IN PARTNERSHIP WITH:
CNRS

Institut polytechnique de Grenoble

Université de Grenoble Alpes

Activity Report 2017

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

Table of contents

Project-Team NECS

Creation of the Project-Team: 2007 January 01

Keywords:

Computer Science and Digital Science:

A1. - Architectures, systems and networks
A1.2. - Networks
A1.2.6. - Sensor networks
A1.2.7. - Cyber-physical systems
A1.2.9. - Social Networks
A1.5. - Complex systems
A3. - Data and knowledge
A3.1. - Data
A6. - Modeling, simulation and control
A6.1. - Mathematical Modeling
A6.2. - Scientific Computing, Numerical Analysis & Optimization
A6.4. - Automatic control

Other Research Topics and Application Domains:

B7. - Transport and logistics
B7.1. - Traffic management
B7.2. - Smart travel

1. Personnel

Research Scientists

Carlos Canudas de Wit [Team leader, CNRS, Senior Researcher, HDR]
Maria Laura Delle Monache [Inria, Researcher]
Federica Garin [Inria, Researcher]
Paolo Frasca [CNRS, Researcher]

Faculty Members

Hassen Fourati [Univ Grenoble Alpes, Associate Professor]
Alain Kibangou [Univ Grenoble Alpes, Associate Professor, HDR]

Post-Doctoral Fellows

Giacomo Casadei [CNRS]
Houda Nouasse [Univ Grenoble Alpes]
Thibault Liard [Inria, from Dec 2017]

PhD Students

Stéphane Durand [Univ Grenoble Alpes]
Sebin Gracy [Univ Grenoble Alpes]
Pietro Grandinetti [CNRS, until Apr 2017]
Andres Alberto Ladino Lopez [CNRS, until Nov 2017]
Nicolas Martin [CNRS]
Thibaud Michel [Univ Grenoble Alpes]
Stéphane Mollier [CNRS]

Muhammad Umar B Niazi [CNRS, from Nov 2017]
Martin Rodriguez [CNRS, from Oct 2017]

Technical staff

Vadim Bertrand [CNRS]
Remi Piotaix [Inria, until Jan 2017]

Interns

Baptiste Gouin [CNRS, from Mar 2017 until Jul 2017]
Dennis Swart [CNRS, from Sep 2017]

Administrative Assistants

Myriam Etienne [Inria]
Lydie Leon [CNRS, from Aug 2017]
Hannah Walter [CNRS, until Jun 2017]

External Collaborator

Anton Andreev [CNRS, until Oct 2017]

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).

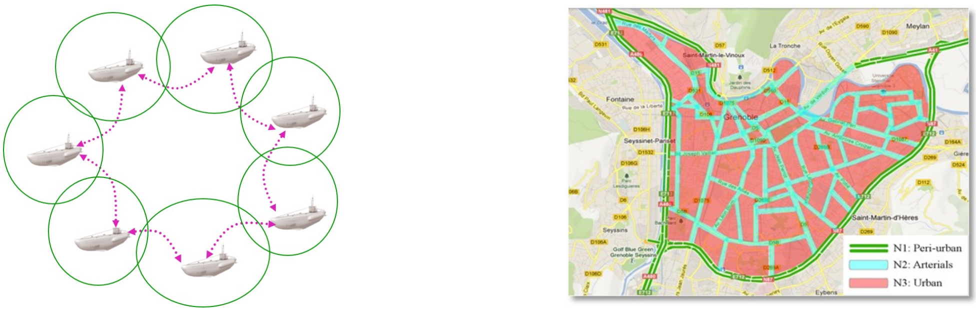

Figure 1. Left: a system of autonomous agents, where the network structure is created by the feedback, used to coordinate agents towards a common goal. Right: a system naturally having a network structure.

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 identified before (e.g., decentralized/collaborative traffic optimal control, density balancing using consensus concepts, data fusion, distributed estimation, etc.). Several specific actions have been continued/launched to this purpose: improvement and finalization of the Grenoble Traffic Lab(GTL), new collaborative EU projects (SPEEDD, ERC-AdG Scale-FreeBack). Further research goals are envisioned, such as:

- Modeling of large scale traffic systems. We aim at reducing the complexity of traffic systems modeling by engaging novel modeling techniques that make use of clustering for traffic networks while relying on its specific characteristics. Traffic networks will be aggregate into clusters and the main traffic quantities will be extrapolated by making use of this aggregation. Moreover, we are developing an extension of the Grenoble Traffic Lab (GTL) for downtown Grenoble which will make use of GPS and probe data to collect traffic data in the city center.
- Modeling and control of intelligent transportation systems. We aim at developing a complete micro-macro modeling approach to describe and model the new traffic dynamics that is developing thanks to mixed (simple, connected and automated) vehicles in the roads. This will require cutting edge mathematical theory and field experiments.

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. 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

- M. L. Delle Monache received the prize "France -Berkeley Fund Award" for young researcher awarded by the College de France for her works in collaboration with United States
- P. Frasca published the book "Introduction to averaging dynamics over networks", with F. Fagnani.
- P. Frasca has been selected as a member of the "Comité de Direction du GdR MACS ", term 2019-2023.
- The team organized the international ERC Scale-free Back workshop on "Modelling reduction tools for large-scale complex networks", Grenoble, September 2017

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

6.2. Benchmarks Attitude Smartphones

KEYWORDS: Performance analysis - Sensors - Motion analysis - Experimentation - Smartphone

SCIENTIFIC DESCRIPTION: 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.

- Participants: Hassen Fourati, Nabil Layaïda, Pierre Genevès and Thibaud Michel
- Partner: GIPSA-Lab
- Contact: Pierre Genevès
- URL: http://tyrex.inria.fr/mobile/benchmarks-attitude/

6.3. GreAR

Grenoble AR-Tour based on geolocation.
KEYWORDS: Augmented reality - Geolocation - Smartphone
FUNCTIONAL DESCRIPTION: This application is an AR navigator specifically designed for pedestrians. This application was initially developed during the Venturi FP7 (2011-2015) project and has been updated with our AR framework since then. Between two visually driven AR experiences (at the time, developed by partners), the navigator provides the user with an audio and visual guidance through a pre-defined touristic path in Grenoble. The position of the user is obtained through a fusion of GPS signal (when available), pedometer estimates and a map-matching algorithm exploiting OpenStreetMap. As the GPS signal is poor in several parts of the old city the integration of the pedometer enables the navigator to obtain a sufficiently reliable position estimate, crucial for AR applications and geofencing. Within the application, there are several options given to the user to view the navigation path through the city, ranging from a satellite image of the streets to a vector map. In the navigation pane, the geofences relating to the AR experiences and other points of interest can be seen.

