IN PARTNERSHIP WITH:
CNRS

Institut polytechnique de Grenoble

Université Grenoble Alpes

Activity Report 2016

Project-Team NECS

Networked Controlled Systems

IN COLLABORATION WITH: Grenoble Image Parole Signal Automatique (GIPSA)

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Optimization and control of dynamic systems

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Project-Team NECS

Creation of the Project-Team: 2007 January 01

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1. Members

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2. Overall Objectives

2.1. Context and overall goal of the project

NECS is a joint INRIA/GIPSA-LAB team, bi-located at the INRIA-Rhône-Alpes Center in Montbonnot and at GIPSA-LAB (http://www.gipsa-lab.grenoble-inp.fr) in the Saint-Martin-d'Hères campus, both locations being in the Grenoble area. NECS team's research is focused on Networked Controlled Systems.
The research field of Networked Controlled Systems deals with feedback systems controlled over networks, but also concerns systems that naturally exhibit a network structure (e.g., traffic, electrical networks, etc.).

The first system category results from the arrival of new control problems posed by the consideration of several factors, such as: new technological components (e.g., wireless, RF, communications, local networks, etc.), increase of systems complexity (e.g., increase in vehicle components), the distributed location of sensor and actuator, and computation constraints imposed by their embedded nature. In this class of systems, the way that the information is transferred and processed (information constraints), and the manner in which the computation resources are used (resources management), have a substantial impact in the resulting stability and performance properties of the feedback controlled systems. One main challenge here is the co-design of control together with one or more other components of different nature. The NECS team has tackled co-design problems concerning:

- Control under communications and network constraints;
- Control under resources constraints.

The second category of systems is motivated by the natural network structure in which the original systems are built. Examples are biologic networks, traffic networks, and electrical networks. The complex nature of such systems makes the classical centralized view of the control design obsolete. New distributed and/or collaborative control and estimation algorithms need to be devised as a response to this complexity. Even if the dynamic behavior of each individual system is still important, the aggregated behavior (at some macroscopic level), and its interconnection graph properties become of dominant importance. To build up this research domain, the team has put a strong focus on traffic (vehicular) networks, and in some associated research topics capturing problems that are specific to these complex network systems (distributed estimation, graph-discovering, etc).

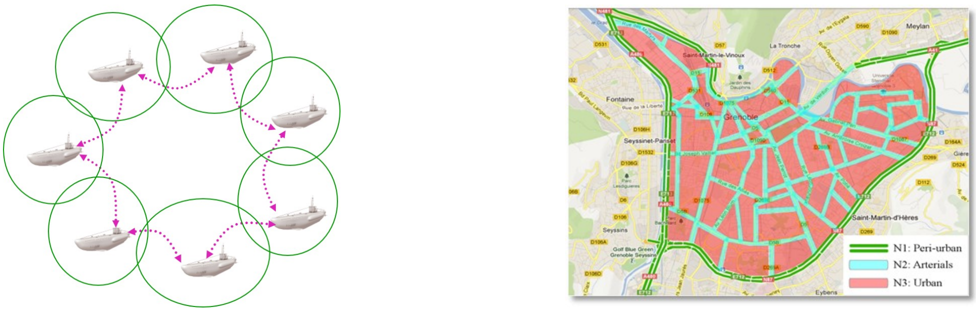

Figure 1. Left: a system of autonomous agents, where the network structure is created by the feedback, used to coordinate agents towards a common goal. Right: a system naturally having a network structure.

3. Research Program

3.1. Introduction

NECS team deals with Networked Control Systems. Since its foundation in 2007, the team has been addressing issues of control under imperfections and constraints deriving from the network (limited computation resources of the embedded systems, delays and errors due to communication, limited energy resources), proposing co-design strategies. The team has recently moved its focus towards general problems on *control of network systems*, which involve the analysis and control of dynamical systems with a network structure or whose operation is supported by networks. This is a research domain with substantial growth and is now recognized as a priority sector by the IEEE Control Systems Society: IEEE has started a new journal, IEEE Transactions on Control of Network Systems, whose first issue appeared in 2014.

More in detail, the research program of NECS team is along lines described in the following sections.

3.2. Distributed estimation and data fusion in network systems

This research topic concerns distributed data combination from multiple sources (sensors) and related information fusion, to achieve more specific inference than could be achieved by using a single source (sensor). It plays an essential role in many networked applications, such as communication, networked control, monitoring, and surveillance. Distributed estimation has already been considered in the team. We wish to capitalize and strengthen these activities by focusing on integration of heterogeneous, multidimensional, and large data sets:

- Heterogeneity and large data sets. This issue constitutes a clearly identified challenge for the future. Indeed, heterogeneity comes from the fact that data are given in many forms, refer to different scales, and carry different information. Therefore, data fusion and integration will be achieved by developing new multi-perception mathematical models that can allow tracking continuous (macroscopic) and discrete (microscopic) dynamics under a unified framework while making different scales interact with each other. More precisely, many scales are considered at the same time, and they evolve following a unique fully-integrated dynamics generated by the interactions of the scales. The new multi-perception models will be integrated to forecast, estimate and broadcast useful system states in a distributed way. Targeted applications include traffic networks and navigation, and concern recent grant proposals that team has elaborated, among which the SPEEDD EU FP7 project, which has started in February 2014.

- Multidimensionality. This issue concerns the analysis and the processing of multidimensional data, organized in multiway array, in a distributed way. Robustness of previously-developed algorithms will be studied. In particular, the issue of missing data will be taken into account. In addition, since the considered multidimensional data are generated by dynamic systems, dynamic analysis of multiway array (or tensors) will be considered. The targeted applications concern distributed detection in complex networks and distributed signal processing for collaborative networks. This topic is developed in strong collaboration with UFC (Brazil).

3.3. Network systems and graph analysis

This is a research topic at the boundaries between graph theory and dynamical systems theory.

A first main line of research will be to study complex systems whose interactions are modeled with graphs, and to unveil the effect of the graph topology on system-theoretic properties such as observability or controllability. In particular, on-going work concerns observability of graph-based systems: after preliminary results concerning consensus systems over distance-regular graphs, the aim is to extend results to more general networks. A special focus will be on the notion of 'generic properties', namely properties which depend only on the underlying graph describing the sparsity pattern, and hold true almost surely with a random choice of the non-zero coefficients. Further work will be to explore situations in which there is the need for new notions different from the classical observability or controllability. For example, in opinion-forming in social networks or in formation of birds flocks, the potential leader might have a goal different from classical controllability. On the one hand, his goal might be much less ambitious than the classical one of driving the system to any possible state (e.g., he might want to drive everybody near its own opinion, only, and not to any combination of different individual opinions), and on the other hand he might have much weaker tools to construct his control input (e.g., he might not know the whole system's dynamics, but only some local partial information). Another example is the question of detectability of an unknown input under the assumption that such an input has a sparsity constraint, a question arising from the fact that a cyber-physical attack might be modeled as an input aiming at controlling the system's state, and that limitations in the capabilities of the attacker might be modeled as a sparsity constraint on the input.

A second line of research will concern graph discovery, namely algorithms aiming at reconstructing some properties of the graph (such as the number of vertices, the diameter, the degree distribution, or spectral properties such as the eigenvalues of the graph Laplacian), using some measurements of quantities related to a dynamical system associated with the graph. It will be particularly challenging to consider directed graphs, and to impose that the algorithm is anonymous, i.e., that it does not makes use of labels identifying the different agents associated with vertices.

