CARMA Workshop on Mathematical Systems Theory and Applications

University of Newcastle, New South Wales, Australia
7–8 December 2017

CARMA

PRIORITY RESEARCH CENTRE for
COMPUTER-ASSISTED RESEARCH MATHEMATICS AND ITS APPLICATION

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Welcome from the Organisers

Welcome to the CARMA Workshop on Mathematical Systems Theory and Applications! We are delighted that you are able to join us for two days of scientific exchange in the beautiful harbour town of Newcastle. We hope you will be able to take some time to swim in the historic Newcastle Ocean Baths, walk along the cliff on the ANZAC Memorial Walk, or take some surf lessons in the Merewether Beaches National Surfing Reserve – home of the famous Surfest surfing competition.

As a single track workshop with a limited number of attendees, we anticipate a flexible and stimulating two days, with ample time to engage outside of the speaking schedule. To this end, we have scheduled a 75 minute lunch break both days as well as dinners Wednesday–Friday and a social program on Saturday.

Once again, welcome!
Chris Kellett and Björn Rüffer

Venues

Meeting Room: The workshop will be held at the University of Newcastle's new inner city presence, NeW Space, in the Moot Courtroom, room X703, on the seventh floor.

Wednesday Dinner: Dinner on Wednesday is not included in the workshop, but we (the organisers) will plan to be at The Grain Store (see map next page) from 6:30pm. The Grain Store is a short, 300m walk from the workshop hotel; ideal to quickly return to the hotel when the jet lag kicks in.

Thursday Dinner: Dinner Thursday night is included in the workshop (we cover the food, buy your own drinks at the bar) and will be at the Honeysuckle Hotel on the Newcastle Harbour. The Honeysuckle Hotel is a short 500m walk from NeW Space and a flat 2km walk along the harbour to the workshop hotel.

Friday Dinner: Dinner Friday is also included in the workshop (again, we cover the food, buy your own drinks at the bar) and will be at the Foghorn Brewhouse. Foghorn is 700m from NeW Space en route to the workshop hotel, which is a further 1.4km.

Saturday Social Program: To be advised.

Other Information

Lunch is not included in the workshop. There are several cafe options for lunch on nearby Darby Street, on King Street near Darby Street, and on the harbour front.

While NeW Space is a flat walk from the workshop hotel, buses in the CBD are free, with one bus route very close to the workshop hotel, but many starting from the former Newcastle Railway Station.


Nobbys Lighthouse
Nobbys
Stony Point
Nobbys Beach Reserve
Nobbys Beach
Shortland Esplanade
Fort Scratchley
Foreshore Park
Fort Dr
Parnell Pl
Stevenson Pl
Wharf Rd
Pirate Point
Pitt Street Reserve
Callen St
Wharf Cres
Mitchell St
Maitland St
Hunter St
Bond St
Pacific St
Ocean St
King St
Scott St
Watt St
Church St
Bolton St
Rose Cottage (Circa 1830)
Queens Wharf Tower
Newcomen St
Christ Church Cathedral
Wolfe St
Tyrrell St
Barker St
Ordnance St
Reserve Rd
King Edward Park
York Dr
The Obelisk
Perkins St
Brown St
The Terrace
High St
Hunter River
Dyke Point
Mosbri Cres
Anzac Parade
Strzelecki Lookout
Kitchener Parade
Nesca Parade
Newcastle Memorial Walk
Crowne Plaza Newcastle
Centenary Rd
Darby St
Burwood St
Laman St
Newcastle Civic Park
Brooks St
Railway St
Dyke Rd
Newcastle Museum
Wright Ln
Civic Theatre
Dawson St
Bull St
Nickson St
Fenton Ave
Wrightson Ave
Gibson St
Council St
Parry St
Honeysuckle Hotel
Civic Ln
John St
Corlette St
Tooke St
Bruce St
Honeysuckle Dr
Steel St
King St
Union St
Centennial Park
Wilson St