- Participant: Thibaud Michel
- Contact: Nabil Layaïda
- Publication: On Mobile Augmented Reality Applications based on Geolocation
- URL: http://tyrex.inria.fr/projects/mrb.html

6.4. TyrAr

Geo Augmented Reality on a Smartphone
KEYWORDS: Augmented reality - Smartphone - Geolocation
FUNCTIONAL DESCRIPTION: This application is an AR viewer to name the mountains, cities and historical buildings over the camera feed of the smartphone. The user can turn on himself with his device to discover names and information about Points of Interest (POIs). POIs are directly extracted from the OSM database thanks to the Overpass Turbo API. POIs are displayed on the screen with their name, an icon and an extra information. City POIs exhibit the number of inhabitants, mountains are associated to their altitude and historical buildings display their date of construction.

- Participant: Thibaud Michel
- Contact: Nabil Layaïda
- Publication: On Mobile Augmented Reality Applications based on Geolocation
- URL: http://tyrex.inria.fr/projects/mrb.html

6.5. AmiAr

Smart Home Augmented Reality on a Smartphone
KEYWORDS: Augmented reality - Smart home - Smartphone - Indoor geolocalisation
FUNCTIONAL DESCRIPTION: This application is a proof of concept of a Geo AR system in a smart apartment. This setup has been conducted in EquipEx Amiqual4Home. The goal here is to control objects in the apartment using widgets over the video feed from the camera. For example, a user points a lamp with his smartphone, a widget appears, then he uses a slider in this widget to modify the light intensity.

- Participant: Thibaud Michel
- Contact: Nabil Layaïda
- Publication: On Mobile Augmented Reality Applications based on Geolocation

7. New Results

7.1. Networks: modeling, analysis and estimation

7.1.1. 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. We study linear network systems, and we aim at characterizing input and state observability (ISO), namely the conditions under which both the whole network state and the unknown input can be reconstructed from some measured local states. We complement the classical algebraic characterizations with novel structural results, which depend only on the graph of interactions (equivalently, on the zero pattern of the system matrices). More precisely, there are two kinds of results: structural results, true for almost all interaction weights, and strongly structural results, true for all non-zero interaction weights.

In [32], we consider linear time-invariant (LTI) systems, for which we provide a full characterization of structural ISO. The characterization of strongly structural ISO is on-going work.

In [33], instead, we consider linear time-varying (LTV) systems, under some assumptions on the input and output matrices, namely that each attack input and each output measurement concerns a single local state, and that there is no direct feedthrough of the input to the output. Under these assumptions, we characterize strongly structural ISO; in [23] we also give the characterization of structural ISO under the same assumptions.

We are currently working on analogous characterizations for the more general case, removing these assumptions.
Observability is also related to privacy issues. In the ProCyPhyS project, started in 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. Precisely, by assuming scenarios where nodes compute an average of their initial condition in a finite number of steps with have state privacy-preserving conditions and devise a simple policy that guarantee privacy in case of observable networks.

7.1.2. Sensor networks: multisensor data fusion for navigation

Participants: H. Fourati [Contact person], T. Michel.

Attitude estimation consists in the determination of rigid body orientation in 3D space (principally in terms of Euler angles, rotation matrix, or quaternion). In [27], we solved the attitude determination problem based on a single sensor observation. The rotation equation is transformed into a quadratic quaternion form and is then derived to a linear matrix equation with pseudoinverse matrices. The analytic solutions to the equation are computed via elementary row operations. The solutions show that the attitude determination from a single sensor observation has infinite solutions and the general one is governed by two limiting quaternions. Accordingly, the variance analysis is given in view of probabilistic characters. The authors explore the experimental results via the accelerometer attitude determination system. The properties of the two limiting quaternions are investigated in the experiment. The results show that the gravity-determination abilities of the two limiting quaternions are quite different. Using the rotation vector and eigenvalue decomposition of the attitude matrix, the authors prove that one limiting quaternion is better than another one geometrically. The singularity analysis is also performed revealing the non-existence of singularities for limiting quaternions. The above findings are novel, which are quite different from the conclusions made in a previously published study. In [26], we presents a novel linear approach to solve this problem. We name the proposed method the Fast Linear Attitude Estimator (FLAE) because it is faster than known representative algorithms. The original Wahba's problem is extracted to several 1-dimensional equations based on quaternions. They are then investigated with pseudo-inverse matrices establishing a linear solution to n-dimensional equations, which are equivalent to the conventional Wahba's problem. To obtain the attitude quaternion in a robust manner, an eigenvalue-based solution is proposed. Symbolic solutions to the corresponding characteristic polynomial is derived showing higher computation speed. Simulations are designed and conducted using test cases evaluated by several classical methods e.g. M. D. Shuster's QUaternion ESTimator (QUEST), F. L. Markley's SVD method, D. Mortari's Second Estimator of the Optimal Quaternion (ESOQ2) and some recent representative methods e.g. Y. Yang's analytical method and Riemannian manifold method. The results show that FLAE generates attitude estimates as accurate as that of several existing methods but consumes much less computation time (about 50% of the known fastest algorithm). Also, to verify the feasibility in embedded application, an experiment on the accelerometer-magnetometer combination is carried out where the algorithms are compared via C++ programming language. An extreme case is finally studied, revealing a minor improvement that adds robustness to FLAE. We have been interested in other work [28] to some critical issues on Kalman filter observed in navigation solutions of Global Navigation Satellite System (GNSS). The Kalman fltering (KF) is optimal under the assumption that both process and observation noises are independent white Gaussian noise. However, this assumption is not always satisfed in real-world navigation campaigns. In this paper, two types of KF methods are investigated, i.e. augmented KF (AKF) and the second moment information based KF (SMIKF) with colored system noises, including process and observation noises. As a popular noise-whitening method, the principle of AKF is briefly reviewed for dealing with the colored system noises. The SMIKF method is developed for the colored and correlated system noises, which directly compensates for the covariance through stochastic model in the sense of minimum mean square error. To accurately implement the SMIKF, a refned SMIKF is further derived regarding the continuous-time dynamic model rather than the discrete one. The computational burdens of the proposed SMIKF along with representative methods are analyzed and compared. The simulation results demonstrate the performances of proposed methods.

7.1.3. Network reduction towards a scale-free structure preserving physical properties

Participants: N. Martin, P. Frasca, C. Canudas de Wit [Contact person].