3.4. Collaborative and distributed network control

This research line deals with the problem of designing controllers with a limited use of the network information (i.e. with restricted feedback), and with the aim to reach a pre-specified global behavior. This is in contrast to centralized controllers that use the whole system information and compute the control law at some central node. Collaborative control has already been explored in the team in connection with the underwater robot fleet, and to some extent with the source seeking problem. It remains however a certain number of challenging problems that the team wishes to address:

- Design of control with limited information, able to lead to desired global behaviors. Here the graph structure is imposed by the problem, and we aim to design the "best" possible control under such a graph constraint [1]. The team would like to explore further this research line, targeting a better understanding of possible metrics to be used as a target for optimal control design. In particular, and in connection with the traffic application, the long-standing open problem of ramp metering control under minimum information will be addressed.

[1] Such a problem has been previously addressed in some specific applications, particularly robot fleets, and only few recent theoretical works have initiated a more systematic system-theoretic study of sparsity-constrained system realization theory and of sparsity-constrained feedback control.

- Clustering control for large networks. For large and complex systems composed of several sub-networks, feedback design is usually treated at the sub-network level, and most of the times without taking into account natural interconnections between sub-networks. The team is exploring new control strategies, exploiting the emergent behaviors resulting from new interconnections between the network components. This requires first to build network models operating in aggregated clusters, and then to re-formulate problems where the control can be designed using the cluster boundaries rather than individual control loops inside of each network. Examples can be found in the transportation application domain, where a significant challenge will be to obtain dynamic partitioning and clustering of heterogeneous networks in homogeneous sub-networks, and then to control the perimeter flows of the clusters to optimize the network operation. This topic is at the core of the Advanced ERC project Scale-FreeBack.

3.5. Transportation networks

This is currently the main application domain of the NECS team. Several interesting problems in this area capture many of the generic networks problems described above. For example, distributed collaborative algorithms can be devised for ramp-metering control and traffic-density balancing can be achieved using consensus concepts. The team is already strongly involved in this field, both this theoretical works on traffic modeling, prediction and control, and with the Grenoble Traffic Lab platform. These activities will be continued and strengthened, also thanks to the contributions from the new staff member M.L. Delle Monache.

4. Application Domains

4.1. A large variety of application domains

Sensor and actuator networks are ubiquitous in modern world, thanks to the advent of cheap small devices endowed with communication and computation capabilities. Potential application domains for research in networked control and in distributed estimation are extremely various, and include the following examples.

- Intelligent buildings, where sensor information on CO_2 concentration, temperature, room occupancy, etc. can be used to control the heating, ventilation and air conditioning (HVAC) system under multi-objective considerations of comfort, air quality, and energy consumption.
- Smart grids: the operation of electrical networks is changing from a centralized optimization framework towards more distributed and adaptive protocols, due to the high number of small local energy producers (e.g., solar panels on house roofs) that now interact with the classic large power-plants.
- Disaster relief operations, where data collected by sensor networks can be used to guide the actions of human operators and/or to operate automated rescue equipment.
- Surveillance using swarms of Unmanned Aerial Vehicles (UAVs), where sensor information (from sensors on the ground and/or on-board) can be used to guide the UAVs to accomplish their mission.
- Environmental monitoring and exploration using self-organized fleets of Autonomous Underwater Vehicles (AUVs), collaborating in order to reach a goal such as finding a pollutant source or tracing a seabed map.
- Infrastructure security and protection using smart camera networks, where the images collected are shared among the cameras and used to control the cameras themselves (pan-tilt-zoom) and ensure tracking of potential threats.

In particular, NECS team is currently focusing in the areas described in detail below.

4.2. Intelligent transportation systems

Throughout the world, roadways are notorious for their congestion, from dense urban network to large freeway systems. This situation tends to get worse over time due to the continuous increase of transportation demand whereas public investments are decreasing and space is lacking to build new infrastructures. The most obvious impact of traffic congestion for citizens is the increase of travel times and fuel consumption. Another critical effect is that infrastructures are not operated at their capacity during congestion, implying that fewer vehicles are served than the amount they were designed for. Using macroscopic fluid-like models, the NECS team has initiated new researches to develop innovative traffic management policies able to improve the infrastructure operations. The research activity is on two main challenges: (1) modeling and forecasting, so as to provide accurate information to users, e.g., travel times; and (2) control, via ramp-metering and/or variable speed limits. The Grenoble Traffic Lab (see http://necs.inrialpes.fr/pages/grenoble-traffic-lab.php) is an experimental platform, collecting traffic infrastructure information in real time from Grenoble South Ring, together with innovative software e.g. for travel-time prediciton, and a show-case where to graphically illustrate results to the end-user. This activity is done in close collaboration with local traffic authorities (DIR-CE, CG38, La Metro), and with the start-up company Karrus (http://www.karrus-its.com/)

4.3. Inertial navigation

Since 2014, the team is exploring techniques for pedestrian navigation and algorithms for attitude estimation, in collaboration with the Tyrex team (Inria-Rhône-Alpes). The goal is to use such algorithms in augmented reality with smartphones. Inertial navigation is a research area related to the determination of 3D attitude and position of a rigid body. Attitude estimation is usually based on data fusion from accelerometers, magnetometers and gyroscopes, sensors that we find usually in smartphones. These algorithms can be used also to provide guidance to pedestrians, e.g., to first responders after a disaster, or to blind people walking in unfamiliar environments. This tasks is particularly challenging for indoor navigation, where no GPS is available.

4.4. Multi-robot collaborative coordination

Due to the cost or the risks of using human operators, many tasks of exploration, or of after-disaster intervention are performed by un-manned drones. When communication becomes difficult, e.g., under water, or in spatial exploration, such robots must be autonomous. Complex tasks, such as exploration, or patrolling, or rescue, cannot be achieved by a single robot, and require a self-coordinated fleet of autonomous devices. NECS team has studied the marine research application, where a fleet of Autonomous Underwater Vehicles (AUVs) self-organize in a formation, adapting to the environment, and reaching a source, e.g., of a pollutant. This has been done in collaboration with IFREMER, within the national project ANR CONNECT and the European FP7 project FeedNetBack [1]. On-going research in the team concerns source localization, with a fleet of mobile robots, including wheeled land vehicles.

4.5. Control design of hydroelectric powerplants

We have started a collaboration with ALSTOM HYDRO, on collaborative and reconfigurable resilient control design of hydroelectric power plants. This work is within the framework of the joint laboratory Inria/ALSTOM (see http://www.inria.fr/innovation/actualites/laboratoire-commun-inria-alstom). A first concrete collaboration has been established with the CIFRE thesis of Simon Gerwig, who has studied how to improve performance of a hydro-electric power-plant outside its design operation conditions, by adaptive cancellation of oscillations that occur in such operation range.

5. Highlights of the Year

5.1. Highlights of the Year

- C. Canudas de Wit has been elevated to the grade of Fellow of the IEEE.
- C. Canudas de Wit has been named a Fellow of the IFAC (International Federation of Automatic Control).
- C. Canudas de Wit has received an ERC Advanced Grant for the project “Scale-FreeBack”.
- The GTL platform and website went public in November.
- G. De Nunzio received the “Prix de thèse 2016 de la COMUE Université Grenoble Alpes” for his doctoral work, co-advised by C. Canudas de Wit and P. Moulin.
- A. Kibangou defended his HDR (Habilitation à diriger les recherches).
- P. Frasca and M.L. Delle Monache have joined the team as permanent researchers.
- H. Fourati has edited the book “Recent Advances on Multisensor Attitude and Heading Estimation: Fundamental Concepts and Applications”, by Taylor & Francis Group LLC.

