FINAL PROGRAM and BOOK OF ABSTRACTS

IFAC

NOLCOS 2013

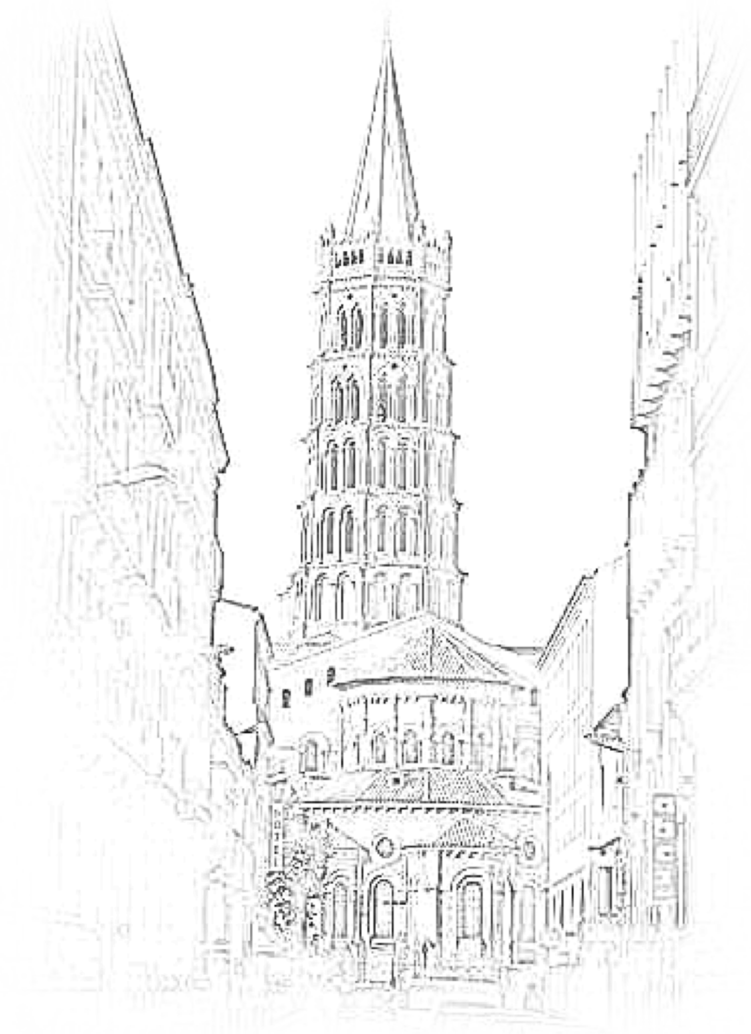
Toulouse (France)

9th IFAC Symposium on Nonlinear Control Systems

September 4-6, 2013

Tutorial day

September 3, 2013



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at INP-ENSEEIHT

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ACKNOWLEDGMENTS

NOLCOS 2013 could not have been successfully organized without the support of many persons and structures that we would like to acknowledge.

A special thanks goes to the nine Area Chairs (F. Allgower, V. Andrieu, D. Angeli, A. Astolfi, Z.P. Jiang, D. Nesic, K. Schlacher, A. Serrani, and A.R. Teel) who scientifically promoted the Symposium and supervised, in an outstanding way, the demanding review activity in their respective areas.

We are also grateful to the IPC members for the scientific advice given in different phases of the organization, and to the NOC members for taking care of many logistic matters.

A special thanks goes also to the technical services of LAAS-CNRS, a CNRS research unit associated to the University of Toulouse, for their involvement in the organization of the Symposium.

We also acknowledge the fruitful collaboration of the Engineering School INP-ENSEEIHT, one of the seven members of the National Polytechnic Institute of Toulouse, who hosts the Symposium and offers its technical support to the organization of NOLCOS 2013. Our acknowledgements are also for the public institutions for their financial support of the Symposium.

Last but not least, our sincere thanks goes to François Lafont and So* Toulouse for their essential support to the organization of NOLCOS 2013.

Christophe Prieur
NOLCOS 2013 IPC Chair

Isabelle Queinnec
NOLCOS 2013 NOC Chair

NOLCOS 2013

9th IFAC Symposium on Nonlinear Control Systems

University of Toulouse, INP-ENSEEIHT, France
September 04-06 2013

FINAL PROGRAM AND BOOK OF ABSTRACTS

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Welcome to the 9th IFAC NOLCOS

Dear Colleagues and Guests, dear Friends,

It is our pleasure to welcome all of you to the 9th IFAC Symposium on Nonlinear Control Systems (NOLCOS 2013) organized by LAAS-CNRS, Toulouse, France. This edition follows a successful series of symposia previously held in Bologna (I) 2010, Pretoria (ZA) 2007, Stuttgart (DE) 2004, Saint-Petersburg (RUS) 2001, Enschede (NL) 1998, Lake Tahoe (USA) 1995, Bordeaux (F) 1992, and Capri (I) 1988.

Following the NOLCOS tradition, the Symposium addresses significant challenges in various fields of nonlinear control by focusing on the latest developments in theory and applications of nonlinear control systems, as well as related areas of research and engineering. The Symposium represents a remarkable opportunity to gather together senior and young researchers sharing the passion for the study of nonlinear phenomena. The organization of the scientific program and of the social activities of NOLCOS 2013 has been specifically arranged in order to facilitate this interaction, to create new opportunities of collaboration, and to stimulate cross-fertilization among different nonlinear control areas.

With more than 200 papers received from more than 37 contributing countries, NOLCOS reaffirms itself as one of the most distinguished IFAC events and testifies to the importance of nonlinear control in the international scientific community. About 850 reviewers have been involved in the technical assessment of the submitted papers. As a result, about 500 reviews have been received, which led to the acceptance of 138 papers constituting the final program of NOLCOS 2013. The scientific program spans three days, with three plenary talks, six semi-plenary talks, and three sessions in parallel with regular and invited talks. As a further distinguished feature of this edition of NOLCOS, three tutorial workshops take place the day before the Symposium.

A noteworthy automatic control tradition characterizes the industrial area surrounding Toulouse, with world-renowned industries, in particular the aerospace industries. The scientific program and the social events of NOLCOS 2013 testifies of this history, culture and industrial tradition that we hope you experience during the Symposium.

We hope you enjoy NOLCOS 2013 and have an unforgettable stay in Toulouse.

Christophe Prieur
NOLCOS 2013 IPC Chair

Isabelle Queinnec
NOLCOS 2013 NOC Chair

Sophie Tarbouriech
NOLCOS 2013 Editor

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Topics

Area with Chairs

Modeling and identification of nonlinear systems (K. Schlacher)
Nonlinear modeling of lumped and/or distributed parameter systems, control of mechanical, electrical and process systems, smart structures, aerospace and marine applications, computer algebra-based methods and tools, numerical methods, bilinear systems, system structure identification, experiment design, parameter estimation, fault detection.

Nonlinear systems optimal control (F. Allgower)
Optimal control, necessary conditions, time optimal control, feasibility and stability issues, robustness, computational efficiency, performance issues, disturbance attenuation, nonlinear model predictive control theory and applications.

Mathematical theory, stability and stabilization of nonlinear systems (Z. P. Jiang)
Stability, I/O stability, absolute stability, input-to-state stability, small gain theorems, dissipativity, passivity, stabilization, Lyapunov methods, dynamical systems techniques, bifurcation and chaos, fundamental limitation of control.

Nonlinear systems complexity and networking (D. Nesic)
Computational complexity, computer network systems, computer network management, complex network, sensor network, river network, network routing, chaos control, anti-control and synchronization, nonlinear cooperative control.

Nonlinear systems observation and observers (V. Andrieu)
Observability and observer design, filter design, state estimation and applications, adaptive observers, adaptive filters, observer and filter design by observer error linearization, Lyapunov stability methods, I/O stability methods, applications of observer design.

Nonlinear systems feedback design methods and problems (A. Astolfi)
Algebraic methods, linear algebraic methods, geometric methods, backstepping, variable structure control and sliding mode, H° control, system inversion.

Hybrid nonlinear systems (A. Teel)
Hybrid nonlinear systems, hybrid nonlinear control systems, control of sampled data systems, discrete events, switching control, quantized feedback and feedback with communication constraints, nonlinear hybrid automata.

Nonlinear control of vehicular and robotic systems (A. Serrani)
Aeronautics, aerospace, automotive systems, marine systems, power systems, transportation systems, mechatronic systems, robotics.

Nonlinear process control applications (D. Angeli)
Biological and biomedical systems, batch processing, chemical process, mining, mineral and metal, model based control, optimization and scheduling, process and control monitoring, manufacturing, components and instruments.

Program at a Glance

NOLCOS 2013 Technical Program Wednesday September 4, 2013

Track 1	Track 2	Track 3
	08:30-09:00 WePLIntro Rooms A001/A002 Introduction of the Symposium	
	09:00-10:00 WePL1 Rooms A001/A002 Plenary 1 - Miroslav Krstic	
10:30-12:10 WeA1 Room C101 Lyapunov Methods	10:30-12:10 WeA2 Room C102 Reliable Methods for Control, State Estimation and Parameter Identification of Uncertain Dynamic Systems I	10:30-12:10 WeA3 Room C103 Aerospace and Motion Planning
13:20-14:20 WeSPS1 Room A001 Semi-Plenary 1 – Daniel Liberzon		13:20-14:20 WeSPS2 Room A002 Semi-Plenary 2 – Kristin Y. Pettersen
14:30-16:30 WeB1 Room C101 Lyapunov and Passivity Based Controls	14:30-16:30 WeB2 Room C102 What's up within the Theory of the Chemostat?	14:30-16:30 WeB3 Room C103 Optimal Control
17:00-18:40 WeC1 Room C101 Hybrid and Impulsive Systems	17:00-18:40 WeC2 Room C102 Biological and Biomedical Systems	17:00-18:40 WeC3 Room C103 Internal Model Control

NOLCOS 2013 Technical Program Thursday September 5, 2013

Track 1	Track 2	Track 3
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10:00-12:00 ThA1 Room C101 Event-Triggered and Self-Triggered Control	10:00-12:00 ThA2 Room C102 Electrical and Mechanical Systems	10:00-12:00 ThA3 Room C103 Distributed Parameters and Heterogeneous Systems
13:20-14:20 ThSPS1 Room A001 Semi-Plenary 3 – Mazyar Mirrahimi		13:20-14:20 ThSPS2 Room A002 Semi-Plenary 4 – Randal W. Beard
14:30-16:30 ThB1 Room C101 Observer Design	14:30-16:30 ThB2 Room C102 Vehicles Control and Mechatronics	14:30-16:30 ThB3 Room C103 Geometric and Algebraic Methods
17:00-18:40 ThC1 Room C101 Invariant Sets for Systems	17:00-18:40 ThC2 Room C102 Reliable Methods for Control, State Estimation and Parameter Identification of Uncertain Dynamic Systems II	17:00-18:40 ThC3 Room C103 Algebraic Methods