In the context of the ERC project, we are addressing a problem of graph reduction, where a given arbitrary weighted graph is reduced to a (smaller) scale-free graph while preserving a consistency with the initial graph and some physical properties. This problem can be formulated as a minimization problem. We give specifications to this general problem to treat a particular case: to this end we define a metric to measure the scale-freeness of a graph and another metric to measure the similarity between two graphs with different dimensions, based on a notion of spectral centrality. Moreover, through the reduction we also preserve a property of mass conservation (essentially, Kirchoff's first law). We study the optimization problem and, based on the gained insights, we derive an algorithm allowing to find an approximate solution. Finally, we have simulated the algorithm both on synthetic networks and on real-world examples of traffic networks that represent the city of Grenoble.

7.1.4. The Observability Radius of Networks

Participants: G. Bianchin, P. Frasca [Contact person], A. Gasparri, F. Pasqualetti.

Our group is undergoing an effort to understand the system-theoretic properties of networks, namely in terms of controllability and observability. In this context, we have studied the observability radius of network systems, which measures the robustness of a network to perturbations of the edges. We consider linear networks, where the dynamics are described by a weighted adjacency matrix and dedicated sensors are positioned at a subset of nodes. We allow for perturbations of certain edge weights with the objective of preventing observability of some modes of the network dynamics. To comply with the network setting, our work considers perturbations with a desired sparsity structure, thus extending the classic literature on the observability radius of linear systems. The paper [14] proposes two sets of results. First, we propose an optimization framework to determine a perturbation with smallest Frobenius norm that renders a desired mode unobservable from the existing sensor nodes. Second, we study the expected observability radius of networks with given structure and random edge weights. We provide fundamental robustness bounds dependent on the connectivity properties of the network and we analytically characterize optimal perturbations of line and star networks, showing that line networks are inherently more robust than star networks.

7.1.5. Distributed Estimation from Relative and Absolute Measurements

Participants: P. Frasca [Contact person], W.s. Rossi, F. Fagnani.

Important applications in machine learning, in robotic coordination and in sensor networks require distributed algorithms to solve the so-called relative localization problem: a node-indexed vector has to be reconstructed from measurements of differences between neighbor nodes. In [22] we define the problem of least-squares distributed estimation from relative and absolute measurements, by encoding the set of measurements in a weighted undirected graph. The role of its topology is studied by an electrical interpretation, which easily allows distinguishing between topologies that lead to “small” or “large” estimation errors. The least-squares problem is solved by a distributed gradient algorithm, which we have studied in detail. Remarkably, we have observed that the computed solution is approximately optimal after a number of steps that does not depend on the size of the problem or on the graph-theoretic properties of its encoding. This fact indicates that only a limited cooperation between the sensors is necessary to solve this problem.

7.2. Multi-agent systems and network games

7.2.1. 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 concerned the complexity of the best response algorithm under round-robin revision sequence, a classical centralized iterative algorithm to find a Nash Equilibrium. In a more recent work, submitted for publication, and described in the report [40], we focus on distributed versions of the same algorithm. We compute the average complexity over all potential games of best response dynamics under a random i.i.d. revision sequence, since it can be implemented in a distributed way using Poisson clocks. We obtain a distributed algorithm whose execution time is within a constant factor of the optimal centralized one. We then show how to take advantage of the structure of the interactions between players in a network game: noninteracting players can play simultaneously. This improves best response algorithm, both in the centralized and in the distributed case.

7.2.2. *Using a linear gain to accelerate average consensus over unreliable networks*

Participants: F. Acciani, P. Frasca [Contact person], G. Heijenk, A. Stoorvogel.

Packet loss is a serious issue in wireless consensus networks, as even few failures might prevent a network to converge to the desired consensus value. In some recent work, we have devised a possible way to compensate for the errors caused by packet collisions, by modifying the updating weights. Such a modification compensates for the loss of information in an unreliable network, but results in a reduced convergence speed. In [30], we propose a faster method - based on a suitable gain in the consensus dynamics - to solve the unreliable average consensus problem. We find a sufficient condition for the gain to preserve stability of the network. Simulations are used to discuss the choice of the gain, and to compare our method with the literature.

7.2.3. *Mean-field analysis of the convergence time of message-passing computation of harmonic influence in social networks*

Participants: W. S. Rossi, P. Frasca [Contact person].

In the study of networks, identifying the most important nodes is of capital importance. The concept of Harmonic Influence has been recently proposed as a metric for the importance of nodes in a social network. This metric evaluates the ability for one node to sway the 'opinions' of the other nodes in the network, under the assumption of a linear diffusion of opinions in the network. A distributed message passing algorithm for its computation has been proposed by Vassio et al., 2014, and proved to converge on general graphs by Rossi and Frasca, 2016. In [36], we presented an want to evaluate the convergence time of this algorithm by using a mean-field approach. The mean-field dynamics is first introduced in a "homogeneous" setting, where it is exact, then heuristically extended to a non-homogeneous setting. The rigorous analysis of the mean-field dynamics is complemented by numerical examples and simulations that demonstrate the validity of the approach.

7.2.4. *Modeling birds on wires*

Participants: A. Aydogdu, P. Frasca [Contact person], C. d'Apice, R. Manzo, J. M. Thornton, B. Gachomo, T. Wilson, B. Cheung, U. Tariq, W.m. Saidel, B. Piccoli.

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

7.2.5. *Network Games: Condensation of the Graph as a Hierarchical interpretation of the Game*

Participants: G. Casadei, C. Canudas de Wit [Contact person].

Control and optimization over large population networks have become a popular topic within the control community. The main reason is that modern applications re- quire multiple systems to communicate and interact with each other to fulfill the desired task. For instance power networks, sensor networks and social networks are solid examples in which is fundamental to control different parts of the network to achieve a global desired behavior. In the recent years, the control community has largely focused on cooperative approaches to networks. In this framework the agents in the network are willing to collaborate and find an agreement between each other in such a way that they coordinate their motion.

However, not in all the frameworks and not in all the situations, it is possible to consider a cooperative approach. In several scenarios, the nodes are selfish and in competition with the others to pursue their goal. This leads to a non-cooperative interaction between the agents and thus to games played over networks. When the number of nodes in the network is large, it becomes analytically impossible to use conventional game theoretic tools to find a solution to the problem. This motivated researchers to define a new type of games, named aggregative, where the response of an agent depends, rather than on each other players decision, on the aggregation of all the other agents action.

We considered a refined typology of networks games in which the aggregate information is depending on a directed communication graph and showed that under a certain number of conditions the players reach a Nash Equilibrium. Then we study the influence of this graph topology on the structure of the game and show that the condensation of the graph leads to a hierarchical interpretation of the game and thus to a quasi-sequential architecture of optimization. Then, we introduce the concept of physical graph and control graph in flow networks, and show that the condensation of the control graph helps in determining the equilibrium the agents will reach.