6. New Software and Platforms

6.1. GTL

Grenoble Traffic Lab
FUNCTIONAL DESCRIPTION

The Grenoble Traffic Lab (GTL) initiative, led by the NeCS team, is a real-time traffic data Center (platform) that collects traffic road infrastructure information in real-time with minimum latency and fast sampling periods. The main elements of the GTL are: a real-time data-base, a show room, and a calibrated micro-simulator of the Grenoble South Ring. Sensed information comes from a dense wireless sensor network deployed on Grenoble South Ring, providing macroscopic traffic signals such as flows, velocities, densities, and magnetic signatures. This sensor network was set in place in collaboration with Inria spin-off Karrus-ITS, local traffic authorities (DIR-CE, CG38, La Metro), and specialized traffic research centers. In addition to real data, the project also uses simulated data, in order to validate models and to test the ramp-metering, the micro-simulator is a commercial software (developed by TSS AIMSUN ©). More details at http://necs.inrialpes.fr/pages/grenoble-traffic-lab.php.

- Participants: Carlos Canudas De Wit, Iker Bellicot, Pascal Bellemain, Dominik Pisarski, Alain Kibangou, Hassen Fourati, Fabio Morbidi, Federica Garin, Andres Alberto Ladino Lopez, Pietro Grandinetti, Enrico Lovisari, Rohit Singhal, Anton Andreev, Remi Piotaix, Vadim Bertrand, Maria Laura Delle Monache and Paolo Frasca
- Contact: Carlos Canudas De Wit
- URL: http://necs.inrialpes.fr/pages/grenoble-traffic-lab.php

6.2. Senslogs – Sensors recorder for Android application

Participants: T. Michel [contact person], H. Fourati, P. Geneves, N. Layaida.

This Android application records direct and computed measurements from internal sensors (Accelerometer, Gyroscope, Magnetometer, Calibrated Gyroscope, Calibrated Magnetic Field, Game Rotation Vector, Geomagnetic, Rotation Vector, Gravity, Linear Acceleration, Significant Motion, Step Counter, Step Detector, Ambient Temperature, Light, Pressure, Relative Humidity, Heart Rate, Proximity, GPS Location, Cell and Wifi Location, Passive Location, NMEA data, Wifi signals, Bluetooth signals (not yet), NFC (not yet), and others available...). Data are stored in files using space-separated values. This application has been designed for post-processing projects. It will be used in pedestrian navigation and augmented reality applications. This application is available online: https://play.google.com/store/apps/details?id=fr.inria.tyrex.senslogs&hl=fr_BE

6.3. Wifi Scan Interval for Android application

Participants: T. Michel [contact person], H. Fourati, P. Geneves, N. Layaida.

This app records the wifi scan sampling rate on your phone. This application is available online: https://play.google.com/store/apps/details?id=fr.inria.tyrex.wifiscaninterval To contribute to a database: http://thibaud-michel.com/mobile/wifi-scan-interval.txt More information: https://github.com/ThibaudM/WifiScanInterval http://stackoverflow.com/questions/37193175

7. New Results

7.1. Networked and multi-agent systems: modeling, analysis, and estimation

7.1.1. *Modeling of animal groups*

Participants: P. Frasca [Contact person], A. Aydogdu [Rutgers University at Camden], C. d'Apice [Univ. Salerno], R. Manzo [Univ. Salerno], W. Saidel [Rutgers University at Camden], B. Piccoli [Rutgers University at Camden].

The paper [13] introduces a mathematical model to study the group dynamics of birds resting on wires. The model is agent-based and postulates attraction-repulsion forces between the interacting birds: the interactions are "topological", in the sense that they involve a given number of neighbors irrespective of their distance. The main properties of the model are investigated by combining rigorous mathematical analysis and simulations. This analysis gives indications about the total length of a group and the inter-animal spacings within it: in particular, the model predicts birds to be more widely spaced near the borders of each group. We compare these insights from the model with new experimental data, derived from the analysis of pictures of pigeons and starlings taken by the team in New Jersey. We have used two different image elaboration protocols to derive the data for the statistical analysis, which allowed us to establish a good agreement with the model and to quantify its main parameters. Our data also seem to indicate potential handedness of the birds: we investigated this issue by analyzing the group organization features and the group dynamics at the arrival of new birds. However, data are still insufficient to draw a definite conclusion on this matter. Finally, arrivals and departures of birds from the group are included in a refined version of the model, by means of suitable stochastic processes.

7.1.2. *Cyber-Physical Systems: a control-theoretic approach to privacy and security*

Participants: A. Kibangou [Contact person], F. Garin, S. Gracy, H. Nouasse.

Cyber-physical systems are composed of many simple components (agents) with interconnections giving rise to a global complex behaviour. Interesting recent research has been exploring how the graph describing interactions affects control-theoretic properties such as controllability or observability, namely answering the question whether a small group of agents would be able to drive the whole system to a desired state, or to retrieve the state of all agents from the observed local states only. A related problem is observability in the presence of an unknown input, where the input can represent a failure or a malicious attack, aiming at disrupting the normal system functioning while staying undetected. In our work [24], we study linear network systems affected by a single unknown input. The main result is a characterization of input and state observability, namely the conditions under which both the whole network state and the unknown input can be reconstructed from some measured local states. This characterization is in terms of observability of a suitably-defined subsystem, which allows the use of known graphical characterizations of observability of cyber-physical systems, leading to structural results (true for almost all interaction weights) or strong structural results (true for all non-zero interaction weights). Observability is also related to privacy issues. In the ProCyPhyS project, started recently (October 2016), we are studying privacy-preserving properties of cyber-physical systems, by analyzing observability properties of such systems, in order to derive privacy-preserving policies for applications related to smart mobility.

7.1.3. Sensor networks: Multisensor data fusion for attitude estimation

Participants: H. Fourati [Contact person], A. Kibangou, A. Makni, T. Michel, P. Geneves [Tyrex, Inria], N. Layaida [Tyrex, Inria], J. Wu [University of Electronic Science and Technology of China, Chengdu], Z. Zhou [University of Electronic Science and Technology of China, Chengdu], D. Belkhiat [University Ferhat Abbas, Setif, Algeria].