NOLCOS 2013 Technical Program Friday September 6, 2013

Track 1	Track 2	Track 3
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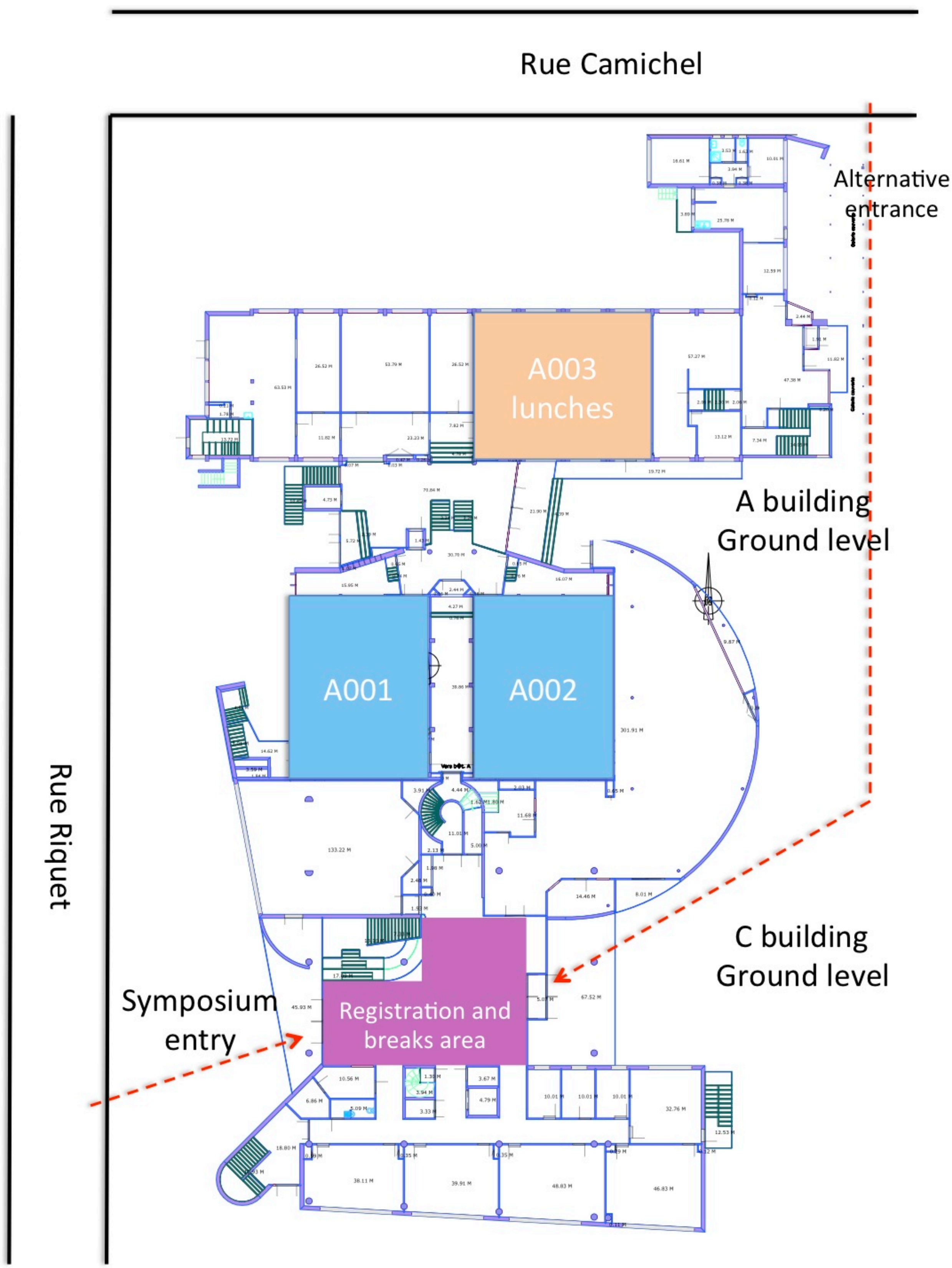
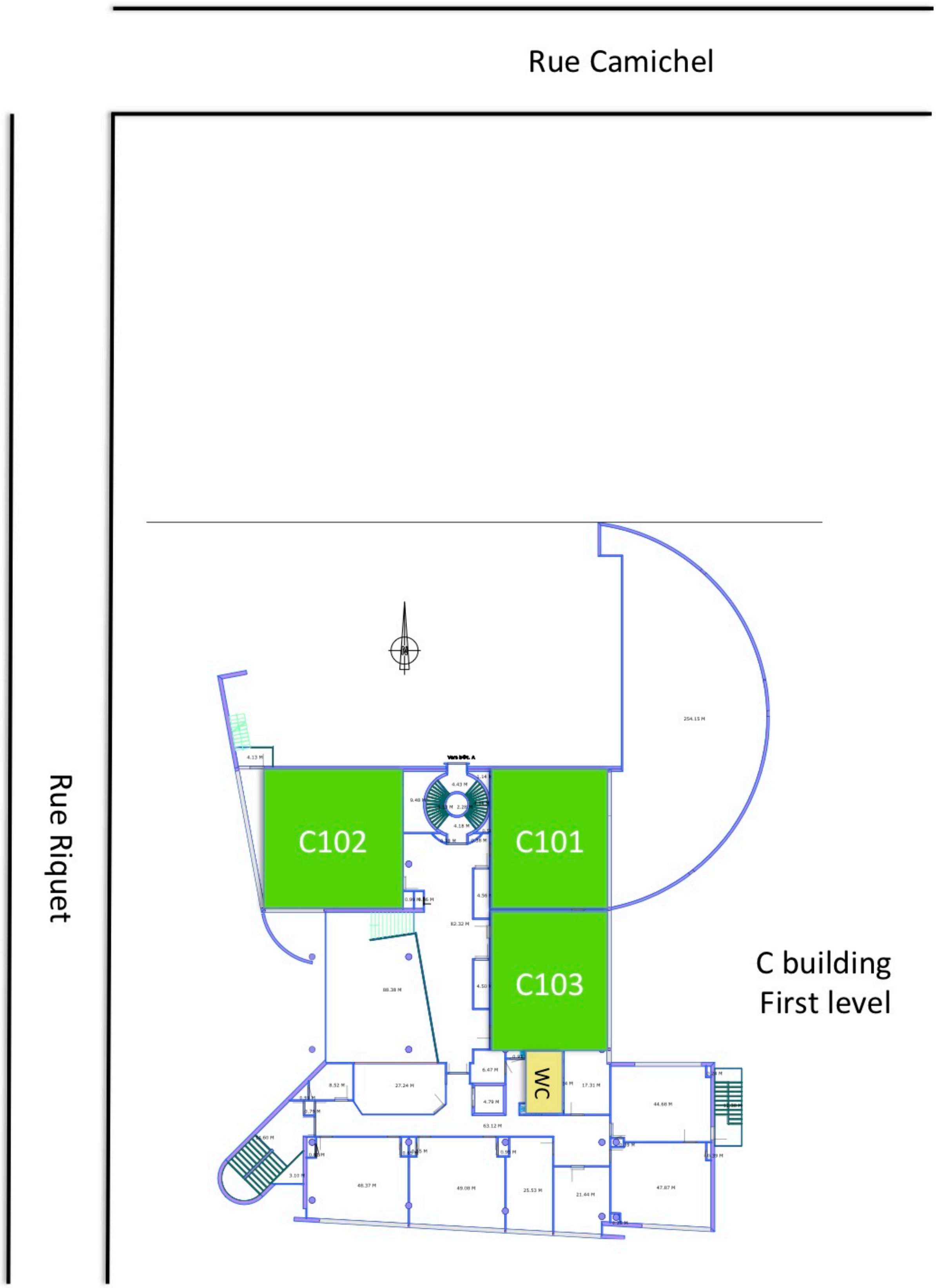
13:20-14:20 FrSPS1 Room A001 Semi-Plenary 5 – Hiroshi Ito	13:20-14:20 FrSPS2 Room A002 Semi-Plenary 6 – Domitilla Del Vecchio	
14:30-16:30 FrB1 Room C101 Networks and Detection	14:30-16:30 FrB2 Room C102 Robotic and Mechanical Control	14:30-16:30 FrB3 Room C103 Model Predictive Control

Map INP-ENSEEIHT – Ground level



Map INP-ENSEEIHT – First level



Plenary speaker 1

Professor Miroslav Krstic
University of California at San Diego, CA, USA

Toulouse, September 4th 2013, 9:00-10:00, A001/A002

Nonlinear Stabilization in Infinite Dimension
with Nikolaos Bekiaris-Liberis

ABSTRACT:
Significant advances have taken place in the last few years in the development of control designs for nonlinear infinite-dimensional systems. Such systems typically take the form of nonlinear ODEs (ordinary differential equations) with delays and nonlinear PDEs (partial differential equations). In this article we review several representative but general results on nonlinear control in the infinite-dimensional setting. First we present designs for nonlinear ODEs with constant, time-varying or state-dependent input delays, which arise in numerous applications of control over networks. Second, we present a design for nonlinear ODEs with a wave (string) PDE at its input, which is motivated by the drilling dynamics in petroleum engineering. Third, we present a design for systems of (two) coupled nonlinear first-order hyperbolic PDEs, which is motivated by slugging flow dynamics in petroleum production in off-shore facilities. Our design and analysis methodologies are based on the concepts of nonlinear predictor feedback and nonlinear infinite-dimensional backstepping. We present several simulation examples that illustrate the design methodology.

BIOSKETCH:
Miroslav Krstic holds the Daniel L. Alspach endowed chair and is the founding director of the Cymer Center for Control Systems and Dynamics at UC San Diego. He also serves as Associate Vice Chancellor for Research at UCSD. Krstic is a recipient of the PECASE, NSF Career, and ONR Young Investigator Awards, as well as the Axelby and Schuck Paper Prizes. Krstic was the first recipient of the UCSD Research Award in the area of engineering (immediately following the Nobel laureate in Chemistry Roger Tsien) and has held the Russell Severance Springer Distinguished Visiting Professorship at UC Berkeley and the Harold W. Sorenson Distinguished Professorship at UCSD. He is a Fellow of IEEE and IFAC and serves as Senior Editor in IEEE Transactions on Automatic Control and Automatica. He has served as Vice President of the IEEE Control Systems Society and chair of the IEEE CSS Fellow Committee. Krstic has coauthored nine books on adaptive, nonlinear, and stochastic control, extremum seeking, control of PDE systems including turbulent flows, and control of delay systems.

Plenary speaker 2

Professor Naomi Ehrich Leonard
Princeton University, NJ, USA

Toulouse, September 5th 2013, 8:30-9:30, A001/A002

Multi-Agent System Dynamics: Bifurcation and Behavior of Animal Groups

ABSTRACT:
Systematic design of decentralized feedback for coordinated control of multi-agent systems has much to gain from the rigorous examination of the nonlinear dynamics of collective animal behavior. Animals in groups, from bird flocks to fish schools, employ decentralized strategies and have limitations on sensing, computation, and actuation. Yet, at the level of the group, they are known to manage a variety of challenging tasks quickly, accurately, robustly and adaptively in an uncertain and changing environment. In this paper we review recent work on models and methods for studying the mechanisms of collective migration and collective decision-making in high-performing animal groups. Through bifurcation analyses we prove systematically how behavior depends on parameters that model the system and the environment. These connections lay the foundations for proving systematic control design methodologies that endow engineered multi-agent systems with the remarkable features of animal group dynamics.