7.3. Transportation networks and vehicular systems

7.3.1. Travel time prediction

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

One of the regular performance metrics for qualifying the level of congestion in traffic networks is the travel time. In [24], we addressed the problem of dynamic travel time (DTT) forecasting within highway traffic networks using speed measurements. 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 a predictor computationally simple to be implemented. To take into account the lack of information in the cluster assignment for the new predicted values, a weighted average fusion based on a similarity measurement 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. We consider in a recent paper submitted to European Control Conference 2018 the problem of joint reconstruction of flow and density in a urban traffic network using heterogeneous sources of information. The traffic network is modeled within the framework of macroscopic traffic models, where we adopt Lighthill-Whitham-Richards model (LWR) conservation equation and a piecewise linear fundamental diagram. The estimation problem considers three key principles. First, the principle governing traffic models where flow is maximized in a junction. Second, the error minimization between the measured and reconstructed flows and velocities, and finally the equilibrium state of the network which establishes flow propagation within the network. All principles are integrated and the problem is casted as a constrained quadratic optimization with inequality and equality constraints in order to shrink the feasible region of estimated variables. Some simulation scenarios based on synthetic data for a Manhattan grid network are provided in order to validate the performance of the proposed algorithm.

7.3.2. Urban traffic control

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

The PhD thesis of Pietro Grandinetti 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, together with balancing densities across the network. 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. A modified version of the algorithm uses simplified optimization (purely local, instead of distributed) but takes into account the real constraints in Grenoble downtown traffic lights network, such as priority to public transportation, and imposed minimal and maximal green duration, leading to a fully realistic implementation, tested using Aimsun microscopic simulator.

7.3.3. Traffic Regulation Via Controlled Speed Limit

Participants: M. L. Delle Monache [Contact person], B. Piccoli, F. Rossi.

The work [21] address the speed limit problem on a single road. The control variable is the maximal allowed velocity, which may vary in time but we assume to be of bounded total variation, and we aim at tracking a given target outgoing flow. More precisely, the main goal is to minimize the quadratic difference between the achieved outflow and the given target outflow. Mathematically the problem is very hard, because of the delays in the effect of the control variable (speed limit). In fact, the link entering time, which represents the entering time of the car exiting the road at time t, depends on the given inflow and the control policy on the whole time interval. Moreover, the input-output map is defined in terms of the Link Entering Time, thus the achieved outflow at time t depends on the control variable on the whole time interval. After formulating the optimal control problem, we consider needle-like variations for the control policy as used in the classical Pontryagin maximum principle. We are able to derive an analytical expression of the one-sided variation of the cost, corresponding to needle-like variations of the control policy, using

fine properties of functions with bounded variation. In particular the one-sided variations depend on the sign of the control variation and involve integrals w.r.t. the distributional derivative of the solution as a measure. This allows us to prove Lipschitz continuity of the cost functional in the space of a bounded variation function and prove existence of a solution. Afterwards, we define three different techniques to numerically solve this problem and we compare the three approaches on two test cases.

7.3.4. Scalar conservation laws with moving flux constraints

Participants: M. L. Delle Monache [Contact person], P. Goatin [Acumes, Inria], C. Chalons.

This problem is motivated by the modeling of a moving bottleneck in traffic flow, which can be caused by a large, slow moving vehicle. A slow moving large vehicle, like a bus or a truck, reduces the road capacity and thus generates a moving bottleneck for the surrounding traffic flow. This situation can be modeled by a PDE–ODE strongly coupled system consisting of a scalar conservation law with moving flux constraint accounting for traffic evolution and an ODE describing the slower vehicle motion. In [18], we introduce a novel approach to solve numerically this problem. The main point here is related to the presence of non-classical shocks in the solutions of the model under consideration. It is well-known that, in this context, standard conservative finite volume methods cannot be applied and fail in producing good numerical results. Glimm's scheme can be used but it is not strictly conservative. In order to propose a numerical scheme which is conservative on fixed meshes and able to compute non-classical solutions, we propose to adapt a reconstruction strategy approach, which allows to precisely capture moving non-classical discontinuities on fixed meshes still guaranteeing conservation, unlike Glimm's scheme. An important feature of the proposed method is to be exact for isolated classical and non-classical shocks, which means in particular only one point of numerical diffusion (on each cell the approximate value corresponds to the value of the average of the exact solution). In the general case, shocks are still computed without numerical diffusion and convergence is proved numerically.

In [19] we study well-posedness of a scalar conservation laws with moving flux constraints. In this work we assume that the constraint trajectory is given and it does not depend on the solution of the PDE. In this setting we then show Lipschitz continuous dependence of bounded variation solutions with respect to the initial data ant the constraint trajectory.

7.3.5. Priority-based Riemann solver for traffic flow on networks

Participants: M. L. Delle Monache [Contact person], P. Goatin [Acumes, Inria], B. Piccoli.

In [20] we introduce a novel solver for traffic intersection which considers priorities among the incoming roads as the first criterion and maximization of flux as the second. The main idea is that the road with the highest priority will use the maximal flow taking into account also outgoing roads constraints. If some room is left for additional flow then the road with the second highest priority will use the left space and so on. A precise definition of the new Riemann solver, called Priority Riemann Solver, is based on a traffic distribution matrix , a priority vector and requires a recursion method. The general existence theorem for Riemann solvers on junctions can not be applied in the present case.Therefore, we achieve existence via a new set of general properties.

7.3.6. Discrete-time system optimal dynamic traffic assignment (SO-DTA) with partial control for horizontal queuing networks

Participants: S. Samaranayake, J. Reilly, W. Krichene, M. L. Delle Monache [Contact person], P. Goatin [Acumes, Inria], A. Bayen.

Dynamic traffic assignment (DTA) is the process of allocating time-varying origin-destination (OD) based traffic demand to a set of paths on a road network. There are two types of traffic assignment that are generally considered, the user equilibrium or Wardrop equilibrium allocation (UE-DTA), in which users minimize individual travel-time in a selfish manner, and the system optimal allocation (SODTA) where a central authority picks the route for each user and seeks to minimize the aggregate total travel-time over all users. It can be shown that the price of anarchy (PoA), the worst-case ratio of the system delay caused by the selfish behavior over the system optimal solution, may be arbitrarily large even in simple networks. System optimal (SO) traffic assignment on the other hand leads to optimal utilization of the network resources, but is hard to achieve in practice since the overriding objective for individual drivers in a road network is to minimize their own travel-time. It is well known that setting a toll on each road segment corresponding to the marginal delay of the demand moves the user equilibrium towards a SO allocation. In [25], we formulate the system optimal dynamic traffic assignment problem with partial control (SO-DTAPC), using a Godunov discretization of the Lighthill-Williams-Richards (LWR) partial differential equation (PDE) with a triangular flux function. We propose solving the SO-DTA-PC problem with the non-convex traffic dynamics and limited OD data with complete split ratios as a non-linear optimal control problem. This formulation generalizes to multiple sources and multiple destinations. We show that the structure of our dynamical system allows for very efficient computation of the gradient via the discrete adjoint method.