Attitude estimation consists in the determination of rigid body orientation in 3D space (principally in terms of Euler angles, rotation matrix, or quaternion). This research area is a multilevel, multifaceted process involving the automatic association, correlation, estimation, and combination of data and information from several sources. Another interest consists in the fact that redundant and complementary sensor data can be fused and integrated using multisensor fusion techniques to enhance system capability and reliability. Data fusion for attitude estimation is therefore a research area that borrows ideas from diverse fields, such as signal processing, sensor fusion, and estimation theory, where enhancements are involved in point-of-view data authenticity or availability. Data fusion for attitude estimation is motivated by several issues and problems, such as data imperfection, data multimodality, data dimensionality, and processing framework. As a majority of these problems have been identified and heavily investigated, no single data fusion algorithm is capable of addressing all the aforementioned challenges. Consequently, a variety of methods in the literature focuses on a subset of these issues. These concepts and ideas are treated in the book [28], as a response to the great interest and strong activities in the field of multisensor attitude estimation during the last few years, both in theoretical and practical aspects. In the team, we have carried out works related to attitude estimation evaluation for pedestrian navigation purpose. In [18], we focused on two main challenges. The first one concerns the attitude estimation during dynamic cases, in which external acceleration occurs. In order to compensate for such external acceleration, we design a quaternion-based adaptive Kalman filter q-AKF. Precisely, a smart detector is designed to decide whether the body is in static or dynamic case. Then, the covariance matrix of the external acceleration is estimated to tune the filter gain. The second challenge is related to the energy consumption issue of gyroscope. In order to ensure a longer battery life for the Inertial Measurement Units, we study the way to reduce the gyro measurements acquisition by switching on/off the sensor while maintaining an acceptable attitude estimation. The switching policy is based on the designed detector. The efficiency of the proposed scheme is evaluated by means of numerical simulations and experimental tests. In [31], we investigate the precision of attitude estimation algorithms in the particular context of pedestrian navigation with commodity smartphones and their inertial/magnetic sensors. We report on an extensive comparison and experimental analysis of existing algorithms. We focus on typical motions of smartphones when carried by pedestrians. We use a precise ground truth obtained from a motion capture system. We test state-of-the-art attitude estimation techniques with several smartphones, in the presence of magnetic perturbations typically found in buildings. We discuss the obtained results, analyze advantages and limits of current technologies for attitude estimation in this context. Furthermore, we propose a new technique for limiting the impact of magnetic perturbations with any attitude estimation algorithm used in this context. We show how our technique compares and improves over previous works. A novel quaternion-based attitude estimator with magnetic, angular rate, and gravity (MARG) sensor arrays is proposed in [20] within the framework of collaboration with Prof. Zhou from University of Electronic Science and Technology of China, Chengdu. A new structure of a fixed-gain complementary filter is designed fusing related sensors. To avoid using iterative algorithms, the accelerometer-based attitude determination is transformed into a linear system. Stable solution to this system is obtained via control theory. With only one matrix multiplication, the solution can be computed. Using the increment of the solution, we design a complementary filter that fuses gyroscope and accelerometer together. The proposed filter is fast, since it is free of iteration. We name the proposed filter the fast complementary filter (FCF). To decrease significant effects of unknown magnetic distortion imposing on the magnetometer, a stepwise filtering architecture is designed. The magnetic output is fused with the estimated gravity from gyroscope and accelerometer using a second complementary filter when there is no significant magnetic distortion. Several experiments are carried out on real hardware to show the performance and some comparisons. Results show that the proposed FCF can reach the accuracy of Kalman filter. It successfully finds a balance between estimation accuracy and time consumption. Compared with iterative methods, the proposed FCF has much less convergence speed. Besides, it is shown that the magnetic distortion would not affect the estimated Euler angles.

7.2. Control design and networked systems

7.2.1. Control design for hydro-electric power-plants

Participants: C. Canudas de Wit [Contact person], S. Gerwig [Feb 2014–Mar 2016], F. Garin, B. Sari [Alstom].

This is the study of collaborative and resilient control of hydro-electric power-plants, in collaboration with Alstom. The goal is to improve performance of a hydro-electric power-plant outside its design operation conditions, by cancellation of oscillations that occur in such an operation range. Indeed, current operation of power-plants requires to operate on a variety of conditions, often different from the ones initially considered when designing the plant. At off-design operation pressure, the hydraulic turbine exhibits a vortex rope below the runner. This vortex generates pressure fluctuations after the turbine and can excite the hydraulic pipes. Indeed the water is compressible and the pipe walls elastic, so the system can oscillate. The goal is to damp these pressure oscillations as they create vibrations in the system and can lead to damages. Our first contribution [23] has been to model the effect of the vortex rope on the hydraulic system as an external perturbation source acting on pipes. The pipes themselves are described with equations taking into account water compressibility and pipe-wall elasticity. The resulting model is nonlinear with hyperbolic functions in the equations (analogous to high-frequency transmission lines), from which we obtain a suitably linearized model. This model can then be used for control design.

7.2.2. Collaborative source seeking

Participants: F. Garin [Contact person], C. Canudas de Wit, R. Fabbiano.

The problem of source localization consists in finding the point or the spatial region from which a quantity of interest is being emitted. We consider collaborative source seeking, where various moving devices, each equipped with a sensor, share information to coordinate their motion towards the source. We focus on the case where information can only be shared locally (with neighbor agents) and where the the agents have no global position information, and only limited relative information (bearing angle of neighbor agents). This setup is relevant when GPS navigation is not available, as in underwater navigation or in cave exploration, and when relative position of neighbors is vision-based, making it easier to measure angles than distances. In [16] we propose and analize a control law, which is able to bring and keep the agents on a circular equispaced formation, and to steer the circular formation towards the source via a gradient-ascent technique; the circular equispaced formation is beneficial to a good approximation of the gradient from local pointwise measurements. This algorithm is different from the ones present in the literature, because it can cope with our above-described restrictive assumptions on the available position information.

7.2.3. Distributed control and game theory: self-optimizing systems

Participants: F. Garin [Contact person], B. Gaujal [POLARIS], S. Durand.

The design of distributed algorithms for a networked control system composed of multiple interacting agents, in order to drive the global system towards a desired optimal functioning, can benefit from tools and algorithms from game theory. This is the motivation of the Ph.D. thesis of Stéphane Durand, a collaboration between POLARIS and NECS teams. The first results of this thesis concern the complexity of a classical algorithm in game theory, the Best Response Algorithm, an iterative algorithm to find a Nash Equilibrium. For potential games, Best Response Algorithm converges in finite time to a pure Nash Equilibrium. The worse-case convergence time is known to be exponential in the number of players, but surprisingly it turns out that on average (over the possible values of the potentials) the complexity is much smaller, only linearly growing, see [27], [26], [22].

7.3. Transportation networks and vehicular systems

7.3.1. Travel time prediction

Participants: A. Kibangou [Contact person], C. Canudas de Wit, H. Fourati, A. Ladino.

One of the regular performance metrics for qualifying the level of congestion in traffic networks is the travel time. Precision in the estimation or measurement of this variable is one of the most desired features for traffic management. The computation of the travel time is regularly performed based on instantaneous information so called instantaneous travel time (ITT), but regularly traffic changes on time and spaces and the computation depends dynamically on the speeds of the system and the notion of dynamic travel time (DTT) is required. Here the computation requires future information of speed so a short term forecast is required. First in [25] we have presented a framework for instantaneous travel time predictions for multiple origins and destinations in a highway. Secondly in [32], a detailed real time application to compute predictions of dynamic travel time (DTT) is presented. Speed measurements describing a spatio-temporal distribution are captured, from there the DTT is constructed. Definitions, computational details and properties in the construction of DTT are provided. DTT is dynamically clustered using a K-means algorithm and then information on the level and the trend of the centroid of the clusters is used to devise predictors computationally simple to be implemented. To take into account lack of information of cluster assignment of the data to be predicted, a fusion strategy based on the best linear unbiased estimator principle is proposed to combine the predictions of each model. The algorithm is deployed in a real time application and the performance is evaluated using real traffic data from the South Ring of the Grenoble city in France.

7.3.2. Urban traffic control

Participants: C. Canudas de Wit [Contact person], F. Garin, P. Grandinetti.