Schedule

Wednesday, 6 December 2017

1830 –	Dinner at The Grain Store

Thursday, 7 December 2017

0850–0900	Welcome
0900–0935	Andrew Fleming and Adrian Wills, University of Newcastle – *Optimization Challenges in Maskless Lithography*
0935–1010	Andrea Serrani, The Ohio State University – *A Combined Reference Management and Anti-Windup Modification for Adaptive Airspeed Control of Hypersonic Vehicles under Input Constraints*
1010–1045	Paul M. J. Van den Hof, Eindhoven University of Technology – *Data-driven modelling in dynamic networks*
1045–1100	Coffee Break
1100–1135	Thomas Schön, Uppsala University – *On the construction of probabilistic Newton-type algorithms*
1135–1210	Vera Roshchina, Royal Melbourne Institute of Technology and Federation University Australia – *A counterexample to De Pierro's conjecture*
1210–1245	Jacquelien Scherpen, University of Groningen – *Model order reduction and composite control of slow-fast systems around hyperbolic and non-hyperbolic points*
1245–1400	Lunch
1400–1435	Giordano Scarciotti, Imperial College – *A stochastic Sylvester equation for output regulation and model reduction of linear stochastic systems*
1435–1510	Pauline Bernhard, MINES ParisTech – *Observer design for nonlinear systems*
1510–1545	Lorenzo Marconi, University of Bologna – *Low-Power High-Gain Observers*
1545–1600	Coffee Break
1600–1635	Chris Kellett, University of Newcastle – *Optimal control and the economics of climate change*
1635–1710	Timm Faulwasser, Karlsruhe Institute of Technology – *Stochastic Discount Rates in Optimal Control: A Case Study in Climate-Economy Assessment*
1800–	Dinner at Honeysuckle Hotel

Friday, 8 December 2017

0900–0935	Philipp Braun, University of Newcastle – *(Nonsmooth) control Lyapunov functions: Discussions on stability, instability, and obstacle avoidance*
0935–1010	Björn Rüffer, University of Newcastle – *A Lyapunov function construction for the Douglas-Rachford operator in a non-convex setting*
1010–1045	Hiroshi Ito, Kyushu Institute of Technology – *How far is the state of iISS connection going to escape?*
1045–1100	Coffee Break
1100–1135	Antoine Chaillet, CentraleSupélec – University Paris Saclay – *Is a point-wise dissipation enough for ISS in time-delay systems?*
1135–1210	Christophe Prieur, Centre National de la Recherche Scientifique – *ISS of hyperbolic systems: Application to quantized and event-based boundary control of conservation laws*
1210–1245	Delphine Bresch-Pietri, MINES ParisTech – *Robust compensation of a chattering time-varying input delay with jumps*
1245–1400	Lunch
1400–1435	Lars Grüne, University of Bayreuth – *Turnpike behaviour and strict dissipativity of optimal control problems with and without state constraints*
1435–1510	Marleen Stieler, University of Bayreuth – *Dissipativity and turnpike phenomena for multi-objective optimal control problems*
1510–1545	Martin Guay, Queen's University – *Extremum seeking control for minimum phase nonlinear systems*
1545–1600	Coffee Break
1600–1635	Luca Zaccarian, Centre National de la Recherche Scientifique and University of Trento – *GAS of PID-based feedback of motion systems with Coulomb friction and a reset-based law for transient improvement*
1635–1710	Steve Weller, University of Newcastle – *A strict monotonicity property of all-pole systems*
1800–	Dinner at Foghorn Brewhouse