7.3.7. Measuring trajectories and fuel consumption in oscillatory traffic: experimental results

Participants: F. Wu, R. Stern, M. Churchill, M. L. Delle Monache [Contact person], K. Han, B. Piccoli.

In [37] we present data collected through a set of experiments with nine to 10 vehicles driving on a ring road constructed on a closed track. Vehicle trajectory data is extracted via a series of vision processing algorithms (for background subtraction, vehicle identification, and trajectory extraction) from a 360-degree panoramic camera placed at the center of the ring. The resulting trajectory data is smoothed via a two-step algorithm which applies a combination of RLOESS smoothing and regularized differentiation to produce consistent position, velocity, and acceleration data that does not exhibit unrealistic accelerations common in raw trajectory data extracted from video. A subset of the vehicles also record real-time fuel consumption data of the vehicles using OBD-II scanners. The tests include both smooth and oscillatory traffic conditions, which are useful for constructing and calibrating microscopic models, as well as fuel consumption estimates from these models. The results show a an increase in fuel consumption in the experiments in which traffic oscillations are observed as compared to experiments where vehicles maintain a smooth ow. However, this is partially due to the higher average speed at which vehicles travel in the experiments in which oscillatory traffic is observed. The article contains a complete, publicly available dataset including the video data, the extracted trajectories, the smoothed trajectories, and the OBD-II logs from each equipped vehicle. In addition to the dataset, this article also contains a complete source code for each step of the data processing. It is the first of several experiments planned to collect detailed trajectory data and fuel consumption data with smooth and unsteady traffic flow in a controlled experimental environment.

7.3.8. Large Scale Traffic Networks and Aggregation

Participants: G. Casadei, V. Bertrand, B. Gouin, C. Canudas de Wit [Contact person].

Large scale traffic networks are a popular topic nowadays due to the impact traffic has in our everyday life, both economically and health-wise. City management are interested in understanding the evolution of traffic and its patterns over the city in order to take decision on potential changes and to design new and more functional infrastructure. However, monitoring the current state of a large scale traffic network is a demanding task. The heterogeneity of available measures poses several question on how to merge different sources of information coming from private and public sources. Furthermore, sparsity is an intrinsic issues related to large scale systems: independently from the source we choose to rely on, we cannot expect the measurements to be sufficiently dense to cover the full network in detail.

For large scale urban network, managing real-time traffic information from thousands of links simultaneously is an overwhelming task and extracting interesting and meaningful insights from these tangle of data can be even a more challenging aim. In recent years more and more data are becoming available from new sources, such as smart phones, GPS navigators, and their technological penetration nowadays allows to have an impressive amount of real-time traffic information, not requiring the placement of physical sensors over the network and thus reducing incredibly costs due to installation and maintenance: in other words, each user becomes a moving sensor inside the network.

One way to deal with this huge amount of data over a urban traffic network is to look at the graph describing the network with a clusterization approach: this would reduce the number of nodes, thus the computational cost, proportionally to the clusterization rate and potentially would help with sparsity by merging areas in which no data are available with areas with sufficient penetration of information. In this work we presented an aggregation-based technique to analyze GPS velocity data from a private source (TomTom) and to calculate multi-origin multi-destination travel time. The technique we propose allows to perform the aggregation and the necessary computation in such a way that its application in a real time framework is feasible. The information and results we obtain are of great interest to understand the macroscopic evolution of the traffic from a large-scale point of view and to evaluate the average time that users spend in transiting between different areas along the day. In practice, we show that reducing the *complexity* of the network by 95% thanks to aggregation, we introduce an error in the calculation of the traveling times that in the average is below 25%.

7.3.9. Two dimensional models for traffic

Participants: S. Mollier, M. L. Delle Monache, C. Canudas de Wit [Contact person].

The work deals with the problem of modeling traffic flow in urban area, e. g. a town. More precisely, the goal is to design a two-dimensional macroscopic traffic flow model suitable to model large network as the one of a city. Macroscopic traffic models are inspired from fluid dynamic. They represent vehicles on the road by a density and describe their evolution with partial differential equations. Usually, these models are one dimensional models and, for instance, give a good representation of the evolution of traffic states in highway. The extension of these 1D models to a network is possible thanks to models of junction but can be tedious according to the number of parameters to fit. In the last few years, the idea of models based on a two dimensional conservation laws arose in order to represent traffic flow in large and dense networks. This study aims to develop such models with new designs especially including the network topology, and validation with simulation.

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. 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 [46]. 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.

8.1.2. Control of Cyber-Social Systems (C2S2)

C2C2 is a two year project funded by the University Grenoble Alpes, MSTIC department. Evolving from recent research on network systems, this exploratory project has the objective to concentrate on "cyber-social" systems, that is, complex systems with interacting social and technological components. A strong motivation for this novel research direction comes from the need for innovative tools for the management of vehicular traffic. In this application, state-of-the-art approaches concentrate on hard control actions, like traffic lights: instead, future management methods should exploit soft control actions aimed at controlling the traffic demand, that is, the aggregated behaviors of the drivers.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. 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

8.2.1.2. 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

8.3. International Initiatives

8.3.1. Participation in Other International Programs

8.3.1.1. 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.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Dr. Walter Musakwa from Univ. of Johannesburg (South Africa) visited the team in August 2017 for working with A. Kibangou on analysis on cycling data collected in Johannesburg and setting up a MoA between UGA and UJ.

Prof. Olga Quintero Montoya, from Universidad EAFIT (Colombia) visited teh team from May 2017 until June 2017 to work with C. Canudas de Wit on traffic flow problems.

Pr. Marcello L.R. de Campos (Federal Univ. of Rio de Janeiro, Brazil) visited the team in October 2017 in the framework of the TICO-MED project.

Dr. Paola Goatin (Inria Sophia Antipolis) visited the team in September to work with M. L. Delle Monache on traffic flow modeling and control using conservation laws.