This work deals with optimal or near-optimal operation of traffic lights in an urban area, e.g., a town or a neighborhood. The goal is on-line optimization of traffic lights schedule in real time, so as to take into account variable traffic demands, with the objective of obtaining a better use of the road infrastructure. More precisely, we aim at maximizing total travel distance within the network, while also ensuring good servicing of demands of incoming cars in the network from other areas. The complexity of optimization over a large area is addressed both in the formulation of the optimization problem, with a suitable choice of the traffic model, and in a distributed solution, which not only parallelizes computations, but also respects the geometry of the town, i.e., it is suitable for an implementation in a smart infrastructure where each intersection can compute its optimal traffic lights by local computations combined with exchanges of information with neighbor intersections.

7.3.3. Optimal control of freeway access

Participants: C. Canudas de Wit [Contact person], D. Pisarski.

The work [19] contains Dominik Pisarski's major results which he obtained during the realization of his Ph.D. thesis at Inria-Rhone Alpes. In concerns the problem of optimal control for balancing traffic density in freeway traffic. The control is realized by ramp metering. The balancing of traffic was proposed as a new objective to improve the vehicular flow on freeways and ring-roads. It was demonstrated that the balancing may result in significantly shortened travel delays and reduced pollution. It may also be beneficial for safety and comfort during a travel. For the controller, a novel modular decentralized structure was proposed where each of the modules computes its optimal decision by using local traffic state and supplementary information arriving from the neighboring controllers. For such a structure, the optimal control problem was formulated as a Nash game, where each player (controller's module) optimizes its local subsystem with respect to decisions of the other players. In comparison to the existing solutions, this new approach significantly reduces the computational burden needed for optimal traffic control, allowing for on-line implementation over long freeway segments. In the paper, the proposed control method was tested via numerical examples with the use of Cell Transmission Model. Later, the performance of the designed method was validated by employing a micro-simulator and real traffic data collected from the south ring of Grenoble. The designed distributed controller resulted in 5% reduction of total time spent on the ring road, 18% reduction of total time spent in the on-ramp queues, 2reduction of the average fuel consumption, and 4% reduction of the traffic density.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

8.1.1. ALSTOM

Contract with ALSTOM in the framework of Inria/ALSTOM joint laboratory, and CIFRE PhD grant of Simon Gerwig. This thesis explores collaborative and reconfigurable resilient control design of hydroelectric power plants; current work is on improving performance of a hydro-electric power-plant outside its design operation conditions, by cancellation of oscillations that occur in such operation range.

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ProCyPhyS

ProCyPhyS is a one year project funded by University Grenoble Alps, MSTIC department, with the aim to study privacy in cyberphysical system. A post-doc (H. Nouasse) has been hired to perform analysis of privacy protection through system-theoretic measures. We are interested with cyber-physical systems that can be viewed as systems of interconnected entities which are locally governed by difference equations of partial differential equations, namely intelligent transportation systems and indoor navigation. A first approach to analyze privacy preservation is to study observability of the overall system, see [8] where a large family of non-observable networks have been characterized for homogeneous systems of consensus type. In this approach, the network structure immunizes the overall system. A second approach, consists in adding information (noise) to the sensitive one: that is the differential privacy concept that leads to differential filtering where the aim is to develop an estimator that is robust enough according to the added noise [33]. In ProCyPhyS the main goal is to make the system partially nonobservable. The idea is to compress the state space while adding noise to the sensitive information in a smarter way.

9.1.2. Collaboration with IFSTTAR, Lyon, and LICIT team

The group has begun a collaboration with IFSTTAR in Lyon and namely with the LICIT team. We held two informal workshops: the first one in Grenoble, where we presented the team, and the second one in Lyon, which was focused on traffic modeling. During this workshop, the NeCS team proposed the following talks:

- C. Canudas de Wit, A variable-length cell transmission model for road traffic system;
- M. L. Delle Monache, Coupled PDE-ODE models for traffic flow.

A third workshop is planned next March and we expect a sustained collaboration during the coming year.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. SPEEDD (Scalable ProactivE Event-Driven Decision making)

Type: STREP

Objective: ICT-2013.4.2a – Scalable data analytics – Scalable Algorithms, software frameworks and viualisation

Duration: Feb. 2014 to Jan. 2017.

Coordinator: National Centre of Scientific Research 'Demokritos' (Greece)

Partners: IBM Israel, ETH Zurich (CH), Technion (Israel), Univ. of Birmingham (UK), NeCS CNRS (France), FeedZai (Portugal)

Inria contact: C. Canudas de Wit

Abstract: SPEEDD is developing a prototype for robust forecasting and proactive event-driven decision-making, with on-the-fly processing of Big Data, and resilient to the inherent data uncertainties. NECS leads the intelligent traffic-management use and show case.

See also: http://speedd-project.eu

9.2.1.2. Scale-FreeBack

Type: ERC Advanced Grant

Duration: Sep. 2016 to Aug. 2021

Coordinator: C. Canudas de Wit

Inria contact: C. Canudas de Wit

Abstract: The overall aim of Scale-FreeBack is to develop holistic scale-free control methods of controlling complex network systems in the widest sense, and to set the foundations for a new control theory dealing with complex physical networks with an arbitrary size. Scale-FreeBack envisions devising a complete, coherent design approach ensuring the scalability of the whole chain (modelling, observation, and control). It is also expected to find specific breakthrough solutions to the problems involved in managing and monitoring large-scale road traffic networks. Field tests and other realistic simulations to validate the theory will be performed using the equipment available at the Grenoble Traffic Lab center (see GTL), and a microscopic traffic simulator replicating the full complexity of the Grenoble urban network.

See also: http://scale-freeback.eu

9.3. International Initiatives

9.3.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.3.1.1. COMFORT

Title: COntrol and FOrecasting in Transportation networks

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Mechanical Engineering - Roberto Horowitz

Start year: 2014

See also: http://necs.inrialpes.fr/v2/pages/comfort/EA_homepage_COMFORT.html

COMFORT addresses open issues for Intelligent Transportation Systems (ITS). The goal of these systems is to use information technologies (sensing, signal processing, machine learning, communications, and control) to improve traffic flow, as well as enhance the safety and comfort of drivers. It has been established over the past several decades, through field studies and many scholarly publications, that the tools of ITS can significantly improve the flow of traffic on congested freeways and streets. Traffic operators can manage the system in a top-down fashion, for example, by changing the speed limit on a freeway, or by controlling the flow on the onramps (ramp metering). Individual drivers can also affect traffic conditions from the bottom up, by making decisions based on reliable predictions. These predictions must be provided by a centralized system that can evaluate the decisions based on global information and sophisticate modeling techniques. It is now crucial to develop efficient algorithms for control and prediction that are well adapted to current and emerging sensing and communication technologies. The areas of traffic modeling and calibration, state estimation, and traffic control remain central to this effort. Specifically, COMFORT addresses issues related to model validation and development of new traffic forecasting and distributed control algorithms. The efficiency of the derived methods will be assessed using large networks simulators and real data obtained from the Californian and the Grenoble's testbed.

This year is the final one of the current project: however, the positive results from the project have lead to the request of its extension, which is pending approval.