BIOSKETCH:
Naomi Ehrich Leonard is the Edwin S. Wilsey Professor of Mechanical and Aerospace Engineering, associated faculty member of the Program in Applied and Computational Mathematics, and affiliated faculty member of the Princeton Neuroscience Institute at Princeton University. Her research and teaching are in nonlinear control and dynamical systems with current interests in coordinated control for multi-agent systems, mobile sensor networks and ocean sampling, collective animal behavior, and decision dynamics in mixed human-robot teams. She received a John D. and Catherine T. MacArthur Foundation Fellowship in 2004, the Mohammed Dahleh Award in 2005, and an Inaugural Distinguished ECE Alumni Award from the University of Maryland in 2012. She is a Fellow of the IEEE, ASME, and SIAM. She received the B.S.E. degree in Mechanical Engineering from Princeton University in 1985 and the M.S. and Ph.D. degrees in Electrical Engineering from the University of Maryland in 1991 and 1994. From 1985 to 1989, she worked as an engineer in the electric power industry.

Plenary speaker 3

Professor Robert Mahony
Australian National University

Toulouse, September 6th 2013, 9:00-10:00, A001/A002

Observers for Kinematic Systems with Symmetry

with Jochen Trumpf and Tarek Hamel

ABSTRACT:
This paper considers the design of nonlinear state observers for finite-dimensional equivariant kinematics of mechanical systems. The observer design problem is approached by lifting the system kinematics onto the symmetry group and designing an observer for the lifted system. Two particular classes of lifted systems are identified, which we term type I and type II systems, that correspond to common configurations of sensor suites for mobile robotics applications. We consider type I systems in detail and define an error signal on the symmetry group using the group structure. We propose an observer structure with a pre-observer or internal model augmented by an equivariant innovation term that leads to autonomous error evolution. A control Lyapunov function construction is used to design the observer innovation that both ensures the required equivariance, and leads to strong convergence properties of the observer error dynamics.

BIOSKETCH:
Robert Mahony obtained a science degree majoring in applied mathematics and geology from the Australian National University in 1989. After working for a year as a geophysicist processing marine seismic data he returned to study at ANU and obtained a PhD in systems engineering in 1994. Between 1994 and 1997 he worked as a Research Fellow in the Cooperative Research Centre for Robust and Adaptive Systems based in the Research School of Information Sciences and Engineering in ANU. From 1997 to 1999 he held a post as a post-doctoral fellow in the CNRS laboratory for Heuristics Diagnostics and complex systems (Heudiasyc), Compiegne University of Technology, FRANCE. Between 1999 and 2001 he was a Logan Fellow in the Department of Engineering and Computer Science at Monash University, Melbourne, Australia. In July 2001 he took up a faculty post in the Department of Engineering, ANU. His research interests are in non-linear control theory with applications in robotics, mechanical systems and motion systems; mathematical systems theory and geometric optimisation techniques with applications in linear algebra, computer vision and machine learning.

Semi-Plenary speaker 1

Professor Daniel Liberzon
University of Illinois at Urbana-Champaign, IL, USA

Toulouse, September 4th 2013, 13:20-14:20, A001

Norm-Controllability, or How a Nonlinear System Responds to Large Inputs
with Matthias A. Muller and Frank Allgower

ABSTRACT:
The purpose of this paper is to survey and discuss recent results on norm-controllability of nonlinear systems. This notion captures the responsiveness of a nonlinear system with respect to the applied inputs in terms of the norm of an output map, and can be regarded as a certain type of gain concept and/or a weaker notion of controllability. We state several Lyapunov-like sufficient conditions for this property in a simplified formulation, and illustrate the concept with several examples.

BIOSKETCH:
Daniel Liberzon was born in the former Soviet Union in 1973. He did his undergraduate studies in the Department of Mechanics and Mathematics at Moscow State University from 1989 to 1993. In 1993 he moved to the United States to pursue graduate studies in mathematics at Brandeis University, where he received the Ph.D. degree in 1998 (supervised by Prof. Roger W. Brockett of Harvard University). Following a postdoctoral position in the Department of Electrical Engineering at Yale University from 1998 to 2000 (with Prof. A. Stephen Morse), he joined the University of Illinois at Urbana-Champaign, where he is now a professor in the Electrical and Computer Engineering Department and the Coordinated Science Laboratory. His research interests include nonlinear control theory, switched and hybrid dynamical systems, control with limited information, and uncertain and stochastic systems. He is the author of the books "Switching in Systems and Control" (Birkhauser, 2003) and "Calculus of Variations and Optimal Control Theory: A Concise Introduction" (Princeton Univ. Press, 2011). His work has received several recognitions, including the 2002 IFAC Young Author Prize and the 2007 Donald P. Eckman Award. He is a fellow of IEEE. He delivered a plenary lecture at the 2008 American Control Conference. He has served as Associate Editor for the journals IEEE Transactions on Automatic Control and Mathematics of Control, Signals, and Systems.

Semi-Plenary speaker 2

Professor Kristin Y. Pettersen
Norwegian Univ. of Science and Technology

Toulouse, September 4th 2013, 13:20-14:20, A002

Snake Robots - from Biology to Nonlinear Control
with Pål Liljebäck, Øyvind Stavdahl and Jan Tommy Gravdahl

ABSTRACT:
Inspired by the motion of biological snakes, this paper presents an overview of recent results in modelling and control of snake robots. The objective of the research underlying this paper is to contribute to the mathematical foundation of the control theory of snake robots. To this end, the paper presents two mathematical models of planar snake robot dynamics, which are employed to investigate stabilisability and controllability properties of snake robots. Furthermore, averaging theory is used to derive properties of the velocity dynamics of snake robots. Moreover, a straight line path following controller is proposed and cascaded systems theory is employed to prove that the controller K-exponentially stabilizes a snake robot to any desired straight path.

BIOSKETCH:
Kristin Y. Pettersen was born in 1969 and obtained the MSc and PhD degrees in Engineering Cybernetics at NTNU, Trondheim, Norway, in 1992 and 1996. She is a Professor in the Department of Engineering Cybernetics, NTNU where she has been a faculty member since 1996. She is Head of Department, and Director of the ICT Programme of Robotics which is one of the university's strategic research areas. 2013 – 2022 she is also a key scientist at the CoE Centre for Autonomous Marine Operations and Systems (AMOS). She has published more than 140 international papers for conferences and journals, and her research interests focus on nonlinear control of mechanical systems with applications to robotics, satellites, AUVs and ships. She has edited a Springer Verlag book on group coordination and cooperative control, and is co-author of a Springer Verlag book on Snake Robots. She is also co-author of a Springer Verlag book to be published in 2013 on Modeling and Control of Vehicle-Manipulator Systems. In 2008, she was a Visiting Professor at the Section for Automation and Control, University of Aalborg, Denmark, and in 1999 she was a Visiting Fellow at the Department of Mechanical and Aerospace Engineering, Princeton University. In 2006, she and her co-authors were awarded the IEEE Trans. on Control Systems Technology Outstanding Paper Award for: Global Uniform Asymptotic Stabilization of an Underactuated Surface Vessel: Experimental Results (K.Y. Pettersen, F. Mazenc and H. Nijmeijer). She has served as AE for several conferences, including, the IEEE CDC, the IEEE ICRA, and the IEEE/RSJ IROS. She has served as a member of the Editorial Board of Simulation Modeling Practice and Theory, and is an Associate Editor of the IEEE Trans. on Control Systems Technology and the IEEE Control Systems Magazine. She is a member of the Board of Governors of IEEE CSS, and she also holds several board positions in industrial and research companies.

Semi-Plenary speaker 3

Doctor Mazyar Mirrahimi
INRIA Paris-Rocquencourt, FR and Yale University, USA

Toulouse, September 5th 2013, 13:20-14:20, A001

Quantum Reservoir Engineering and Single Qubit Cooling

with Zaki Leghtas and Uri Vool

ABSTRACT:
Stabilizing a quantum system in a desired state has important implications in quantum information science. In control engineering, stabilization is usually achieved by the use of feedback. The closed-loop control paradigm consists of measuring the system in a non-destructive manner, analyzing in real-time the measurement output to estimate the dynamical state and finally, calculating a feedback law to stabilize the desired state. However, the rather short dynamical time-scales of most quantum systems impose important limitations on the complexity of real-time output signal analysis and retroaction. An alternative control approach for quantum state stabilization, bypassing a real-time analysis of output signal, is called reservoir engineering.
In this paper, we start with a general description of quantum reservoir engineering. We then apply this method to stabilize the ground state (lowest energy state) of a single two-level quantum system. Applying the averaging theorem and some simple Lyapunov techniques, we prove the convergence of our proposed scheme. This scheme has recently been successfully implemented on a superconducting qubit and has led to a fast and reliable reset protocol for these qubits.

BIOSKETCH:
Mazyar Mirrahimi was born in Tehran, Iran, in 1981. He received the M.S. degree from Ecole Polytechnique, Paris, France, in 2003 and the Ph.D. degree in mathematics and control theory from Ecole des Mines de Paris, Paris, France, in 2006. Since 2006, he has been a Research Scientist at INRIA Paris-Rocquencourt. Since February 2011, he has been a Sabbatical Visitor with the Applied Physics Department, Yale University, CT. His fields of interest include the theory and applications of nonlinear control of ODEs, PDEs or SDEs. His research is particularly focused on estimation and control of quantum systems in the aim of achieving robust processing of quantum information.

Semi-Plenary speaker 4

Professor Randal W. Beard
Brigham Young University, Utah, USA

Toulouse, September 5th 2013, 13:20-14:20, A002

Recursive RANSAC: Multiple Signal Estimation with Outliers
with Peter Niedfeldt

ABSTRACT:
The random sample consensus (RANSAC) algorithm is frequently used in computer vision to estimate the parameters of a signal in the presence of noisy and even spurious observations called gross errors. Instead of just one signal, we desire to estimate the parameters of multiple signals, where at each time step a set of observations of generated from the underlying signals and gross errors are received. In this paper, we develop the recursive RANSAC (RRANSAC) algorithm to solve the inherent data association problem and recursively estimate the parameters of multiple signals without prior knowledge of the number of true signals. We compare the performance of RRANSAC with several existing algorithms, and also demonstrate the capabilities of RRANSAC in an aerial geolocation problem.

BIOSKETCH:
Randal W. Beard received the B.S. degree in electrical engineering from the University of Utah, Salt Lake City, in 1991, the M.S. degree in electrical engineering in 1993, the M.S. degree in mathematics in 1994, and the Ph.D. degree in electrical engineering in 1995, all from Rensselaer Polytechnic Institute, Troy, N.Y. Since 1996, he has been with the Electrical and Computer Engineering Department at Brigham Young University, Provo, UT, where he is currently a professor. In 1997 and 1998, he was a Summer Faculty Fellow at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA. In 2006-2007 he was a National Research Council Fellow at the Air Force Research Labs at Eglin Air Force Base, Fort Walton Beach, Florida, where he worked on vision based guidance and control algorithms for micro air vehicles. His primary research focus is in autonomous systems, unmanned air vehicles, and multiple vehicle coordination and control. He has published over 130 peer reviewed articles and has received funding from AFOSR, AFRL, NASA, DARPA, and NSF. He is a senior member of the IEEE and the AIAA. He is an associate editor for the IEEE Transactions on Automatic Control, and a former associate editor for the Journal of Intelligent and Robotics Systems, and the IEEE Control Systems Magazine. In 1998 and 2004 he was voted the outstanding teacher in the BYU Electrical and Computer Engineering Department by graduating seniors, and in 2002 he received the Outstanding Professor award from the BYU Electrical and Computer Engineering Department. In 2004 he was awarded the BYU Young Scholar Award and in 2006 he was awarded the BYU Technology Transfer Award, and in 2009 he was award the Karl G. Maeser Research and Creative Arts Award for excellence in research. His students have won numerous competitions and awards for their work on micro air vehicles.