F. Acciani (U. Twente, Netherlands) visited the team in November 2017 to work with P. Frasca.

W. S. Rossi (U. Twente, Netherlands) visited the team in November 2017 to work with P. Frasca.

Professor Per-Olof Gutman visited the on February 9th and 10th 2017. he gave two talks on "Modelling of and Controller Design for a Virtual Skydiver" and "Dynamic model for estimating the Macroscopic Fundamental Diagram" to the NeCS team. He exchanged ideas with Carlos Canudas de Wit, Paolo Frasca and Giacomo Casadei.

Professor Ioannis Paschalidis visited the team on September 2017. He gave a talk "Inverse Equilibrium Problems and Price-of-Anarchy Estimation in Transportation Networks". He exchanged ideas with Carlos Canudas De Wit, Paolo Frasca and Stephane Mollier.

8.4.1.1. Research Stays Abroad

A. Kibangou visited the University of Johanesburg (UJ) in March and October 2017. During his stay, he gave lectures to students of Department of Town and Regional Planning of UJ on Mobility and traffic management.

A. Kibangou visited University of Cape Town (UCT) in October 2017. During his stay, he gave a lecture to students and researchers of Control department of UCT.

Federica Garin spent three weeks in Lund, Sweden, in June, for the LCCC Focus Period on Large-Scale and Distributed Optimization (http://www.lccc.lth.se/index.php?page=june-2017-optimization)

Paolo Frasca visited the University of Cagliari, Cagliari, Italy in April–May 2017.

M. L. Delle Monache visited Rutgers University (USA) in June 2017. During her stay they worked on control of traffic with conservation laws.

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events Organisation

9.1.1.1. General Chair, Scientific Chair

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

9.1.1.2. Member of the Organizing Committees

The team organized the international ERC Scale-free Back workshop on “Modelling reduction tools for large-scale complex networks”, Grenoble, September 2017.
P. Frasca organized an open Invited session on “Dynamics and control in social networks”, IFAC World Congress, July 2017 (with G. Como) .

9.1.2. Scientific Events Selection

9.1.2.1. Member of the Conference Program Committees

Paolo Frasca has served as Associate Editor in the IEEE Robotics and Automation Society CASE Conference Editorial Board for the 13th IEEE International Conference on Automation Science and Engineering, 2017 .
Federica Garin is Associate Editor in the IEEE Control System Society Conference Editorial Board (this year, she served for CDC 2017, ACC 2018)., and Associate Editor in the European Control Association (EUCA) Conference Editorial Board (this year, she served for ECC 2018).
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 STA2017, 2017.

9.1.2.2. 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, IFAC World Congress, IFAC Workshop on Control for Transportartion Systems (CTS).

9.1.3. Journal

9.1.3.1. 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).
Hassen Fourati is guest editor of the special issue titled “Multi-sensor Integrated Navigation and Location based services applications” for International Journal of Distributed Sensor Networks (IJDSN), 2017 and Associate Editor of the Asian Journal of Control AJC (since January 2016). Paolo Frasca is Subject Editor of the International Journal of Robust and Nonlinear Control (Wiley) (since February 2014), Associate Editor of IEEE Control System Letters (from February 2017) and Associate Editor of the Asian Journal of Control (Wiley) (since January 2017).

9.1.3.2. 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, AIMS Networks and Heterogeneous Network (NHM), Wiley Mathematical Methods in the Applied Sciences (MMAS), Journal of Mathematical Analysis and Applications (JMMA), Journal of Nonlinear Science and Applications (JNSA), Journal of the Franklin Institute, AMS Mathematical Reviews, IEEE Journal of Intelligent Transportation Systems, Asian Journal of Control, IEEE Transaction on Intelligent Transportation Systems, Elsevier Transportation Research Part B.

9.1.4. Invited Talks

- M. L. Delle Monache, "Traffic regulation via controlled speed limit", SIAM Conference on Optimization, Vancouver, Canada, May 22, 2017.
- M. L. Delle Monache, "Control of traffic flow via ramp metering and automated vehicles", France Berkeley Fund Symposium, Collège de France, Paris, France, June 7, 2017.
- M. L. Delle Monache, "Coupled PDE-ODE systems: applications to traffic flow modeling and control", Institute de Mathematiques de Marseille, Marseille, France, November 14, 2017.
- M. L. Delle Monache, "Control of Traffic: from ramp metering to autonomous vehicles", The Finite volume schemes and traffic modeling workshop,Besançon, France, November 23, 2017.
- P. Frasca, "Message-passing computation of the harmonic influence in social networks", L2S, Paris-Saclay, November 21, 2017.
- P. Frasca, "Harmonic influence in social networks and identification of influencers by message passing", WUDS'17 workshop, Banyuls-sur-mer, July 6, 2017.
- P. Frasca, "Non-smooth dynamical systems in opinion dynamics", University of Twente, Enschede ,NL, June 15, 2017.
- P. Frasca, "The observability radius of network systems", University of Cagliari, Cagliari, Italy, May 4, 2017.
- F. Garin, "Input-and-state observability of structured network systems", LCCC Focus Period on Large-Scale and Distributed Optimization, Lund, Sweden, June 2017.

9.1.5. 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.

9.1.6. 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).

9.2. Teaching - Supervision - Juries

9.2.1. 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, 30h, L2, IUT1 (GEII), Univ. Grenoble Alpes, France.

Licence: H. Fourati, Automatique, 38h, L3, UFR physique, Univ. Grenoble Alpes, France.

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

Licence: H. Fourati, Automatique complément, 12h, L2, IUT 1 (GEII), Univ. Grenoble Alpes, France.

Licence: H. Fourati, Mathématiques, 18h, L2, IUT1 (GEII1), 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.

9.2.2. Supervision

PhD: Pietro Grandinetti, Control of large-scale traffic networks, Sept. 2017, co-advised by C. Canudas de Wit and F. Garin.

PhD: Thibaud Michel, Mobile Augmented Reality Applications for Smart Cities, Nov. 2017, co-advised by N. Layaïda, H. Fourati and P. Geneves.

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: 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.

PhD in progress: Martin Rodriguez-Vega, Traffic density, traveling time and vehicle emission estimation in large - scale traffic networks, from Oct. 2017, co-advised by C. Canudas de Wit and H. Fourati.

PhD in progress: Muhammad Umar B Niazi, State-state estimation design and optimal sensor placement algorithms for large-scale evolutionary dynamical networks, from Dec. 2017, co-advised by C. Canudas de Wit and A. Kibangou.