9.3.2. Participation in Other International Programs

9.3.2.1. TICO-MED

TicoMed (Traitement du signal Traitement numérique multidimensionnel de l'Information avec applications aux Télécommunications et au génie Biomédical) is a French-Brazilian project funded by CAPES-COFECUB. It started in February 2015 with University of Nice Sophia Antipolis (I3S Laboratory), CNAM, SUPELEC, University of Grenoble Alpes (Gipsa-Lab), Universidade Federal do Ceara, Universidade Federal do Rio de Janeiro, and Universidade Federal do Santa Catarina as partners.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Prof. Andre L.F. de Almeida from (Universidade Federal do Ceara, Fortaleza, Brazil) visited the team in June 2015 within the framework of the French-Brazilian CAPES-COFECUB project TICO-MED.

Dr. Thibault Liard (University Pierre et Marie Curie, Paris VI) visited the team in November. He gave a seminar to the team with the title "A Kalman rank condition for the indirect controllability of coupled systems of linear operator groups" and discussed with M. L. Delle Monache on traffic flow modeling and control using conservation laws.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Maria Laura Delle Monache and Giacomo Casadei visited UC Berkeley in December. They had research meeting with faculty and students at ITS and PATH and in particular with Prof. M. Arcak.

A. Kibangou visited the Nelson Mandela Metropolitan University (Port Elizabeth) and the University of Johanesburg (UJ) in May 2016. During his stay, he gave a lecture to students of Department of Town and Regional Planning of UJ on Mobility and traffic management.

A. Kibangou visited Universidade Federal do Ceara (UFC) in Fortaleza (Brazil) in November 2016 within the framework of the Tico-Med bilateral project. During his stay, he worked with Prof. Andre L.F. de Almeida on tensor models for graph filters and gave a course on Graph Signal Processing to researchers and doctoral students of UFC.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. General Chair, Scientific Chair

C. Canudas de Wit has been appointed General Chair of the 58th IEEE Conference on Decision and Control, 2019.

10.1.2. Scientific Events Selection

10.1.2.1. Member of the Conference Program Committees

P. Frasca has been Associate Editor-at-Large in the International Program Committee of the 55th IEEE Conference on Decision and Control, 2016.

P. Frasca and F. Garin are Associate Editors in the IEEE Control System Society Conference Editorial Board. This year, they served for the 2016 American Control Conference, the 2017 American Control Conference, and the 55th IEEE Conference on Decision and Control, 2016.

P. Frasca is Associate Editor in the European Control Association (EUCA) Conference Editorial Board. This year, he served for the 2016 European Control Conference.

P. Frasca has been appointed as Associate Editor in the IEEE Robotics and Automation Society CASE Conference Editorial Board: he shall serve for 13th IEEE International Conference on Automation Science and Engineering, 2017.

Hassen Fourati was a member of the International and Scientific Program Committees of the International Conference on Control, Automation and Diagnosis (ICCAD'17), 2017, and the International Conference on Sciences and Techniques of Automatic Control and Computer Engineering STA2016, 2016.

10.1.2.2. Reviewer

Team members, and in particular faculty, have been reviewers for several conferences (including the most prestigious ones in their research area): IEEE Conference on Decision and Control CDC, European Control Conference ECC, American Control Conference ACC, European Signal Processing Conference, IEEE International Conference on Robotics and Automation ICRA, IEEE/RSJ International Conference on Intelligent Robots and Systems IROS, IFAC Workshop on Distributed Estimation and Control in Networked Systems (NecSys), Indian Control Conference.

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

Carlos Canudas de Wit is Associate Editor of IEEE Transactions on Control of Networks Systems IEEE-TCNS (since June 2013), Associate Editor of IEEE Transactions on Control System Technology IEEE-TCST (since January 2013), and Editor of the Asian Journal of Control AJC (since 2010).

Paolo Frasca is Subject Editor of the International Journal of Robust and Nonlinear Control (Wiley) (since February 2014) and has been appointed as starting Associate Editor of IEEE Control System Letters (from February 2017).

Hassen Fourati is Associate Editor of the Asian Journal of Control AJC (since January 2016).

10.1.3.2. Reviewer - Reviewing Activities

Team members, and in particular faculty, have been reviewers for several journals (including the most prestigious ones in their research area): IEEE Trans. on Automatic Control, IEEE Trans. on Control of Network Systems, IEEE Trans. on Signal Processing, Automatica, IEEE Signal Processing Letters, Systems and Control Letters, IEEE Transactions on Information Theory, Elsevier Signal Processing, Int. Journal of Robust and Nonlinear Control, IET Communications, IET Wireless Sensor Networks. IEEE/ASME Trans. on Mechatronics, IEEE Trans. on Instrumentations and Measurements, IEEE Sensors journal, IEEE Trans. on Robotics, Networks and Heterogeneous Network (NHM), Mathematical Methods in the Applied Sciences (MMAS), Journal of Mathematical Analysis and Applications (JMMA), AMS Mathematical Reviews, Journal of Intelligent Transportation Systems.

10.1.4. Invited Talks

- C. Canudas de Wit, "Optimal Traffic Control: Eco-driving, Green-waves, Adaptive traffic lights" (plenary talk), Latin American Conference on Automatic Control 2016, Medellin, Colombia, October 2016.
- M. L. Delle Monache, "Some control strategies for conservation laws with applications to traffic flow", Séminaire de théorie du contrôle de Toulon, University of Toulon, November 2016.
- P. Frasca, "Non-smooth and hybrid systems in opinion dynamics", IEEE CDC satellite workshop on Dynamics and Control in Social Networks, Las Vegas, Nevada, December 2016.
- P. Frasca, "Non-smooth and hybrid systems in opinion dynamics", ANR Workshop "Control subject to computational and communication constraints" (CO4), Toulouse, France, October 2016.

10.1.5. Leadership within the Scientific Community

C. Canudas de Wit has been president of the European Control Association (EUCA) until June 2015, and is now (until 2017) Past-president and member of the EUCA Council.

10.1.6. Scientific Expertise

Team members participate to the following technical committees of IEEE Control Systems Society and of the International Federation of Automatic Control:
CSS Technical Committee “Networks and Communications Systems” (P. Frasca and F. Garin);
IFAC Technical Committee 1.5 on Networked Systems (P. Frasca and C. Canudas de Wit);
IFAC Technical Committee 2.5 on Robust Control (P. Frasca);
IFAC-TC7.1 Automotive Control (C. Canudas de Wit);
IFAC-TC7.4 Transportation systems (C. Canudas de Wit).

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Master: F. Garin, Distributed Algorithms and Network Systems, 13.5h, M2, Univ. Grenoble Alpes, France.

Licence: H. Fourati, Informatique Industrielle, 105h, L1, IUT 1 (GEII), Univ. Grenoble Alpes, France;

Licence: H. Fourati, Réseaux locaux industriels, 50h, L1 et L2, IUT1 (GEII), Univ. Grenoble Alpes, France.

Licence: H. Fourati, Automatique, 61,5h, L3, UFR physique, Univ. Grenoble Alpes, France.

Licence: H. Fourati, Automatique échantillonnée, 15h, L2, IUT 1 (GEII), Univ. Grenoble Alpes, France.

Licence: A. Kibangou, Automatique, 52h, L2, IUT1(GEII1), Univ. Grenoble Alpes, France.

Licence: A. Kibangou, Mathématiques, 33h, L2, IUT1 (GEII1), Univ. Grenoble Alpes, France.

Licence: A. Kibangou, Mathématiques, 44h, L1, IUT1 (GEII1), Univ. Grenoble Alpes, France.

Licence: A.Kibangou, Automatique, 16h, L3, IUT1 (GEII1), Univ. Grenoble Alpes, France.