Abstracts

Speaker: Pauline Bernhard, MINES ParisTech
Title: Observer design for nonlinear systems
Abstract: Unlike for linear systems, no systematic method exists for the design of observers for nonlinear systems. However, observer design may be more or less straightforward depending on the coordinates we choose to express the system dynamics. In particular, some specific structures, called normal forms, have been identified for allowing a direct and easier observer construction. It follows that a common way of addressing the problem consists in looking for a reversible change of coordinates transforming the expression of the system dynamics into one of those normal forms, design an observer in those coordinates, and finally deduce an estimate of the system state in the initial coordinates via inversion of the transformation. This talk will present some contributions to each of those three steps. In particular, we show the interest of a new triangular normal form with continuous (non-Lipschitz) nonlinearities. Indeed, systems which are observable for any input but with an order of differential observability larger than the system dimension, may not be transformable into the standard Lipschitz triangular form, but rather into an "only continuous" triangular form. In this case, the famous high gain observer no longer is sufficient, and we propose to use homogeneous observers instead. As for the inversion of the transformation, this step is far from trivial in practice, in particular when the domain and image spaces have different dimensions. When no explicit expression for a global inverse is available, numerical inversion usually relies on the resolution of a minimization problem with a heavy computational cost. That is why we have developed a method to avoid the explicit inversion of the transformation by bringing the observer dynamics (expressed in the normal form coordinates) back into the initial system coordinates. This is done by dynamic extension, i.e. by adding some new coordinates to the system and augmenting an injective immersion into a surjective diffeomorphism. *(Joint work with Laurent Praly and Vincent Andrieu.)*

Speaker: Philipp Braun, University of Newcastle
Title: (Nonsmooth) control Lyapunov functions: Discussions on stability, instability and obstacle avoidance
Abstract: We review existing results on (nonsmooth) control Lyapunov functions in the context of stability and stabilization of nonlinear dynamical systems. Moreover, we highlight open problems and results on the ongoing research topic of control Lyapunov functions for destabilization of nonlinear systems. The talk concludes with ideas combining the concepts of stability and instability in one control Lyapunov function in the context of obstacle avoidance. Here we particularly point out the necessity of nonsmoothness in the function definition.

Speaker: Delphine Bresch-Pietri, MINES ParisTech
Title: Robust compensation of a chattering time-varying input delay with jumps
Abstract: In this talk, we consider the case of a time-varying input delay, not necessarily First-In/First-Out (FIFO). This means that the input signals can be reordered, as appears in communication networks, resulting in delay jumps and time instants for which the delay derivative is larger than one. These features complexify significantly the control design.

We propose to apply a prediction-based controller using the current delay value in the prediction. It does not exactly compensate for the delay in the closed-loop dynamics. However, it does not require to predict future delay values, contrary to the standard prediction technique, which cannot be applied in this context.

Using an extension of Halanay inequality and a partial differential equation representation of the delay, we prove robust delay compensation, that is, asymptotic stabilization of the system state, providing that the average L2-norm of the delay time-derivative over some time-window is sufficiently

small and that the average time between two discontinuities (average dwell time) is sufficiently large.

Speaker: Antoine Chaillet, CentraleSupélec – University Paris Saclay
Title: Is a point-wise dissipation enough for ISS in time-delay systems?
Abstract: The internal stability of time-delay systems can be ensured by a Lyapunov-Krasovskii functional, provided that it strictly dissipates along solutions. For this, the dissipation rate is required to be only in terms of the point-wise (instantaneous) value of the state.

When inputs are considered, a similar characterization exists for the input-to-state stability (ISS) property. However, unlike in the autonomous case, the only existing results impose a dissipation rate involving the whole Lyapunov-Krasovskii functional, rather than the mere instantaneous value of the state norm.

In this talk, after reviewing classical results for ISS of time-delay systems, we thus address the question of whether ISS of time-delay systems is guaranteed when the dissipation rate involves merely the present value of the state norm. Such a result would simplify the ISS analysis of time-delay systems and would unify the theory with respect to the input-free case.

We do not yet confirm or infirm this conjecture, but rather identify growth restrictions (often satisfied in practice) under which it holds true. The results are illustrated by an example taken from the neuroscience literature. We also list a series of robustness properties that naturally hold under this point-wise dissipation inequality, and discuss possible strategies of proof or counter-example.