9.2.3. Juries

- P. Frasca was committee member of the PhD defence of Florian Dietrich. Analyse et controle de systemes de dynamiques d'opinions. CRAN, Université de Lorraine, Nancy, France. Ph.D. advisors: Marc Jungers and Samuel Martin, November 22, 2017
- H. Fourati was committee member of the PhD defense of Alexis Nez, Univ. Poitiers, July 2017

- F. Garin was member of the recruiting committee, held in March-May 2017, for two Researcher ('CR2') positions at Inria Grenoble-Rhône Alpes.
- F. Garin was Member of the recruiting committee, held in April-May 2017, for an Associate Professor position ('poste de Maître de Conférences, section 61') at Univ. Grenoble Alpes and the Automatic Control Departement of GIPSA-lab.
- F. Garin was opponent for the licentiate thesis of Riccardo Lucchese, LuleåUniversity of Technology, Luleå, Sweden, May 2017.
- P. Frasca was member of the recruiting committee, held in March-May 2017, for two Researcher ('CR2') positions at Inria Saclay.

9.3. Popularization

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

- G. Casadei, V. Bertrand, DEMO on the GTL at the "Rencontres Inria Industrie", Inria, Paris, Oct. 2017

10. Bibliography

Major publications by the team in recent years

[1] G. BIANCHIN, P. FRASCA, A. GASPARRI, F. PASQUALETTI. *The Observability Radius of Networks*, in "IEEE Transactions on Automatic Control", June 2017, vol. 62, n^{o} 6, pp. 3006-3013 [*DOI :* 10.1109/TAC.2016.2608941], https://hal.archives-ouvertes.fr/hal-01528187

[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] M. L. DELLE MONACHE, B. PICCOLI, F. ROSSI. *Traffic Regulation Via Controlled Speed Limit*, in "SIAM Journal on Control and Optimization", 2017, vol. 55, n^{o} 5, pp. 2936–2958, https://hal.archives-ouvertes.fr/hal-01577927

[4] 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

[5] 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

[6] 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^{o} 1, pp. 149-157 [*DOI :* 10.1109/TMECH.2012.2225151], https://hal.archives-ouvertes.fr/hal-00690145

[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^o 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^o 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^o 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] P. GRANDINETTI. *Control of large-scale traffic networks*, Univ. Grenoble Alpes, Sept. 2017

[12] T. MICHEL. *On Mobile Augmented Reality Applications based on Geolocation*, Université Grenoble Alpes, November 2017, https://hal.inria.fr/tel-01651589

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. M. 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. BIANCHIN, P. FRASCA, A. GASPARRI, F. PASQUALETTI. *The Observability Radius of Networks*, in "IEEE Transactions on Automatic Control", June 2017, vol. 62, n^o 6, pp. 3006-3013 [*DOI :* 10.1109/TAC.2016.2608941], https://hal.archives-ouvertes.fr/hal-01528187

[15] N. CARDOSO DE CASTRO, D. E. QUEVEDO, F. GARIN, C. CANUDAS DE WIT. *Energy-Aware Radio Chip Management for Wireless Control*, in "IEEE Transactions on Control Systems Technology", 2017, forthcoming [*DOI :* 10.1109/TCST.2016.2634460], https://hal.inria.fr/hal-01505312

[16] G. CASADEI, D. ASTOLFI. *Multi-pattern output consensus in networks of heterogeneous nonlinear agents with uncertain leader: a nonlinear regression approach*, in "IEEE Transactions on Automatic Control", August 2018, forthcoming [*DOI :* 10.1109/TAC.2017.2771316], https://hal.archives-ouvertes.fr/hal-01626655

[17] G. CASADEI, A. ISIDORI, L. MARCONI. *About disconnected topologies and synchronization of homogeneous nonlinear agents over switching networks*, in "International Journal of Robust and Nonlinear Control", 2017, vol. 50, n^o 5, pp. 655 - 661 [*DOI :* 10.1002/RNC.3910], https://hal.archives-ouvertes.fr/hal-01587668

[18] C. CHALONS, M. L. DELLE MONACHE, P. GOATIN. *A conservative scheme for non-classical solutions to a strongly coupled PDE-ODE problem*, in "Interfaces and Free Boundaries", 2017, forthcoming, https://hal.inria.fr/hal-01070262

[19] M. L. DELLE MONACHE, P. GOATIN. *Stability estimates for scalar conservation laws with moving flux constraints*, in "Networks and Heterogeneous Media", June 2017, vol. 12, n^{o} 2, pp. 245–258 [*DOI :* 10.3934/NHM.2017010], https://hal.inria.fr/hal-01380368

[20] M. L. DELLE MONACHE, P. GOATIN, B. PICCOLI. *Priority-based Riemann solver for traffic flow on networks* , in "Communications in Mathematical Sciences", 2017, forthcoming, https://hal.inria.fr/hal-01336823

[21] M. L. DELLE MONACHE, B. PICCOLI, F. ROSSI. *Traffic Regulation Via Controlled Speed Limit*, in "SIAM Journal on Control and Optimization", 2017, vol. 55, n^{o} 5, pp. 2936–2958, https://arxiv.org/abs/1603.04785 , https://hal.archives-ouvertes.fr/hal-01577927

[22] P. FRASCA, W. S. ROSSI, F. FAGNANI. *Distributed Estimation from Relative and Absolute Measurements*, in "IEEE Transactions on Automatic Control", 2017, vol. 62, n^{o} 12, pp. 6385-6391 [*DOI :* 10.1109/TAC.2017.2661400], https://hal.archives-ouvertes.fr/hal-01614098

[23] S. GRACY, F. GARIN, A. KIBANGOU. *Structural and Strongly Structural Input and State Observability of Linear Network Systems*, in "IEEE transactions on control of network systems", 2017, forthcoming [*DOI :* 10.1109/TCNS.2017.2782489], https://hal.archives-ouvertes.fr/hal-01663175

[24] A. LADINO, A. Y. KIBANGOU, C. CANUDAS DE WIT, H. FOURATI. *A real time forecasting tool for dynamic travel time from clustered time series*, in "Transportation research. Part C, Emerging technologies", May 2017, vol. 80, n^{o} July, pp. 216-238 [*DOI :* 10.1016/J.TRC.2017.05.002], https://hal.inria.fr/hal-01521723

[25] S. SAMARANAYAKE, J. REILLY, W. KRICHENE, M. L. DELLE MONACHE, P. GOATIN, A. BAYEN. *Discrete-time system optimal dynamic traffic assignment (SO-DTA) with partial control for horizontal queuing networks*, in "Transportation Science", 2017, forthcoming, https://hal.inria.fr/hal-01095707