Doctorat: C. Canudas de Wit has organized the 37th International Summer School of Automatic Control Grenoble, France September, 12-16, 2016 on the topic “Advanced algorithms for traffic prediction and control”.

10.2.2. Supervision

PhD: Aida Makni, Inertial and magnetic data fusion for attitude estimation under energetic constraint for accelerated rigid body, Univ. Grenoble Alpes, March 2016, co-advised by H. Fourati, A. Kibangou and C. Canudas de Wit.

PhD in progress: Simon Gerwig, Collaborative, reconfigurable and resilient control for hydro-electric power-plants, from Feb. 2014 until Mar. 2017, co-advised by C. Canudas de Wit, F. Garin and B. Sari (Alstom).

PhD in progress: Pietro Grandinetti, Control of large-scale traffic networks, from Apr. 2014, co-advised by C. Canudas de Wit and F. Garin.

PhD in progress: Andrés Alberto Ladino Lopez, Robust estimation and prediction in large scale traffic networks, from Oct. 2014, co-advised by C. Canudas de Wit, A. Kibangou and H. Fourati.

PhD in progress: Thibaud Michel, Mobile Augmented Reality Applications for Smart Cities, from Nov. 2014, co-advised by N. Layaïda, H. Fourati and P. Geneves.

PhD in progress: Sebing Gracy, Cyber-physical systems: a control-theoretic approach to privacy and security, from Oct. 2015, co-advised by A. Kibangou and F. Garin.

PhD in progress: Stéphane Durand, Coupling distributed control and game theory: application to self-optimizing systems, from Oct. 2015, co-advised by B. Gaujal and F. Garin.

PhD in progress: Stéphane Mollier, Aggregated Scale-Free Models for 2-D Large-scale Traffic Systems, from Oct. 2016, co-advised by C. Canudas de Wit, M. L. Delle Monache and B. Seibold.

PhD in progress: Nicolas Martin, On-line partitioning algorithms for evolutionary scale-free networks, from Dec. 2016, co-advised by C. Canudas de Wit and P. Frasca.

10.2.3. Juries

- C. Canudas de Wit was committee member of the PhD defence of Kuo-Yun Liang, KTH Stockholm. Ph.D. advisor: K.H. Johansson, June 10, 2016.
- H. Fourati was committee member of the PhD defense of Christophe Combettes, Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFSTTAR), Spécialité : Automatique et Informatique appliquée, October 17, 2016.
- P. Frasca was committee member of the PhD defence of Laura Dal Col, *On distributed control analysis and design for multi-agent systems subject to limited information*, Institut National des Sciences Appliquées, Toulouse, France. Ph.D. advisors: Luca Zaccarian and Sophie Tarbouriech, October 25, 2016.
- H. Fourati was committe member of “Qualification Maître de Conferences 2016” during January 2016, Autrans, France.

10.3. Popularization

The GTL webpage (http://gtl.inrialpes.fr/status) went public in November: more generally the traffic activities have been popularized via the following public talks.

- M. L. Delle Monache. DEMO on the GTL at the “Journées des nouveaux arrivants”, Inria, Paris, Dec. 2016
- M. L. Delle Monache, Traffic flow modeling, GIPSA-Lab days, Grenoble, Nov. 2016

11. Bibliography

Major publications by the team in recent years

[1] L. Brinon Arranz, A. Seuret, C. Canudas De Wit. *Cooperative Control Design for Time-Varying Formations of Multi-Agent Systems*, in "IEEE Transactions on Automatic Control", 2014, vol. 59, n^o 8, http://hal.archives-ouvertes.fr/hal-00932841

[2] G. De Nunzio, C. Canudas de Wit, P. Moulin, D. Di Domenico. *Eco-Driving in Urban Traffic Networks Using Traffic Signals Information*, in "International Journal of Robust and Nonlinear Control", 2016, n^o 26, pp. 1307–1324 [*DOI :* 10.1002/rnc.3469], https://hal.archives-ouvertes.fr/hal-01297629

[3] H. Fourati. *Multisensor Data Fusion: From Algorithms and Architectural Design to Applications (Book)*, Series: Devices, Circuits, and Systems, CRC Press, Taylor & Francis Group LLC, August 2015, 663 p. , https://hal.inria.fr/hal-01169514

[4] H. Fourati, N. Manamanni, L. Afilal, Y. Handrich. *Rigid body motions capturing by means of wearable inertial and magnetic MEMS sensors assembly : from the reconstitution of the posture toward the dead reckoning: an application in Bio-logging*, in "Novel Advances in Microsystems Technologies and Their Applications (Devices, Circuits, and Systems)", L. A. Francis, K. Iniewski (editors), Taylor & Francis Books, July 2013, pp. 393-409, http://hal.inria.fr/hal-00690146

[5] H. FOURATI, N. MANAMANNI, L. AFILAL, Y. HANDRICH. *Complementary Observer for Body Segments Motion Capturing by Inertial and Magnetic Sensors*, in "IEEE/ASME Transactions on Mechatronics", February 2014, vol. 19, n° 1, pp. 149-157 [*DOI :* 10.1109/TMECH.2012.2225151], https://hal.archives-ouvertes.fr/hal-00690145

[6] F. GARIN, S. ZAMPIERI. *Mean square performance of consensus-based distributed estimation over regular geometric graphs*, in "SIAM Journal on Control and Optimization", 2012, vol. 50, n° 1, pp. 306-333 [*DOI :* 10.1137/10079402X], http://hal.inria.fr/hal-00641107

[7] F. GARIN, L. SCHENATO. *A Survey on Distributed Estimation and Control Applications Using Linear Consensus Algorithms*, in "Networked Control Systems", A. BEMPORAD, M. HEEMELS, M. JOHANSSON (editors), Lecture Notes in Control and Information Sciences, Springer, 2011, vol. 406, pp. 75-107 [*DOI :* 10.1007/978-0-85729-033-5_3], http://hal.inria.fr/inria-00541057/en/

[8] A. Y. KIBANGOU, C. COMMAULT. *Observability in Connected Strongly Regular Graphs and Distance Regular Graphs*, in "IEEE Transactions on Control of Network Systems", December 2014, vol. 1, n° 4, pp. 360-369 [*DOI :* 10.1109/TCNS.2014.2357532], https://hal.archives-ouvertes.fr/hal-01092954

[9] A. Y. KIBANGOU, G. FAVIER. *Tensor analysis for model structure determination and parameter estimation of block-oriented nonlinear systems*, in "IEEE Journal of Selected Topics in Signal Processing", 2010, vol. Special issue on Model Order Selection in Signal Processing Systems, vol. 4, n° 3, pp. 514-525, http://hal.inria.fr/hal-00417815/en

[10] D. PISARSKI, C. CANUDAS DE WIT. *Nash Game Based Distributed Control Design for Balancing of Traffic Density over Freeway Networks*, in "IEEE Transactions on Control of Network Systems", 2016, vol. 3, n° 2, pp. 149-161 [*DOI :* 10.1109/TCNS.2015.2428332], https://hal.archives-ouvertes.fr/hal-01251805

Publications of the year

Doctoral Dissertations and Habilitation Theses

[11] A. Y. KIBANGOU. *Contributions à l'analyse des systèmes en réseau*, Université Grenoble Alpes, June 2016, Habilitation à diriger des recherches, https://hal.archives-ouvertes.fr/tel-01368049