Speaker: Timm Faulwasser, Karlsruhe Institute of Technology
Title: Stochastic Discount Rates in Optimal Control ? A Case Study in Climate-Economy Assessment
Abstract: Many problems in Economics are analyzed through solving discounted optimal control problems. This includes climate economy assessment based on integrated assessment models. At the same time, it is widely recognized by economists that the obtained solutions depend crucially on the considered discount rates and that the correct discount rate is very difficult to select, hence surrounded by uncertainty.

In this talk, we investigate efficient solution strategies for stochastically discounted discrete- time optimal control problems that arise in climate economy assessment. We show that tools from uncertainty quantification, more precisely Polynomial Chaos Expansions, allow numerically efficient reformulations of such problems. Specifically, we investigate the computation of the Social Cost of Carbon Dioxide (SC- CO 2) using the Dynamic Integrated model of Climate and the Economy (DICE), whereby the discount rate is assumed to be uncertain, i.e. specified by a non-Gaussian probability density function. Our results show that under suitable technical assumptions, optimal control problems with stochastic discounting are equivalent to problems with time-varying discounting.

Speaker: Andrew Fleming, University of Newcastle
Title: Optimization Challenges in Maskless Lithography
Abstract: Laser scanning lithography is a maskless method for exposing films of photoresist during semiconductor manufacturing. In this method, a focused beam is scanned over a surface with varying intensity to create features in the photoresist. Given the shape of a desired feature, an exposure pattern must be found that approximates this shape in the developed photoresist. This can be cast as an optimization problem, which is complicated by the non-negative nature of the exposure function and the non-linear photochemistry of the film. This talk will describe these optimization challenges and report on the progress of three approaches currently being researched.

Speaker: Lars Grüne, University of Bayreuth
Title: Turnpike behaviour and strict dissipativity of optimal control problems with and without state constraints

Abstract: In recent years, the turnpike property has received renewed interest, particularly in model predictive control and in optimal control for PDEs. The turnpike property describes a particular behaviour of optimal or near optimal trajectories in both finite and infinite horizon optimal control, which has been extensively studied in mathematical economy since the 1940s. The property demands that these trajectories most of the time stay close to a particular reference trajectory which is often constant, i.e., an equilibrium. The turnpike property opens the way to efficient numerical methods for computing approximately optimal trajectories on long horizons, which we will illustrate in the first part of this talk. The crucial question is then to determine which optimal control problems have the turnpike property. To this end, the concept of dissipativity, in the systems theoretic sense introduced by Willems in the early 1970s, turns out to be useful. Particularly, under suitable controllability conditions a property called strict dissipativity is equivalent to the occurrence of the turnpike property for all near optimal trajectories. In this talk these relations will first be explained and then conditions under which strict dissipativity and the turnpike property hold will be discussed. Particularly, we will explain that (and why) already in the simplest possible setting, i.e., for linear quadratic optimal control problems, the conditions on the optimal control problem become considerably less restrictive in the presence of state constraints.

Speaker: Martin Guay, Queen's University
Title: Extremum seeking control for minimum phase nonlinear systems
Abstract: The presentation provides a description to some ongoing work on Extremum seeking control as a model free control algorithm for the combined task of optimization, stabilization and output regulation. We consider an input-output linearization approach for the design of tracking systems subject to unknown disturbance dynamics. The approach requires the knowledge of the relative degree of the system fo minimum phase nonlinear systems with strong relative degree and unknown dynamics. The output regulation problems is considered using a similar IO linearization frameworks. Various extremum seeking control frameworks are considered which include standard perturbation based extremum seeking control, Lie bracket averaging techniques and estimation-based techniques.