Semi-Plenary speaker 5

Professor Hiroshi Ito
Kyushu Institute of Technology, Fukuoka, Japan

Toulouse, September 6th 2013, 13:20-14:20, A001

Utility of Iiss in Composing Lyapunov Functions for Interconnections

ABSTRACT:
Decomposition of a system into smaller components sometimes allows us to analyze and design the system effectively based on properties of the components. The notion of input-to-state stability (ISS) has been widely used to characterize components that refuse linear-like properties. It is, however, still restrictive, and it cannot cover a lot of saturation mechanisms which often arise in practical systems. The notion of integral input-to-state stability (iISS) is a way to remove the limitation of ISS. This paper collects and illustrates some recent advances in the framework of iISS that allows us to broaden the class of nonlinearities we can address in analysis and design of interconnected systems by making use of Lyapunov functions.

BIOSKETCH:
Hiroshi Ito received the B.E. degree, the M.E. degree and the Ph.D. degree in Electrical Engineering from Keio University, Japan, in 1990, 1992 and 1995, respectively. From 1994 to 1995, he was a research fellow of the Japan Society for the Promotion of Science (JSPS). He has been with Kyushu Institute of Technology, Japan since 1995. He is currently an Associate Professor at the Department of Systems Design and Informatics. From 1998 to 1999, he held visiting researcher positions in Northwestern University and University of California, San Diego. He has published over 100 technical articles in major international journals and major international conferences. He received the 1990 Young Author Prize of The Society of Instrument and Control Engineers (SICE) and the Pioneer Award of Control Division of SICE in 2008. He is also a recipient of the SICE-ICCAS 2006 Best Paper Award and the SICE 2008 International Award. His main research interests include stability of nonlinear systems, large-scale systems, theory of robustness, dynamical systems with time-delays, discontinuous feedback control, multi-rate sampled data control and asynchronous systems with emphasis on applications to the power and microgrid systems, biological and communication networks. He has served as an Associate Editor of IEEE Transactions on Automatic Control. Currently, he is an Associate Editor of Automatica and on the IEEE CSS Conference Editorial Board. He is also an Associate Editor of SICE Journal of Control, Measurement, and System Integration. He is a Senior Member of the IEEE.

Semi-Plenary speaker 6

Professor Domitilla Del Vecchio
MIT, Cambridge, MA, USA

Toulouse, September 6th 2013, 13:20-14:20, A002

A Control Theoretic Framework for the Analysis and Design of Biological Networks

ABSTRACT:
Control theory has been instrumental for the analysis and design of a number of engineering systems, including aerospace and transportation systems, robotics and intelligent machines, manufacturing chains, electrical, power, and information networks. In the past several years, the ability of de novo creating biomolecular systems and of measuring key physical quantities has come to a point in which quantitative analysis and design of biological networks is now possible. While a modular approach to analyze and design networked dynamical systems has proven critical in most control theory applications, it is still subject of intense debate whether a modular approach is viable in biomolecular networks. The dynamics of these networks are highly nonlinear and therefore addressing this question requires the use of tools from nonlinear control theory. In this talk, we present a theoretical framework to quantify the extent of modularity in biomolecular networks and to establish modular analysis and design techniques. Specifically, we address the fundamental question of modularity by demonstrating that impedance-like effects are found in biomolecular systems, just like in many engineering systems. These effects, which we call retroactivity, can be severe and alter the behavior of a module upon interconnection, undermining modular behavior. Leveraging nonlinear model reduction tools, we show how one can determine interconnection rules that account for retroactivity by calculating equivalent network descriptions, just like Thevenin's theorem does for linear electrical circuits. By merging disturbance rejection and singular perturbation techniques for nonlinear systems, we further provide an approach that exploits the distinctive structure of biomolecular networks to design biomolecular insulating amplifiers. These devices buffer systems from retroactivity and restore modular behavior, allowing a bottom-up approach to creating synthetic biological circuits. We provide experimental demonstrations of our theory and illustrate concrete biological realizations of insulating amplifiers in living cells.

BIOSKETCH:
Domitilla Del Vecchio received the Ph. D. degree in Control and Dynamical Systems from the California Institute of Technology, Pasadena, and the Laurea degree in Electrical Engineering from the University of Rome at Tor Vergata in 2005 and 1999, respectively. From 2006 to 2010, she was an Assistant Professor in the Department of Electrical Engineering and Computer Science and in the Center for Computational Medicine and Bioinformatics at the University of Michigan, Ann Arbor. In 2010, she joined the Department of Mechanical Engineering and the Laboratory for Information and Decision Systems (LIDS) at the Massachusetts Institute of Technology (MIT), where she is currently an associate professor. She is a recipient of the Donald P. Eckman Award from the American Automatic Control Council (2010), the W. M. Keck Career Development Professorship, MIT (2010), the NSF Career Award (2007), the Crosby Award, University of Michigan (2007), the American Control Conference Best Student Paper Award (2004), and the Bank of Italy Fellowship (2000). Her research interests include analysis and control of nonlinear and hybrid dynamical systems with application to biomolecular networks and transportation networks.

Book of Abstracts

Technical Program for Wednesday September 4, 2013

WePL1	Rooms A001/A002
Nonlinear Stabilization in Infinite Dimension (Plenary Session)	
Chair: Prieur, Christophe	CNRS

09:00-10:00 WePL1.1

Nonlinear Stabilization in Infinite Dimension, pp. 1-14

Krstic, Miroslav — Univ. of California at San Diego
Bekiaris-Liberis, Nikolaos — UCSD

Significant advances have taken place in the last few years in the development of control designs for nonlinear infinite-dimensional systems. Such systems typically take the form of nonlinear ODEs (ordinary differential equations) with delays and nonlinear PDEs (partial differential equations). In this article we review several representative but general results on nonlinear control in the infinite-dimensional setting. First we present designs for nonlinear ODEs with constant, time-varying or state-dependent input delays, which arise in numerous applications of control over networks. Second, we present a design for nonlinear ODEs with a wave (string) PDE at its input, which is motivated by the drilling dynamics in petroleum engineering. Third, we present a design for systems of (two) coupled nonlinear first-order hyperbolic PDEs, which is motivated by slugging flow dynamics in petroleum production in off-shore facilities. Our design and analysis methodologies are based on the concepts of nonlinear predictor feedback and nonlinear infinite-dimensional backstepping. We present several simulation examples that illustrate the design methodology.

WeA1	Room C101
Lyapunov Methods (Regular Session)	
Chair: van der Schaft, Arjan J.	Univ. of Groningen
Co-Chair: Kellett, Christopher M.	Univ. of Newcastle

10:30-10:50 WeA1.1

On Differentially Dissipative Dynamical Systems, pp. 15-20

Forni, Fulvio — Univ. of Liège
Sepulchre, Rodolphe J. — Univ. de Liege

Dissipativity is an essential concept of systems theory. The paper provides an extension of dissipativity, named differential dissipativity, by lifting storage functions and supply rates to the tangent bundle. Differential dissipativity is connected to incremental stability in the same way as dissipativity is connected to stability. It leads to a natural formulation of differential passivity when restricting to quadratic supply rates. The paper also shows that the interconnection of differentially passive systems is differentially passive, and provides preliminary examples of differentially passive electrical systems.

10:50-11:10 WeA1.2

On Differential Passivity, pp. 21-25

van der Schaft, Arjan J. — Univ. of Groningen

Motivated by developments on differential Lyapunov functions for contraction analysis in Forni, Sepulchre (2012) we propose a definition of differential passivity, based on the geometric framework of the prolongation of a nonlinear system in Crouch, van der Schaft (1987). We explore the ramifications of this definition and its potential uses.

11:10-11:30 WeA1.3

A Non-Conservative Small-Gain Theorem for GAS Discrete-Time Systems, pp. 26-31

Geiselhart, Roman — Univ. of Wuerzburg
Gielen, Rob H. — Eindhoven Univ. of Tech.
Lazar, Mircea — Eindhoven Univ. of Tech.
Wirth, Fabian R. — Univ. Würzburg

This paper makes use of the concept of a finite–time Lyapunov function to derive a non–conservative small-gain theorem for stability analysis of interconnected discrete–time nonlinear systems. Firstly, it is shown that the existence of a global finite–time Lyapunov function is equivalent to global asymptotic stability (GAS) of the overall interconnected system. Secondly, it is indicated that existence of Lyapunov–type functions for each subsystem, together with a small-gain condition implies GAS of the interconnected system. Thirdly, the main result of this paper establishes that GAS of the interconnected system always yields a set of Lyapunov–type functions that satisfy the small-gain condition for a rather general class of GAS nonlinear systems. A simple example demonstrates the non–conservatism of the proposed small-gain theorem.

11:30-11:50 WeA1.4

Stabilization of Generalized Triangular Form Systems with Dynamic Uncertainties by Means of Small Gain Theorems, pp. 32-37

Dashkovskiy, Sergey — Univ. of Applied Sciences Erfurt
Pavlichkov, Svyatoslav — Univ. of Applied Sciences Erfurt
Jiang, Zhong-Ping — Pol. Inst. of New York Univ.

We prove that a nonlinear control system with periodic dynamics in the generalized triangular form (GTF) which is affected by external disturbances can be uniformly input-to-state stabilized by means of a periodic feedback and the gain can be chosen arbitrarily small in some sense. This allows us to stabilize such a system in presence of unmeasured dynamic uncertainties.

11:50-12:10 WeA1.5

Input-To-State Stability, Integral Input-To-State Stability, and Unbounded Level Sets, pp. 38-43

Kellett, Christopher — Univ. of Newcastle

Wirth, Fabian R. — Univ. Würzburg
Dower, Peter M. — Univ. of Melbourne

We provide partial Lyapunov characterizations for a recently proposed generalization of input-to-state and integral input-to-state stability (ISS and iISS, respectively). This generalization relies on the notion of stability with respect to two measures originally introduced by Movchan [1960]. We show that the two classical Lyapunov characterizations of ISS-type properties, i.e., decrease conditions in an implication or dissipative form, correspond to ISS and iISS, respectively. We also demonstrate via an example that, for the generalization considered here, ISS does not necessarily imply iISS.

WeA2	Room C102
Reliable Methods for Control, State Estimation and Parameter Identification of Uncertain Dynamic Systems I (Invited Session)	
Chair: Rauh, Andreas	Univ. of Rostock
Co-Chair: Ramdani, Nacim	Univ. d'Orléans
Organizer: Rauh, Andreas	Univ. of Rostock
Organizer: Ramdani, Nacim	Univ. d'Orléans

10:30-10:50 — WeA2.1

Guaranteed Characterization of the Explored Space of a Mobile Robot by Using Subpavings (I), pp. 44-49

Drevelle, Vincent — ENSTA Bretagne
Jaulin, Luc — ENSTA-Bretagne
Zerr, Benoit — Lab. - ENSTA Bretagne

This paper proposes a method to characterize the space explored by a mobile robot during a mission. Because of localization uncertainty, the area osculated by a sensor at a given time is uncertain too. The problem is modeled by using intervals to represent trajectory uncertainties and a “visibility function” to describe the area in view at a given time. A set-inversion method is then applied to compute a “guaranteed visible area” and a “possible visible area” with respect to positioning uncertainty. A bracketing of the actual explored area between a “guaranteed explored area” and a “possible explored area” for the whole mission is finally obtained by respectively taking the union of the guaranteed and possible areas. Results from a simulated underwater exploration mission are presented.