[12] A. MAKNI. *Inertial and magnetic data fusion for attitude estimation under energetic constraint for accelerated rigid body*, Université Grenoble Alpes, March 2016, https://tel.archives-ouvertes.fr/tel-01318310

Articles in International Peer-Reviewed Journals

[13] A. AYDOGDU, P. FRASCA, C. D'APICE, R. MANZO, J. THORNTON, B. GACHOMO, T. WILSON, B. CHEUNG, U. TARIQ, W. SAIDEL, B. PICCOLI. *Modeling birds on wires*, in "Journal of Theoretical Biology", 2017, vol. 415, pp. 102-112 [*DOI :* 10.1016/J.JTBI.2016.11.026], http://hal.univ-grenoble-alpes.fr/hal-01426501

[14] G. DE NUNZIO, C. CANUDAS DE WIT, P. MOULIN, D. DI DOMENICO. *Eco-Driving in Urban Traffic Networks Using Traffic Signals Information*, in "International Journal of Robust and Nonlinear Control", 2016, n° 26, pp. 1307–1324 [*DOI :* 10.1002/RNC.3469], https://hal.archives-ouvertes.fr/hal-01297629

[15] G. DE NUNZIO, G. GOMES, C. CANUDAS DE WIT, R. HOROWITZ, P. MOULIN. *Speed Advisory and Signal Offsets Control for Arterial Bandwidth Maximization and Energy Consumption Reduction*, in "IEEE

Transactions on Control Systems Technology", June 2016 [*DOI :* 10.1109/TCST.2016.2577002], https://hal.inria.fr/hal-01332172

[16] R. FABBIANO, F. GARIN, C. CANUDAS DE WIT. *Distributed Source Seeking without Global Position Information*, in "IEEE Transactions on Control of Network Systems", 2016 [*DOI :* 10.1109/TCNS.2016.2594493], https://hal.archives-ouvertes.fr/hal-01354294

[17] E. LOVISARI, C. CANUDAS DE WIT, A. KIBANGOU. *Density/Flow reconstruction via heterogeneous sources and Optimal Sensor Placement in road networks*, in "Transportation Research Part C: Emerging Technologies", August 2016, vol. 69, pp. 451 - 476 [*DOI :* 10.1016/J.TRC.2016.06.019], https://hal.archives-ouvertes.fr/hal-01375928

[18] A. MAKNI, H. FOURATI, A. Y. KIBANGOU. *Energy-aware Adaptive Attitude Estimation Under External Acceleration for Pedestrian Navigation*, in "IEEE/ASME Transactions on Mechatronics", January 2016 [*DOI :* 10.1109/TMECH.2015.2509783], https://hal.inria.fr/hal-01241403

[19] D. PISARSKI, C. CANUDAS DE WIT. *Nash Game Based Distributed Control Design for Balancing of Traffic Density over Freeway Networks*, in "IEEE Transactions on Control of Network Systems", June 2016, vol. 3, n° 2, pp. 149-161 [*DOI :* 10.1109/TCNS.2015.2428332], https://hal.archives-ouvertes.fr/hal-01251805

[20] J. WU, Z. ZHOU, J. CHEN, H. FOURATI, R. LI. *Fast Complementary Filter for Attitude Estimation Using Low-Cost MARG Sensors*, in "IEEE Sensors Journal", July 2016, vol. 16, n° 18, pp. 6997-7007, https://hal.inria.fr/hal-01368473

International Conferences with Proceedings

[21] C. CANUDAS DE WIT, A. FERRARA. *A Variable-Length Cell Road Traffic Model: Application to Ring Road Speed Limit Optimization*, in "55th IEEE Conference on Decision and Control (CDC 2016)", Las Vegas, United States, December 2016, https://hal.archives-ouvertes.fr/hal-01391239

[22] S. DURAND, B. GAUJAL. *Complexity and Optimality of the Best Response Algorithm in Random Potential Games*, in "Symposium on Algorithmic Game Theory (SAGT) 2016", Liverpool, United Kingdom, September 2016, pp. 40-51 [*DOI :* 10.1007/978-3-662-53354-3_4], https://hal.archives-ouvertes.fr/hal-01404643

[23] S. GERWIG, B. SARI, F. GARIN, C. CANUDAS DE WIT. *Reduced model for control in a hydroelectric unit at off-design operation*, in "15th European Control Conference (ECC 2016)", Aalborg, Denmark, June 2016, pp. 2096-2101, https://hal.inria.fr/hal-01354358

[24] A. Y. KIBANGOU, F. GARIN, S. GRACY. *Input and State Observability of Network Systems with a Single Unknown Input*, in "6th IFAC Workshop on Distributed Estimation and Control in Networked Systems (NecSys'16)", Tokyo, Japan, Proc. 6th IFAC Workshop on Distributed Estimation and Control in Networked Systems (NecSys), IFAC, September 2016, https://hal.inria.fr/hal-01368906

[25] A. LADINO, A. KIBANGOU, H. FOURATI, C. CANUDAS DE WIT. *Travel time forecasting from clustered time series via optimal fusion strategy*, in "15th European Control Conference (ECC 2016)", Aalborg, Denmark, June 2016, https://hal.archives-ouvertes.fr/hal-01296525

Conferences without Proceedings

[26] S. DURAND, B. GAUJAL. *Average complexity of the Best Response Algorithm in Potential Games* , in "Atelier Evalution de Performance 2016", Toulouse, France, March 2016, https://hal.archives-ouvertes.fr/hal-01396906

[27] S. DURAND, B. GAUJAL. *Average complexity of the Best Response Algorithm in Potential Games*, in "17ème conférence dela Société française de Recherche Opérationnelle et d'Aide à la Décision (ROADEF 2016)", Compiegne, France, February 2016, https://hal.archives-ouvertes.fr/hal-01396902

Scientific Books (or Scientific Book chapters)

[28] H. FOURATI, D. E. C. BELKHIAT. *Recent Advances on Multisensor Attitude and Heading Estimation: Fundamental Concepts and Applications*, Taylor & Francis Group, August 2016, https://hal.inria.fr/hal-01402566

Research Reports

[29] S. DURAND, B. GAUJAL. *Complexity and Optimality of the Best Response Algorithm in Random Potential Games*, Inria - Research Centre Grenoble – Rhône-Alpes ; Grenoble 1 UGA - Université Grenoble Alpe, June 2016, n° RR-8925, 30 p. , https://hal.inria.fr/hal-01330805

Other Publications

[30] M. L. DELLE MONACHE, P. GOATIN. *Stability estimates for scalar conservation laws with moving flux constraints*, October 2016, working paper or preprint [*DOI :* 10.3934/XX.XX.XX.XX], https://hal.inria.fr/hal-01380368

[31] T. MICHEL, P. GENEVÈS, H. FOURATI, N. LAYAÏDA. *On Attitude Estimation with Smartphones*, September 2016, Accepted for the International Conference on Pervasive Computing and Communications (PerCom 2017), Mar 2017, Kona, United States, https://hal.inria.fr/hal-01376745

References in notes

[32] A. LADINO, A. Y. KIBANGOU, H. FOURATI, C. CANUDAS DE WIT. *A real time forecasting tool for dynamic travel time from clustered time series*, August 2016, Submitted to Transportation Research Part C. Emerging Technologies

[33] J. LE NY, G. PAPPAS. *Differentially private filtering*, in "IEEE Transactions on Automatic Control", 2014, vol. 59, n° 2, pp. 341-354