Speaker: Hiroshi Ito, Kyushu Institute of Technology
Title: How far is the state of iISS connection going to escape?
Abstract: This talk will be about understanding and assessing behavior of nonlinear dynamical systems in view of integral input-to-state stability (iISS). In particular, we forces on the configuration in which two systems are connected in feedback. iISS allows the state of a system to be unbounded even for bounded external input, while in contrast, input-to-state stability (ISS) guarantees the state to be bounded. The concept of iISS captures inevitable dynamics arising from saturation and bilinearity. Interestingly, the state going far away can be pulled back by connecting an ISS system to it if the stability of the ISS system is strong enough. A small-gain condition allows one to check if this mechanism kicks in. The small-gain condition is merely a test. Constructing a Lyapunov function of the feedback and investigating its sublevel sets can provide one with useful information of system behavior, One may conjecture that the magnitude of the state increases very large temporarily when stability margins are small. The aim of this talk is to correct this conjecture. As expected, sublevel sets of a previously available Lyapunov function is flattened extremely when stability margins are small. It is, however, demonstrated that it is not necessary, and a new Lyapunov function producing surprisingly better sublevel sets is proposed.

Speaker: Chris Kellett, University of Newcastle
Title: Optimal control and the economics of climate change
Abstract: The Social Cost of Carbon (SCC) has been called "the most important number you've never heard of". This number is used in a variety of ways by governments, international finance organisations, and companies as a dollar value for greenhouse gas emissions. As a consequence, the

SCC materially contributes to trillions of dollars of investment decisions worldwide. The most widely used modeling framework for the calculation of the SCC involves a nonlinear time-varying discrete time system and the solution of an optimal control problem. In this talk, I will introduce the model and optimal control problem (in terminology and notation familiar to systems and control researchers) and describe a few interesting results.

Speaker: Lorenzo Marconi, University of Bologna
Title: Low-Power High-Gain Observers
Abstract: High-gain observers are customarily used in many control contexts, such as state observation, robust output stabilisation, output regulation, fault detection and identification, and many others. They play a role in the so-called nonlinear separation principle due to the main property that the speed of convergence of the observer can be arbitrarily tuned by acting on a single (high-gain) parameter. Despite the evident benefits of this class of observers, their use in real applications is questionable due to some drawbacks inherently related to the high-gain nature of the observer. Numerical issues in implementation for high-order systems, peaking phenomena, high sensitivity to measurement noise are the main criticisms that, legitimately, are typically moved forward by the detractors of this kind of observers.

In this talk we present a new class of nonlinear high-gain observers, denoted as "low-power high-gain observers", that has been recently introduced. The new observer preserves the same features of the classical one but substantially overtaking the aforementioned drawbacks. The low-power high-gain observers, in fact, are characterised by having coefficients that do not grow with the system dimension, by avoiding the peaking phenomenon and by improving the sensitivity to high-frequency measurement noise.The proposed observers can be used in all the control frameworks where standard observers are used with a clear improvement in practical implementations.

The talk will overview the structure of the classical and new observers by presenting the main asymptotic properties and showing the performances by means of simulation results.

Speaker: Christophe Prieur, Centre National de la Recherche Scientifique
Title: ISS of hyperbolic systems: Application to quantized and event-based boundary control of conservation laws
Abstract: In this talk, we will consider a system of linear hyperbolic partial differential equations in closed loop with a boundary dynamic controller and in presence of boundary disturbances. The stability analysis of the nominal system and the input-to-state stability are studied by means of a Lyapunov function in an appropriate state space. We will see how this approach could be instrumental for the design of boundary controllers. Moreover the developed tools are fruitful for the synthesis of an event-based boundary controller and of a quantized boundary controller, paralleling what is known for nonlinear finite-dimensional systems.

Speaker: Vera Roshchina, Royal Melbourne Institute of Technology and Federation University Australia
Title: A counterexample to De Pierro's conjecture
Abstract: The method of alternating projections converges to a point in the intersection of two closed convex sets in a Hilbert space. When the two sets have an empty intersection, the method converges under mild assumptions to a pair of points that realise the distance between these sets. Cyclic projections is the generalisation of this method to a finite collection of closed convex sets. It was shown by Baillon, Combettes and Cominetti in 2012 that there is no such variational characterisation of the limit cycles for three and more sets that have an empty intersection.