10:50-11:10 — WeA2.2

Control of Uncertain Nonlinear Systems Using Ellipsoidal Reachability Calculus (I), pp. 50-55

Asselborn, Leonhard — Univ. of Kassel
Gross, Dominic — Univ. of Kassel
Stursberg, Olaf — Univ. of Kassel

This paper proposes an approach to algorithmically synthesize control strategies for discrete-time nonlinear uncertain systems based on reachable set computations using the ellipsoidal calculus. For given ellipsoidal initial sets and bounded ellipsoidal disturbances, the proposed algorithm iterates over conservatively approximating and LMI-constrained optimization problems to compute stablizing controllers. The method uses first-order Taylor approximation of the nonlinear dynamics and a conservative approximation of the Lagrange remainder. An example for illustration is included.

11:10-11:30 — WeA2.3

Guaranteed Characterization of Exact Non-Asymptotic Confidence Regions in Nonlinear Parameter Estimation (I), pp. 56-61

Kieffer, Michel — CNRS - Supélec - Univ. Paris-Sud, Inst.
Walter, Eric — CNRS

Recently, a new family of methods has been proposed for characterizing accuracy in nonlinear parameter estimation by Campi et al. These methods make it possible to obtain exact, non-asymptotic confidence regions for the parameter estimates under relatively mild assumptions on the noise distribution, namely that the noise samples are independently and symmetrically distributed.

The numerical characterization of an exact confidence region with this new approach is far from being trivial, however. The aim of this paper is to show how interval analysis, which has been used for a guaranteed characterization of confidence regions for the parameter vector in other contexts, can contribute.

11:30-11:50 — WeA2.4

Bounds on Reachable Sets Using Ordinary Differential Equations with Linear Programs Embedded (I), pp. 62-67

Harwood, Stuart — Massachusetts Inst. of Tech.
Scott, Joseph — Massachusetts Inst. of Tech.
Barton, Paul — Massachusetts Inst. of Tech.

This work considers the computation of time-varying enclosures of the reachable sets of nonlinear control systems via the solution of an initial value problem in ordinary differential equations (ODEs) with linear programs (LPs) embedded. To ensure the numerical tractability of such a formulation, the properties of the ODEs with LPs embedded are discussed including existence and uniqueness of the solutions of the initial value problem in ODEs with LPs embedded. This formulation is then applied to the computation of rigorous componentwise time-varying bounds on the states of a nonlinear control system. The bounding theory used in this work exploits physical information to yield tight bounds on the states; this work develops a new implementation of this theory. Finally, the tightness of the bounds are demonstrated for a model of a reacting chemical system with uncertain rate parameters.

11:50-12:10 — WeA2.5

On Interval Observer Design for a Class of Continuous-Time LPV Systems (I), pp. 68-73

Chebotarev, Stanislav — Saint Petersburg State Univ. of InformationTechnologies Mec
Efimov, Denis — INRIA - LNE
Raïssi, Tarek — Conservatoire National des Arts et Métiers
Zolghadri, Ali — Univ. Bordeaux I

This work is devoted to interval observer design for Linear

Parameter-Varying (LPV) systems under assumption that the vector of scheduling parameters is not available for measurements. Stability conditions are expressed in terms of matrix inequalities, which can be solved using standard numerical solvers. Robustness and estimation accuracy with respect to model uncertainty is analyzed using L_infty/L_1 framework. Two solutions are proposed for nonnegative systems and for a generic case. The efficiency of the proposed approach is demonstrated through computer simulations.

WeA3	Room C103
Aerospace and Motion Planning (Regular Session)	

Chair: Zips, Patrik	Automation and Control Inst. Vienna Univ. of Tech.
Co-Chair: Yamashita, Yuh	Hokkaido Univ.

10:30-10:50 WeA3.1

Landing of a Transport Aircraft Using Image Based Visual Servoing, pp. 74-79

Gibert, Victor	Airbus Operations S A S
Puyou, Guilhem	Airbus

In this paper, an image-based visual servoing scheme is presented in order to control a transport aircraft in final approach phase by overcoming the need for external information (e.g. ILS or GPS systems) and runway knowledge. Based on three decoupled visual features and inertial data, the guidance scheme is designed and validated on a simplified model and tested on a realistic nonlinear simulator. Finally simulation results are presented in order to validate the choice of the visual features and the guidance laws to land the aircraft.

10:50-11:10 WeA3.2

Quadrotor Tracking Control Based on a Moving Frame, pp. 80-85

Konz, Matthias	Saarland Univ.
Rudolph, Joachim	Saarland Univ.

A model for a quadrotor helicopter, its flatness-based parameterization, and its control are investigated. The model is transformed by expressing the configuration in terms of a reference trajectory and the deviation from the latter. A flat output for the error system is introduced. A dynamic and a quasi-static feedback for asymptotic stabilization of reference trajectories are derived. The approach avoids introducing artificial singularities and provides the possibility for tracking ”acrobatic” trajectories. A simulation result with the quadrotor flying a loop is shown.

11:10-11:30 WeA3.3

Fast Optimization Based Motion Planning and Path-Tracking Control for Car Parking, pp. 86-91

Zips, Patrik	Automation and Control Inst. Vienna Univ. of Tech.
Boeck, Martin	Vienna Univ. of Tech.
Kugi, Andreas	Vienna Univ. of Tech.

This paper presents a car parking control concept for real-time application. It utilizes a two-degrees-of-freedom control scheme consisting of a feedforward and a feedback controller. The reference trajectory is constructed in two steps. First a geometric path is planned by solving a local static optimization problem, which is formulated by discretizing the path. Second a pathfollowing problem in the form of an optimal control problem considering the physical limitations is solved. The solution of this optimal control problem yields the time parametrization of the geometric path. In order to account for model uncertainties and disturbances, a Lyapunov-based feedback controller is designed for the trajectory error system. Simulation studies show the applicability and efficiency of the proposed approach.

11:30-11:50 WeA3.4

Control of Two-Wheeled Mobile Robot Via Homogeneous Semiconcave Control Lyapunov Function, pp. 92-97

Kimura, Shunsuke	Tokyo Univ. of Science
Nakamura, Hisakazu	Tokyo Univ. of Science
Yamashita, Yuh	Hokkaido Univ.

Semiconcave control Lyapunov functions for globally asymptotic stabilizing controllable systems are available.However, a semiconcave control Lyapunov function for nonholonomic systems has not been proposed yet.For a two-wheeled mobile robot, we construct a homogeneous semiconcave control Lyapunov function and a control law with the function.The advantages of the proposed method are confirmed by computer simulation.

11:50-12:10 WeA3.5

2D Path Following for Marine Craft: A Least-Square Approach, pp. 98-103

Peymani, Ehsan	Norwegian Univ. of Science and Tech.
Fossen, Thor I.	NTNU

We study the problem of straight-line path following for fully actuated marine craft. We propose a controller that adjusts the speed of the marine craft according to the geometric distance and the rate of convergence to the path. The control law is derived using the method of least squares, which is used to find an approximate solution for overdetermined systems. The conditions under which the closed-loop system is globally asymptotically stable are found. Moreover, a method to ensure zero cross-track error in the presence of ocean currents is proposed. The stability proof relies on the theory of cascaded systems. The effectiveness of the method is verified by performing computer simulations.

WeSPS1	Room A001
Norm-Controllability, or How a Nonlinear System Responds to Large Inputs (Semi-Plenary Session)	

Chair: Teel, Andrew R.	Univ. of California at Santa Barbara

13:20-14:20 WeSPS1.1

Norm-Controllability, or How a Nonlinear System Responds to Large Inputs, pp. 104-109

Muller, Matthias A.	Univ. of Stuttgart
Liberzon, Daniel	Univ. of Illinois at Urbana-Champaign

Allgower, Frank | Univ. of Stuttgart

The purpose of this paper is to survey and discuss recent results on norm-controllability of nonlinear systems. This notion captures the responsiveness of a nonlinear system with respect to the applied inputs in terms of the norm of an output map, and can be regarded as a certain type of gain concept and/or a weaker notion of controllability. We state several Lyapunov-like sufficient conditions for this property in a simplified formulation, and illustrate the concept with several examples.

WeSPS2 Room A002

Snake Robots - from Biology to Nonlinear Control (Semi-Plenary Session)

Chair: Leonard, Naomi Ehrich | Princeton Univ.

13:20-14:20 WeSPS2.1

Snake Robots - from Biology to Nonlinear Control, pp. 110-115

Pettersen, Kristin Y. | Norwegian Univ. of Science and Tech.
Liljebäck, Pål | NTNU
Stavdahl, Øyvind | Norwegian Univ. of Science and Tech. (NTNU)
Gravdahl, Jan Tommy | Norwegian Univ. of Science & Tech.

Inspired by the motion of biological snakes, this paper presents an overview of recent results in modelling and control of snake robots. The objective of the research underlying this paper is to contribute to the mathematical foundation of the control theory of snake robots. To this end, the paper presents two mathematical models of planar snake robot dynamics, which are employed to investigate stabilisability and controllability properties of snake robots. Furthermore, averaging theory is used to derive properties of the velocity dynamics of snake robots. Moreover, a straight line path following controller is proposed and cascaded systems theory is employed to prove that the controller K-exponentially stabilizes a snake robot to any desired straight path.

WeB1 Room C101

Lyapunov and Passivity Based Controls (Regular Session)

Chair: Eberard, Damien | Univ. de Lyon, INSA de Lyon
Co-Chair: Hudon, Nicolas | Univ. Catholique de Louvain

14:30-14:50 WeB1.1

Energy Level Stabilization of Pendulum on a Cart with Restricted Cart Track Based on Elliptic Functions and Integrals, pp. 116-121

Turker, Turker | Yildiz Tech. Univ.
Praly, Laurent | Ec. des Mines

This study presents an energy level stabilization algorithm for the pendulum on a cart system with restricted cart track length. The objective is to bring the pendulum to its unstable equilibrium. To do so the energy level of the pendulum is increased or decreased by accelerating the cart in the appropriate direction while keeping within imposed limit positions. To achieve, the equation of motion of the pendulum is solved by means of elliptic integrals considering the cart is moved with constant acceleration, and all the calculations are performed numerically to obtain the bounds for elapsed time and change of the energy level of the pendulum. The algorithm is tested on the system by means of numerical simulations.

14:50-15:10 WeB1.2

Stabilization of Nonlinear Systems Via Potential-Based Realization, pp. 122-127

Guay, Martin | Queen's Univ.
Hudon, Nicolas | Univ. Catholique de Louvain

This paper considers the problem of representing a sufficiently smooth nonlinear system as a structured potential-driven system and to exploit the obtained structure for the design of nonlinear state feedback stabilizing controllers. The problem has been studied in recent years for systems modeled as structured potential-driven systems, for example gradient systems, generalized Hamiltonian systems and systems given in Brayton–Moser form. To recover the advantages of those representations for the stabilization of general nonlinear systems, the present note proposes a geometric decomposition technique to re-express a given vector field into a desired potential-driven form. The decomposition method is based on the Hodge decomposition theorem, where a one-form associated to the given vector field is decomposed into its exact, co- exact, and harmonic parts.