[26] J. WU, Z. ZHOU, B. GAO, R. LI, Y. CHENG, H. FOURATI. *Fast Linear Quaternion Attitude Estimator Using Vector Observations*, in "IEEE Transactions on Automation Science and Engineering", April 2017, forthcoming [*DOI :* 10.1109/TASE.2017.2699221], https://hal.inria.fr/hal-01513263

[27] J. WU, Z. ZHOU, R. LI, L. YANG, H. FOURATI. *Attitude Determination Using a Single Sensor Observation: Analytic Quaternion Solutions and Property Discussion (accepted)*, in "IET Science Measurement and Technology", March 2017, vol. 11, n^{o} 6, 731 p. [*DOI :* 10.1049/IET-SMT.2016.0202], https://hal.inria.fr/hal-01514132

[28] Z. ZHOU, J. WU, Y. LI, C. FU, H. FOURATI. *Critical issues on Kalman filter with colored and correlated system noises*, in "Asian Journal of Control", March 2017, pp. 1 - 12 [*DOI :* 10.1002/ASJC.0000], https://hal.inria.fr/hal-01496860

[29] J. H. DE MORAIS GOULART, A. KIBANGOU, G. FAVIER. *Traffic data imputation via tensor completion based on soft thresholding of Tucker core*, in "Transportation research. Part C, Emerging technologies", December 2017, vol. 85, pp. 348 - 362 [*DOI :* 10.1016/J.TRC.2017.09.011], https://hal.archives-ouvertes.fr/hal-01623213

International Conferences with Proceedings

[30] F. ACCIANI, P. FRASCA, G. HEIJENK, A. STOORVOGEL. *Using a linear gain to accelerate average consensus over unreliable networks*, in "56th IEEE Conference on Decision and Control, CDC 2017", Melbourne, Australia, December 2017, pp. 3569-3574, https://hal.archives-ouvertes.fr/hal-01614110

[31] G. CASADEI, C. CANUDAS DE WIT. *Network Games: Condensation of the Graph as a Hierarchical interpretation of the Game*, in "IFAC World Congress 2017", Toulouse, France, IFAC-PapersOnLine, IFAC, July 2017, vol. 50, pp. 9655-9660, https://hal.archives-ouvertes.fr/hal-01561947

[32] F. GARIN. *Structural Delay-1 Input-and-State Observability*, in "56th IEEE Conference on Decision and Control, CDC 2017", Melbourne, Australia, December 2017, https://hal.inria.fr/hal-01592199

[33] S. GRACY, F. GARIN, A. Y. KIBANGOU. *Strong Structural Input and State Observability of LTV Network Systems with Multiple Unknown Inputs*, in "IFAC World Congress", Toulouse, France, IFAC, July 2017, pp. 7618-7623, http://hal.univ-grenoble-alpes.fr/hal-01507387

[34] T. MICHEL, P. GENEVE`S, H. FOURATI, N. LAYAÏDA. *On Attitude Estimation with Smartphones*, in "IEEE International Conference on Pervasive Computing and Communications", Kona, United States, March 2017, Accepted for the International Conference on Pervasive Computing and Communications (PerCom 2017), Mar 2017, Kona, United States, https://hal.inria.fr/hal-01376745

[35] S. MOLLIER, M. L. DELLE MONACHE, C. CANUDAS DE WIT. *A simple example of two dimensional model for traffic: discussion about assumptions and numerical methods*, in "Transportation Research Board (TRB) 97th Annual Meeting", Washington, D.C., United States, January 2018, https://hal.archives-ouvertes.fr/hal-01665285

[36] W. S. ROSSI, P. FRASCA. *Mean-field analysis of the convergence time of message-passing computation of harmonic influence in social networks*, in "20th World Congress The International Federation of Automatic Control", Toulouse, France, Proceedings of the 20th World Congress The International Federation of Automatic Control, July 2017, https://hal.archives-ouvertes.fr/hal-01563755

[37] F. WU, R. STERN, M. CHURCHILL, M. L. DELLE MONACHE, K. HAN, B. PICCOLI, D. B. WORK. *Measuring trajectories and fuel consumption in oscillatory traffic: experimental results*, in "TRB 2017 - Transportation Research Board 96th Annual Meeting", Washington DC, United States, January 2017, 14 p. , https://hal.archives-ouvertes.fr/hal-01516133

Conferences without Proceedings

[38] N. MARTIN, P. FRASCA, C. CANUDAS DE WIT. *Network reduction towards a scale-free structure preserving physical properties*, in "6th International Conference on Complex Networks and Their Applications", Lyon, France, November 2017, https://hal.archives-ouvertes.fr/hal-01632482

Scientific Books (or Scientific Book chapters)

[39] F. FAGNANI, P. FRASCA. *Introduction to Averaging Dynamics over Networks*, Springer, 2017 [*DOI :* 10.1007/978-3-319-68022-4], https://hal.archives-ouvertes.fr/hal-01614915

Research Reports

[40] S. DURAND, F. GARIN, B. GAUJAL. *Best Response Algorithms for Random Network Games*, Inria ; Université Grenoble - Alpes ; Gipsa-lab ; Persival, May 2017, n° RR-9066, https://hal.inria.fr/hal-01522919

Other Publications

[41] C. CANUDAS DE WIT. *An Average Study of the Signalized Cell Transmission Model*, November 2017, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01635539

[42] T. MICHEL, P. GENEVÈS, H. FOURATI, N. LAYAÏDA. *Attitude Estimation with Smartphones*, November 2017, working paper or preprint, https://hal.inria.fr/hal-01650142

[43] R. E. STERN, S. CUI, M. L. DELLE MONACHE, R. BHADANI, M. BUNTING, M. CHURCHILL, N. HAMILTON, R. HAULCY, H. POHLMANN, F. WU, B. PICCOLI, B. SEIBOLD, J. SPRINKLE, D. B. WORK. *Dissipation of stop-and-go waves via control of autonomous vehicles: Field experiments*, October 2017, working paper or preprint, https://hal.inria.fr/hal-01614638

[44] F. WU, R. E. STERN, S. CUI, M. L. DELLE MONACHE, R. BHADANI, M. BUNTING, M. CHURCHILL, N. HAMILTON, R. HAULCY, B. PICCOLI, B. SEIBOLD, J. SPRINKLE, D. WORK. *Tracking vehicle trajectories and fuel rates in oscillatory traffic*, October 2017, working paper or preprint, https://hal.inria.fr/hal-01614665

[45] Z. ZHOU, J. WU, J. WANG, H. FOURATI. *Optimal, Recursive and Suboptimal Linear Solutions to Attitude Determination from Vector Observations*, December 2017, working paper or preprint, https://hal.inria.fr/hal-01525603

References in notes

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