The problem can be partially overcome by considering modified processes of under-relaxed projections: in this case the method makes epsilon-steps towards the projection, with diminishing values of the parameter epsilon. It was conjectured by De Pierro in 2001 that such modified cycles converge to

a point that minimises the sum of squared distances to the sets, given that such a solution exists. We show that it is possible to construct a system of three sets in the three-dimensional Euclidean space for which a least squares solution exists, but the appropriately constructed epsilon-cycles diverge, hence disproving the conjecture.

(Joint work with Roberto Cominetti (Universidad Adolfo Ibanez, Chile) and Andrew Williamson (RMIT University))

Speaker: Björn Rüffer, University of Newcastle
Title: A Lyapunov function construction for the Douglas-Rachford operator in a non-convex setting
Abstract: A Lyapunov function construction for the Douglas-Rachford operator in a non-convex setting
Abstract: Local quadratic Lyapunov functions are combined to a global Lyapunov function for the Douglas-Rachford algorithm in the case of a non-convex geometry, in order to prove global convergence to the intersection points, as well as various robustness properties. Specifically, the case where one set is a line and the other a union of two lines is considered, with the latter set being non-convex. An explicit formula for the global Lyapunov function is given in terms of the problem parameters.

Speaker: Giordano Scarciotti, Imperial College
Title: A stochastic Sylvester equation for output regulation and model reduction of linear stochastic systems
Abstract: The characterization of the steady-state response of dynamical systems is at the basis of the solution of several problems in the control and systems field. In this talk, a characterization of the steady-state response of a general class of linear stochastic systems is considered. For general class we mean systems in which the state, control variable and exogenous variable may appear simultaneously in the drift term and in the diffusion term of the differential equation. Similarly, we consider a stochastic signal generator which is able to produce Brownian motions in addition to deterministic trajectories. The steady-state response of the interconnection of the system with the signal generator is characterized in terms of a stochastic differential matrix equation, which is a generalization of the Sylvester equation. This result is then applied to classical and recent problems in control systems, namely the (full information) output regulation problem and the (moment matching) model reduction problem. The talk is concluded with a discussion of the numerical implementation and of some open challenges.

Speaker: Jacquelien Scherpen, University of Groningen
Title: Model order reduction and composite control of slow-fast systems around hyperbolic and non-hyperbolic points
Abstract: We investigate two classes of slow-fast systems for which the classical model order reduction technique based on singular perturbations does not apply. The first class of slow-fast systems we treat is the class of slow-fast port-Hamiltonian for which we aim to preserve the port-Hamiltonian structure for the slow and fast subsystems in order to be able to apply passivity based control techniques. The second class of systems we treat lack a normally hyperbolic critical manifold. We show, however, that there exists a class of slow-fast systems that after a well-defined change of coordinates have a normally hyperbolic critical manifold. This allows the use of model order reduction techniques and to qualitatively describe the dynamics from auxiliary reduced models even in the neighborhood of a non-hyperbolic point. As an important consequence of the model order reduction step, we show that it is possible to design composite controllers that stabilize the (non-hyperbolic) origin.

Speaker: Thomas Schön, Uppsala University
Title: On the construction of probabilistic Newton-type algorithms
Abstract: It has recently been shown that many of the existing quasi-Newton algorithms can be formu-

lated as learning algorithms, capable of learning local models of the cost functions. Importantly, this understanding allows us to safely start assembling probabilistic Newton-type algorithms, applicable in situations where we only have access to noisy observations of the cost function and its derivatives. This is where our interest lies.

We make contributions to the use of the non-parametric and probabilistic Gaussian process models in solving these stochastic optimisation problems. Specifically, we present a new algorithm that unites these approximations together with recent probabilistic line search routines to deliver a probabilistic quasi-Newton approach.

We also show that the probabilistic optimisation algorithms deliver promising results on challenging nonlinear system identification problems where the very nature of the problem is such that we can only access the cost function and its derivative via noisy observations, since there are no closed-form expressions available.