15:10-15:30 WeB1.3

Control Lyapunov Function Based Feedback Design for Quasi-Polynomial Systems, pp. 128-133

Magyar, Attila | Univ. of Pannonia
Hangos, Katalin M. | Computer and Automation Res. Inst. HAS

The aim of this work is to present an entropy-like Lyapunov function based dynamic feedback design technique for quasi-polynomial and Lotka-Volterra systems. It is shown, that the dynamic feedback design problem is equivalent to the feasibility of a bilinear matrix inequality. The problem is also formulated as a control Lyapunov function based feedback design when the Lyapunov function parameters are given, the solution of this problem can be obtained by solving a linear matrix inequality.

15:30-15:50 WeB1.4

Discrete IDA-PBC Design for 2D Port-Hamiltonian Systems, pp. 134-139

Aoues, Saïd | INSA de Lyon
Eberard, Damien | Univ. de Lyon, INSA de Lyon
wilfrid, marquis-favre | INSA de Lyon

We address the discrete-time passivity-based control laws synthesis within port-Hamiltonian framework. We focus on IDA-PBC design for canonical port-Hamiltonian systems with separable energy being quadratic in momentum. For this class of systems, we define a discrete Hamiltonian dynamics that exactly satisfies a discrete energy balance. We then derive a discrete controller following the IDA-PBC procedure. The proposed methodology relies on an energy discretization scheme with suitable discrete conjugate port variables. The main result is illustrated on two examples: a nonlinear pendulum in order to compare with some simulation results of the literature, and the impact oscillator which requires robust discretization scheme.

15:50-16:10 WeB1.5

Finite-Time Stabilization Using Implicit Lyapunov Function Technique, pp. 140-145

Polyakov, Andrey — INRIA Lille Nord-Europe
Efimov, Denis — INRIA - LNE
Perruquetti, Wilfrid — Ec. Centrale de Lille

The Implicit Lyapunov Function (ILF) method for finite-time stability analysis is introduced. The control algorithm for finite-time stabilization of a chain of integrators is developed. The scheme of control parameters selection is presented by a Linear Matrix Inequality (LMI). The robustness of the finite-time control algorithm with respect to system uncertainties and disturbances is studied. The new high order sliding mode (HOSM) control is derived as a particular case of the developed finite-time control algorithm. The settling time estimate is obtained using ILF method. The algorithm of practical implementation of the ILF control scheme is discussed. The theoretical results are supported by numerical simulations.

16:10-16:30 WeB1.6

Optimality of Passivity-Based Controls for Distributed Port-Hamiltonian Systems, pp. 146-151

Nishida, Gou — Kyoto Univ.
Yamaguchi, Kyosuke — Nagoya Univ.
Sakamoto, Noboru — Nagoya Univ.

This paper discusses the (inverse) optimality and practical usage of passivity-based controls for distributed port-Hamiltonian systems. We first clarify that passivity-based controls, damping assignment and potential shaping can be derived from a linear quadratic type optimal control problem. Next, we describe the limitation of passivity-based boundary controls and propose a practical usage of the methods in terms of discretization. Finally, we illustrate numerical results having a similar property to the strain feedback methods derived from semigroup theory for stabilizing and stiffness controlling flexible beams.

WeB2 Room C102

What's up within the Theory of the Chemostat? (Invited Session)

Chair: Rapaport, Alain — INRA
Co-Chair: Harmand, Jérome — INRA
Organizer: Harmand, Jérome — INRA

14:30-14:50 WeB2.1

Extremum Seeking Via Continuation Techniques for Optimizing Biogas Production in the Chemostat (I), pp. 152-157

Rapaport, Alain — INRA
Sieber, Jan — Univ. of Exeter
Rodrigues, Serafim — Plymouth Univ.
Desroches, Mathieu — INRIA Paris-Rocquencourt Res. Centre

We consider the chemostat model with the substrate concentration as the single measurement. We propose a control strategy that drives the system at a steady state maximizing the gas production without the knowledge of the specific growth rate. Our approach separates the extremum seeking problem from the feedback control problem such that each of the two subproblems can be solved with relatively simple algorithms. We are then free to choose any numerical optimization algorithm. We give a demonstration for two choices: one is based on slow-fast dynamics and numerical continuation, the other is a combination of golden-section and Newton iteration. The method copes with non-monotonic growth functions.

14:50-15:10 WeB2.2

Fed-Batch Bioreactor with Mortality Rate (I), pp. 158-163

Bayen, Terence — Univ. of Montpellier 2
Mairet, Francis — Inria
Mazade, Marc — Univ. Montpellier II

We address the problem of finding an optimal feedback control for feeding a fed-batch bioreactor with one species and one substrate, from a given initial condition to a given target value in a minimal amount of time. Mortality rate for the biomass and nutrient recycling are taken into account in this work. The optimal synthesis (optimal feeding strategy) has been obtained by Moreno in 1999 when both mortality and recycling are considered negligible, in the case of Monod and Haldane growth function. Our objective is to study the effect of mortality and recycling on the optimal synthesis. We provide an optimal synthesis of the problem using Pontryagin maximum principle, which extends the result of Moreno in the impulsive framework with mortality and recycling effect.

15:10-15:30 WeB2.3

Constant-Yield Control of the Chemostat (I), pp. 164-169

Savoglidis, Georgios — Univ. of Patras
Kravaris, Costas — Univ. of Patras

The present work addresses the problem of chemostat stabilization around an optimal steady state, in the sense of enlargement of its stability region. The need for stabilization becomes imperative under conditions where the growth of biomass is subject to substrate inhibition, and the primary concern is to prevent washout of the biomass in the presence of disturbances. Inspired by the empirical concept of constant-yield control, a nonlinear state feedback control law is derived, and the stability basin of resulting closed-loop system is estimated using a Lyapunov function approach. Our analysis extends previous results in the sense that it accounts for biomass decay and endogenous metabolism and, moreover, it covers the case where the product is soluble in the effluent stream.

15:30-15:50 WeB2.4

Global Stabilization of the Chemostat with Delayed and Sampled Measurements and Control (I), pp. 170-174

Mazenc, Frederic — INRIA-CNRS-Supelec,
Harmand, Jérome — INRA
Mounier, Hugues — Lab. des Signaux et

Systèmes, CNRS SUPELEC
Université Paris

The classical model of the chemostat with one substrate, one species and a Haldane type growth rate function is considered. The input substrate concentration is supposed to be constant and the dilution rate is considered as the control. The problem of globally asymptotically stabilizing a positive equilibrium point of this system in the case where the measured concentrations are delayed and piecewise constant with a piecewise constant control is addressed. The result relies on the introduction of a dynamic extension of a new type.

15:50-16:10	WeB2.5

Driving Species Competition in a Light-Limited Chemostat (I), pp. 175-180

Mairet, Francis	Inria
Muñoz-Tamayo, Rafael	INRIA
Bernard, Olivier	INRIA

In this paper, we tackle the problem of microalgae selection in a continuous photobioreactor where microalgae growth is limited by light. We propose a closed-loop control for selecting, for a given range of light intensity, the strain with the maximum growth rate from the microalgae population. In particular, we are interested in strains with high growth rate for high light intensity, i.e.,strains with high resistance to photoinhibition. Firstly, we recall the framework of the light-limited chemostat. Then, we propose a nonlinear adaptive control which regulates the light intensity at the bottom of the photobioreactor in monoculture. This light is of particular interest as it defines the winner of the competition in a multispecies culture operated in open-loop mode. Finally, we show that the proposed controller allows the selection of a strain of interest in the case of a culture with n species.

16:10-16:30	WeB2.6

The Buffered Chemostat with Non-Monotonic Response Functions (I), pp. 181-186

Rapaport, Alain	INRA
Haidar, Ihab	SupElec
Harmand, Jérome	INRA

We show how a particular spatial structure with a buffer globally stabilizes the chemostat dynamics with non-monotonic response function, while this is not possible with single, serial or parallel chemostats of the same total volume and input flow. We give a characterization of the set of such configurations that satisfy this property, as well as the configuration that ensures the best nutrient conversion. Furthermore, we characterize the minimal buffer volume to be added to a single chemostat for obtaining the global stability. These results are illustrated with the Haldane kinetic function.

WeB3	Room C103
Optimal Control (Regular Session)	
Chair: Mease, Kenneth D.	Univ. of California at Irvine
Co-Chair: del Re, Luigi	Johannes Kepler Univ.

14:30-14:50	WeB3.1

Solving Partially Hyper-Sensitive Optimal Control Problems Using Manifold Structure, pp. 187-192

Aykutlug, Erkut	Univ. of California, Irvine
Maggia, Marco	Univ. of California, Irvine
Mease, Kenneth D.	Univ. of California at Irvine

Hyper-sensitivity to unknown boundary conditions plagues indirect methods of solving optimal control problems as a Hamiltonian boundary-value problem for both state and costate. Yet the hyper-sensitivity may imply manifold structure in the Hamiltonian flow, knowledge of which would yield insight regarding the optimal solutions and suggest a solution approximation strategy that circumvents the hyper-sensitivity. Finite-time Lyapunov exponents and vectors provide a means of diagnosing hyper- sensitivity and determining the associated manifold structure. A solution approximation approach is described that requires determining the unknown boundary conditions, such that the solution end points lie on certain invariant manifolds, and matching of forward and backward segments. The approach is applied to the optimal control of a nonlinear spring-mass-damper system. The approximate solution is shown to be accurate by comparison with a solution obtained by a collocation method.

14:50-15:10	WeB3.2

Transformation of Output Constraints in Optimal Control Applied to a Double Pendulum on a Cart, pp. 193-198

Käpernick, Bartosz	Univ. of Ulm
Graichen, Knut	Univ. of Ulm

This paper describes a constraint transformation technique for optimal control problems (OCP) with nonlinear single-input single-output (SISO) systems subject to output constraints. An input-output transformation and saturation functions are used to transform the system dynamics into a new unconstrained representation. This method allows to reformulate the original OCP into an unconstrained counterpart. The transformation technique is applied to a double pendulum on a cart in order to compute optimal trajectories for a multi-stage transition scenario. Simulation as well as experimental results with an additional feedback control demonstrate the applicability of the presented method.

15:10-15:30	WeB3.3

Approximate Finite-Horizon Optimal Control for Input-Affine Nonlinear Systems with Input Constraints, pp. 199-204

Scarciotti, Giordano	Imperial Coll. London
Astolfi, Alessandro	Imperial Col. London & Univ. of Rome Tor Vergata

The finite-horizon optimal control problem with input constraints consists in controlling the state of a dynamical system over a finite time interval (possibly unknown) minimizing a cost functional, while satisfying hard constraints on the input. For linear systems the solution of the problem often relies upon the use of bang-bang control signals. For nonlinear systems the "shape" of the optimal input is in general not known. The control input can be found solving an Hamilton-Jacobi-Bellman (HJB) partial differential equation (pde): it typically consists of a combination of bang-bang arcs and singular arcs. In the paper a methodology to approximate the solution of the

HJB pde arising in the finite-horizon optimal control problem with input constraints is proposed. This approximation yields a dynamic state feedback law. The theory is illustrated by means of an example: the minimum time optimal control problem for an industrial wastewater treatment plant.

