébrique des paramètres intrinsèques d'un signal sinusoïdal biaisé en environnement bruité. In *Gretsi*, Bordeaux, France, September 2011.

[ZGB10] D. Zaltni, M. Ghanes, and Jean-Pierre Barbot. Observateur super twisting pour un moteur synchrone à aimants permanents montés en surface. In *IEEE CIFA 2010, 6ème Conférence Internationale Francophone d'Automatique*, Nancy, France, 2010.