Speaker: Andrea Serrani, The Ohio State University
Title: A Combined Reference Management and Anti-Windup Modification for Adaptive Airspeed Control of Hypersonic Vehicles under Input Constraints
Abstract: The topic of this talk is the incorporation of limits of operability of a scramjet engine within an adaptive guidance and flight control architecture for a 6DOF model of a generic hypersonic air-breathing vehicle. Lower bounds on the throttle setting arise from the necessity of maintaining a minimal fuel rate due to thermal management considerations, whereas upper bounds are determined from the necessity to avoiding thermal chocking of the engine. The proposed strategy employs a seamless integration between a dynamic reference management and a model-recovery anti-windup modification for an adaptive airspeed controller. In particular, a feasible input reference trajectory (which depends on the parameter estimates) is provided to the adaptive controller so that convergence to a feasible setpoint for the throttle setting is attained, while the anti-windup modification prevents the parameter update law to react abnormally to prolonged saturations during transient.

Speaker: Marleen Stieler, University of Bayreuth
Title: Dissipativity and turnpike phenomena for multi-objective optimal control problems
Abstract: The systems theoretic concept of dissipativity and turnpike properties have been extensively investigated in the literature in the past decades. Recent interest was triggered by the finding that asymptotic stability of economic model predictive control (MPC) schemes can be established under dissipativity assumptions. In this talk we would like to discuss how dissipativity can be generalized and interpreted in the presence of multiple objectives. Moreover, we illustrate turnpike behavior of Pareto-optimal trajectories and present surprising effects. Finally, we investigate what kind of results can be obtained for multiobjective economic MPC using dissipativity and adress challenges that have to be tackled in future research.

Speaker: Paul M. J. Van den Hof, Eindhoven University of Technology
Title: Data-driven modelling in dynamic networks
Abstract: In many areas of science and technology, increased complexity and interconnections of systems is a strong motivation for developing modelling, control and optimization methods for dynamic networks. While in the control field attention is paid to decentralized, distributed and networked control, as e.g. in multi agent systems, data-driven modelling is still dominantly restricted to considering simple open-loop and closed-loop structures. In this seminar we consider several questions that appear when addressing the problem of data-driven modelling in structured linear dynamic networks, and we will set up a framework for addressing those questions. They include identification of a particular module (local identification) within the network andsensor location selection for achieving consistency. The concept of network identifiability is introduced and it is shown how classical

closed-loop identification methods can be generalized to the dynamic network situation.

Speaker: Steve Weller, University of Newcastle
Title: A strict monotonicity property of all-pole systems
Abstract: We establish a strict monotonicity property of all-pole linear systems. Such systems arise in many problems of practical interest, including chemical engineering and biological systems. For a stable, all-pole, linear time-invariant system of order $n \geq 2$ with impulse response $h(t)$ and zero initial conditions, we prove that $\dot{h}(t)/h(t)$ is a monotonically strictly decreasing function of time t. Our approach employs only elementary methods, principally the application of Descartes' rule of signs for exponential polynomials to establish a tight upper bound on the number of roots of an auxiliary polynomial related to h. A much shorter proof due to Nahum Shimkin is discussed, wherein the monotonicity result follows from log-concavity of the impulse response function.

Speaker: Luca Zaccarian, Centre National de la Recherche Scientifique and University of Trento
Title: GAS of PID-based feedback of motion systems with Coulomb friction and a reset-based law for transient improvement
Abstract: We will discuss the use of a discontinuous Lyapunov-like function certifying GAS of motion systems with Coulomb friction, in addition to suitable ISS properties in the case of more general friction effects (e.g., stribeck). A novel reset control approach will also be discussed, which improves the transient performance, and is independent of the static friction level, thereby preserving the desirable internal model features of PID laws. The arising closed loop is hybrid and requires alternative proof techniques to certify GAS of the feedback interconnection.