15:30-15:50 WeB3.4

Non-Existence of Minimizing Trajectories for Steer-Braking Systems, pp. 205-210

Rucco, Alessandro — Univ. of Salento
Hauser, John — Univ. of Colorado at Boulder
Notarstefano, Giuseppe — Univ. del Salento (Univ. of Lecce)

In this paper we investigate an optimal control problem in which the objective is to decelerate a simplified vehicle model, subject to input constraints, from a given initial velocity down to zero by minimizing a quadratic cost functional. The problem is of interest because, although it involves apparently simple drift-less dynamics, a minimizing trajectory does not exist. This problem is motivated by a minimum-time problem for a fairly complex car vehicle model on a race track. Numerical computations run on the car problem provide evidence of non-existence of a minimizing trajectory and of an apparently unmotivated ripple in the steer angle. We abstract this situation to a very simple dynamics/objective setting, show that no minimizing trajectory exists, and reproduce the oscillating behavior on the steer angle as a mean to reduce the cost functional.

15:50-16:10 WeB3.5

Minimum-Time Control of a Class of Nonlinear Systems with Partly Unknown Dynamics and Constrained Input, pp. 211-216

Schwarzgruber, Thomas — Johannes Kepler Univ. Linz
Colaneri, Patrizio — Pol. di Milano
del Re, Luigi — Johannes Kepler Univ.

The minimum-time problem frequently arises in the design of control for actuators, and is usually solved assuming to know the correct model of the system. In industrially important cases, however, important parts of the dynamics, like friction forces or disturbances by exosystems, are hardly known or even unknown. Against this background, this paper presents an iterative approach to achieve the minimum-time control for a nonlinear, single input second-order system with constrained input and partly unknown dynamics, effectively removing the requirement of perfect knowledge of the system and its parameters to achieve the minimum-time solution in application. First it is shown that, under reasonable assumptions about the unknown part of the dynamics, the optimal control exists for the presented class of systems and that it is a bang-bang control, with at most one switch. Then this property is exploited in the proposed algorithm, that finds the single optimal switching time by an iterative method, without involving any kind of identification of the unknown system parts.

WeC1 Room C101

Hybrid and Impulsive Systems (Regular Session)

Chair: Brogliato, Bernard — UR Rhone-Alpes
Co-Chair: Efimov, Denis — INRIA - LNE

17:00-17:20 WeC1.1

Sure Almost Global vs. Global Almost Sure Synchronization on the Circle: The Virtues of Stochastic Hybrid Feedback, pp. 223-228

Teel, Andrew R. — Univ. of California at Santa Barbara

This paper introduces a stochastic, hybrid algorithm for global almost sure synchronization of two agents evolving on the circle. Recent results on stochastic hybrid systems are exploited and a Lyapunov-based proof of global almost sure synchronization is obtained. The same arguments establish that global almost sure practical synchronization is achieved in the presence of sufficiently small disturbances. In contrast, sure almost global algorithms are more seriously affected by adversarial disturbances. Namely, there is a set of initial conditions with nonzero measure from which the agents may not approximately synchronize.

17:20-17:40 WeC1.2

Conditions of Existence of Oscillations for Hybrid Systems, pp. 229-234

Efimov, Denis — INRIA - LNE
Perruquetti, Wilfrid — Ec. Centrale de Lille
Shiriaev, Anton — Umea Univ.

The paper extends the notion of oscillations in the sense of Yakubovich to hybrid dynamics. Several sufficient stability and instability conditions for a forward invariant set are presented. The consideration is illustrated by analysis of a model of two-link compass-gait biped robot.

17:40-18:00 WeC1.3

On the Relation between Dwell-Time and Small-Gain Conditions for Interconnected Impulsive Systems, pp. 235-240

Dashkovskiy, Sergey — Univ. of Applied Sciences Erfurt
Promkam, Ratthaprom — Univ. of Bremen

For interconnection of impulsive systems a relation between dwell-time and small-gain conditions is considered in this paper. In particular we show how the choice of gains or supply rates affects the restriction on time intervals between impulses to assure stability properties.

18:00-18:20 WeC1.4

Nonlinear Feedback Types in Impulse and Fast Control, pp. 241-246

Daryin, Alexander — Moscow State (Lomonosov) Univ.
Kurzhanski, A.B. — Moscow State Univ. and Univ. of California, Berkeley

It is well-known that a system with linear structure subjected to bounded control inputs for optimal closed-loop control yields nonlinear feedback of discontinuous bang-bang type. This paper investigates a of nonlinear feedback in the case of optimal impulsive closed-loop control which may naturally generate discontinuous trajectories. The realization of such feedback under impulsive inputs that are allowed to use $delta$-functions with their higher derivatives requires physically realizable approximations.

Described in this paper is a new class of realizable feedback inputs that also allows to produce smooth approximation of controls. Such approach also applies to problems in micro time scales that require so-called fast or ultra-fast controls.

18:20-18:40 WeC1.5

On Stability of Measure Driven Differential Equations, pp. 247-252

Tanwani, Aneel	Inst. National de Recherche en Informatique et Automatique (I
Brogliato, Bernard	UR Rhone-Alpes
Prieur, Christophe	CNRS

We consider the problem of stability in a class of differential equations which are driven by a differential measure associated with the inputs of locally bounded variation. After discussing some existing notions of solution for such systems, we derive conditions on the system's vector fields for asymptotic stability under a specific class of inputs. These conditions present a trade-off between the Lebesgue-integrable and the measure-driven components of the system. In case the system is not asymptotically stable, we derive weaker conditions such that the norm of the resulting trajectory is bounded by some function of the total variation of the input, which generalizes the notion of integral input-to-state stability in measure-driven systems.

WeC2 Room C102

Biological and Biomedical Systems (Regular Session)

Chair: Sbarciog, Mihaela	Mons Univ.
Co-Chair: Grognard, Frederic	INRIA Sophia-Antipolis

17:00-17:20 WeC2.1

A Cascade MPC-Feedback Linearizing Strategy for the Multivariable Control of Animal Cell Cultures, pp. 253-258

Sbarciog, Mihaela	Mons Univ.
Coutinho, Daniel	Univ. Federal de Santa Catarina
Vande Wouwer, Alain	Univ. de Mons

In this study, a multivariable control structure is developed to simultaneously control the concentrations of cells and of one of the nutrients in an animal cell cultivation system operated in perfusion. A cascade control structure is considered consisting of (i) an inner loop with a partially linearizing feedback controller, tuned so as to ensure robustness with respect to parameter uncertainties and non-canceled nonlinearities; and (ii) an outer loop involving two linear predictive controllers. The resulting control strategy shows robustness and performance properties similar to more computationally demanding strategies (such as a multivariable nonlinear MPC strategy), while requiring less measurements and involving an easier implementation.

17:20-17:40 WeC2.2

An Alternative Approach for Oscillatory Behaviour Control in a Nonlinear Bioprocess, pp. 259-264

Skupin, Piotr	Silesian Univ. of Tech.
Metzger, Mieczyslaw	Faculty of Automatic Control, Electronics and Computer Science,

The nonlinear nature of bioprocesses often leads to the occurrence of the self-sustained oscillations of the biomass concentration in continuous flow bioreactors. For some practical reasons, sometimes it is necessary to control the oscillatory behaviour, which is usually achieved by changing the dilution rate, but this is not always the best option. Hence, the main idea of this paper is to introduce an additional substrate, which has been previously diluted. Based on the numerical analysis of an unstructured mathematical model, it is shown that by mixing two various substrates (the main and the diluted one), it is possible to induce or eliminate the sustained oscillations. As a result, the contribution of both substrates to the mixture and the degree of dilution of the additional substrate can be treated as new control variables.

17:40-18:00 WeC2.3

L1 Adaptive Control of End-Tidal CO2 by Optimizing the Muscular Power for Mechanically Ventilated Patients, pp. 265-270

Pomprapa, Anake	RWTH Aachen Univ.
Walter, Marian	RWTH Aachen Univ.
Goebel, Christof	Weinmann Geraete fuer Medizin GmbH
Misgeld, Berno	RWTH Aachen Univ.
Leonhardt, Steffen	RWTH Aachen

In this paper, a novel approach to control end-tidal CO2 in mechanically ventilated patients is presented. Assuming a homogeneous lung model, a regulation of arterial CO2 tension in blood can be achieved non-invasively using L1 adaptive control with the aid of an extremum seeking method to set the proper respiratory rate. Using these integrated approaches, not only is end-tidal CO2 regulated at the specific level, but also muscular power for breathing is optimized to comfort the muscles involved in the respiratory system. The simulation of the control algorithms show the distinctive results based on linear and nonlinear Hammerstein models of the process. These were obtained from measurement data from a human volunteer. The algorithm is applicable under pressure-controlled ventilation and provides a practical solution in various clinical situations.

18:00-18:20 WeC2.4

Positive Control for Global Stabilization of Predator-Prey Systems, pp. 271-276

Grognard, Frederic	INRIA Sophia-Antipolis
Rault, Jonathan	Aix-Marseille Univ.
Gouze, Jean-Luc	INRIA

In this paper we propose a positive linear control law for the stabilization of positive equilibria in predator-prey systems; this problem is motivated by the introduction of predators in biological control applications, to prevent excessive levels of prey (pests). We build a linear controller that we saturate at zero and prove, under some conditions, the global asymptotic stability of the equilibrium. Without one of these conditions, the point is shown to be globally attractive but may be unstable. Finally, we discuss how the control parameters should be chosen to reduce

the total control effort and the size of the transient peak in the prey population.

18:20-18:40 WeC2.5

A Class of Switched Piecewise Quadratic Systems for Coupling Gene Expression with Growth Rate in Bacteria, pp. 277-282

Carta, Alfonso — Inria Sophia Antipolis - Méditerranée
Chaves, Madalena — INRIA
Gouze, Jean-Luc — INRIA

In this paper we propose a novel qualitative formalism to model gene expression dynamics dependent on dilution due to growth rate of the cell. We extend the piecewise linear (PL) systems by keeping the use of step functions to model the interactions between the elements and adding a growth rate expression to model the dilution effect. Focusing on the global gene expression machinery in bacteria, we model the growth rate as the minimum of two limiting factors: RNA polymerase (RNAP) and ribosomes. The resulting system is a switched system with two piecewise quadratic (PQ) modes. We study the stability of such switched piecewise quadratic (SPQ) system starting from the stability analysis of the (PQ) modes. We also present and analyze by means of phase-planes a bidimensional SPQ model involving RNAP and ribosomes concentrations, which brings out the important differences with respect to PL systems. Finally, we qualitatively show that our growth rate expression acts well in different biological conditions.

WeC3 Room C103
Internal Model Control (Regular Session)

Chair: De Persis, Claudio — Univ. of Groningen
Co-Chair: Lin, Wei — Case Western Res. Univ.

17:00-17:20 WeC3.1

A Revisit of Marino-Tomei's Result on Output Feedback Control of a Class of Non-Minimum Phase Nonlinear Systems, pp. 283-288

Lin, Wei — Case Western Res. Univ.
Wei, Wei — Harbin Inst. of Tech. Shenzhen Graduate School
Liu, Xinghua — Harbin Inst. of Tech. Shenzhen Graduate School

In this paper, global stabilization by output feedback is investigated for a class of non-minimum-phase nonlinear systems previously considered by Marino and Tomei [4]. It is shown that it is possible to construct, via a new design method that involves no filter transformation, a globally stabilizing dynamic output feedback controller of order n, instead of $n + 2(\rho - 1)$, for the non-minimum phase nonlinear system in output feedback form [4], under a slightly general condition (i.e., Assumption 2.2) together with the assumption that the nonlinear system is non-minimum-phase with respect to the original output, but minimum-phase with respect to a virtual linear output. Two examples are given to illustrate the simplicity of the new design approach and its effectiveness.

17:20-17:40 WeC3.2

Robust Design of Internal Models by Nonlinear Regression, pp. 289-294

Forte, Francesco — Univ. of Bologna
Isidori, Alberto — Univ. of Rome "La Sapienza"
Marconi, Lorenzo — Univ. di Bologna

This paper focuses on the design of robust internal model-based regulators for a class of nonlinear systems and exosystems such that the desired steady state control law fulfills a nonlinear regression formula affine in possible uncertainties. The design methodology builds upon the ideas presented in a paper by the authors on Automatica in the context of linear adaptive output regulation. The design methodology relies upon an assumption of left invertibility of a matrix. Through numerical analysis we show how the design methodology succeeds in relevant cases, such as the cases in which the desired steady state is generated by uncertain Van der Pol, Duffing, and Lorentz oscillators.

17:40-18:00 WeC3.3

Internal Models for Nonlinear Output Agreement and Optimal Flow Control, pp. 295-300

Bürger, Mathias — Univ. of Stuttgart
De Persis, Claudio — Univ. of Groningen

This paper studies the problem of output agreement in networks of nonlinear dynamical systems under time-varying disturbances. Necessary and sufficient conditions for output agreement are derived for the class of incrementally passive systems. Following this, it is shown that the optimal distribution problem in dynamic inventory systems with time-varying supply and demand can be cast as a special version of the output agreement problem. We show in particular that the time-varying optimal distribution problem can be solved by applying an internal model controller to the dual variables of a certain convex network optimization problem.

18:00-18:20 WeC3.4

Nonlinear Output Regulation by Post-Processing Internal Model for Multi-Input Multi-Output Systems, pp. 301-306

Astolfi, Daniele — Univ. of Bologna
Isidori, Alberto — Univ. of Rome "La Sapienza"
Marconi, Lorenzo — Univ. di Bologna
Praly, Laurent — Ec. des Mines

The paper deals with the problem of output regulation for the class of multi-input multi-output square nonlinear systems satisfying a minimum-phase assumption and a ``positivity" condition on the high-frequency gain matrix. By following a design paradigm proposed in [12] for single-input single-output nonlinear systems, it is shown how an internal model-based controller can be obtained, whose dimension depends on the number of regulated outputs and on the dimension of the exosystem. Thanks a scalability property of the regulator structure highlighted in [12], it is shown how a ``pre-processing" internal model can be shifted from input to output, yielding in this way a ``post-processing" internal model. This makes it possible to run a high-gain asymptotic analysis that bypasses the need of finding a normal form, as it would normally be the case.

18:20-18:40 WeC3.5

Nonlinear Model-Based Control of Two-Phase Flow in Risers by Feedback Linearization, pp. 307-312

Jahanshahi, Esmaeil	Norwegian Univ. of Science and Tech.
Skogestad, Sigurd	Norwegian Univ. of Science & Tech.
Grøtli, Esten Ingar	Norwegian Univ. of Science and Tech.

Active control of the production choke valve is the recommended solution to prevent severe slugging flow conditions at offshore oilfields. The slugging flow constitutes an unstable and highly nonlinear system; the gain of the system changes drastically for different operating points. Although PI and PID controllers are the most widely used controllers in the industry, they need to be re-tuned for different operating conditions. The focus of this paper is designing a model-based nonlinear controller in order to counteract nonlinearities of the system. The feedback linearization based on the riser-base pressure and the topside pressure was used for the control design. Stability and convergence of the closed-loop system was verified in theory as well as by experiments on a test rig.

ThPL1	Rooms A001/A002
Multi-Agent System Dynamics: Bifurcation and Behavior of Animal Groups (Plenary Session)	
Chair: Isidori, Alberto	Univ. of Rome "La Sapienza"

08:30-09:30 ThPL1.1

Multi-Agent System Dynamics: Bifurcation and Behavior of Animal Groups, pp. 313-323

Leonard, Naomi Ehrich — Princeton Univ.

Systematic design of decentralized feedback for coordinated control of multi-agent systems has much to gain from the rigorous examination of the nonlinear dynamics of collective animal behavior. Animals in groups, from bird flocks to fish schools, employ decentralized strategies and have limitations on sensing, computation, and actuation. Yet, at the level of the group, they are known to manage a variety of challenging tasks quickly, accurately, robustly and adaptively in an uncertain and changing environment. In this paper we review recent work on models and methods for studying the mechanisms of collective migration and collective decision-making in high-performing animal groups. Through bifurcation analyses we prove systematically how behavior depends on parameters that model the system and the environment. These connections lay the foundations for proving systematic control design methodologies that endow engineered multi-agent systems with the remarkable features of animal group dynamics.

ThA1	Room C101
Event-Triggered and Self-Triggered Control (Invited Session)	
Chair: Postoyan, Romain	CNRS-CRAN
Co-Chair: Dimarogonas, Dimos V.	Royal Inst. of Tech.
Organizer: Postoyan, Romain	CNRS-CRAN
Organizer: Nesic, Dragan	Univ. of Melbourne

10:00-10:20 ThA1.1

Nonlinear Event-Triggered Tracking Control of a Mobile Robot: Design, Analysis and Experimental Results (I), pp. 324-329

Postoyan, Romain — CNRS-CRAN
Bragagnolo, Marcos Cesar — Univ. de Lorraine
Galbrun, Ernest — Univ. de Lorraine
Daafouz, Jamal — CRAN -INPL
Nesic, Dragan — Univ. of Melbourne
Castelan, Eugenio B. — Univ. Federal de Santa Catarina

We consider the scenario where a controller communicates with a mobile robot via a network. Our objective is to design the control law such that the robot tracks a given reference trajectory while reducing the usage of the communication channel. For that purpose, we design a nonlinear event-triggered feedback law. We follow an emulation-like approach in the sense that we first synthesize the controller while ignoring the communication constraints and we then derive an appropriate triggering condition. We prove that the states of the robot's model practically converge towards the states of the reference system which generates the desired trajectory to be tracked, using an invariance principle for hybrid systems. The existence of a dwell-time between any two transmissions is discussed. We have implemented the proposed strategy on a benchmark where the controller is located on a remote computer which communicates with the mobile robot via a IEEE 802.11g wireless network. The proposed event-triggering strategy is shown to significantly reduce the need for communication compared to a classical time-triggered setup while ensuring similar, if not better, tracking performances.

10:20-10:40 ThA1.2

Lyapunov Event-Triggered Control: A New Event Strategy Based on the Control (I), pp. 330-334

Marchand, Nicolas — GIPSA-Lab. CNRS
Martinez Molina, John J. — Grenoble-INP, GIPSA-Lab.
Durand, Sylvain — CNRS - CINVESTAV
Guerrero Castellanos, Jose Fermi — Autonomous Univ. of Puebla (BUAP)

Event-triggered control is a sampling strategy that updates the control value only when when some event occurs. This event is usually generated by an event-function that indicates if the control signal must be updated or not. If one excepts self-triggered implementation, event-triggered control requires the evaluation of the event function at each time instant. Unfortunately, in the literature of nonlinear system event-based control, computing the event function is more resource consuming than computing the control itself. Moreover, it requires the knowledge of the Lyapunov function that is not necessarily available. The purpose of this paper is to propose for affine nonlinear systems a new event function that only requires the computation of the control. This reduces the complexity of computing the event and avoids to have the Lyapunov function.

10:40-11:00 ThA1.3

Distributed Model Based Event-Triggered Control for Synchronization of Multi-Agent Systems (I), pp. 335-340

Liuzza, Davide — Univ. of Naples Federico II
Dimarogonas, Dimos V. — Royal Inst. of Tech.
di Bernardo, Mario — Univ. of Naples Federico II
Johansson, Karl H. — Royal Inst. of Tech.

This paper investigates the problem of event-based control for the synchronization of networks of nonlinear dynamical agents. A distributed model based approach able to guarantee that all the agents converge to an adjustable synchronization region is derived. In such control scheme all the agents use a model of their neighborhood in order to generate triggering instants in which the local controller is updated and, if needed, local information is broadcasted to neighboring agents. The existence of a minimum lower bound between inter-event times is proven both for broadcasted information as well as for control signal updating, thus allowing implementation of the proposed strategy in applications where both the communication bandwidth and the maximum updating frequency of actuators are critical.

11:00-11:20	ThA1.4

A Self-Triggered Control Based on Convex Embeddings for Perturbed LTI Systems (I), pp. 341-346

Fiter, Christophe	Tel-Aviv Univ.
Hetel, Laurentiu	CNRS
Perruquetti, Wilfrid	Ec. Centrale de Lille
Richard, Jean-Pierre	Ec. Centrale de Lille

In this work, we present a novel self-triggered control which aims at decreasing the number of sampling instants for the state feedback control of perturbed linear time invariant systems. The approach is based on convex embeddings that allow for designing a state-dependent sampling function guaranteeing the system's exponential stability for a desired decay-rate and norm-bounded perturbations. One of the main contributions of this paper is an LMI based algorithm that optimizes the choice of the Lyapunov function so as to enlarge the lower-bound of the sampling function while taking into account both the perturbations and the decay-rate. The advantages of the approach are illustrated with a numerical example from the literature.

11:20-11:40	ThA1.5

Event-Triggered Control with LQ Optimality Guarantees for Saturated Linear Systems (I), pp. 347-352

Seuret, Alexandre	CNRS / LAAS
Prieur, Christophe	CNRS
Tarbouriech, Sophie	LAAS-CNRS
Zaccarian, Luca	LAAS-CNRS

Given a predesigned linear state feedback law for a linear plant ensuring (global) exponential stability of the linear closed loop, together with a certain level of performance, we address the problem of recovering (local or global) exponential stability and performance in the presence of plant input saturation and of a communication channel between the controller output and the saturated plant input. To this aim, we adopt Lyapunov-based techniques which combine generalized sector conditions to deal with the saturation nonlinearity and event- triggered techniques to deal with the communication channel. The arising analysis yields an event-triggered algorithm to update the saturated plant input based on conditions involving the closed-loop state. The proposed Lyapunov formulation leads to numerically tractable conditions that guarantee local (or global) exponential stability of the origin of the sampled-data system with an estimate of the domain of attraction.

11:40-12:00	ThA1.6

Event-Triggered Control of Nonlinear Singularly Perturbed Systems Based Only on the Slow Dynamics (I), pp. 353-358

Abdelrahim, Mahmoud Mohammed Othman	Univ. de Lorraine
Postoyan, Romain	CNRS-CRAN
Daafouz, Jamal	CRAN -INPL

We study event-triggered control based on a reduced or simplified model of the plant's dynamics. In particular, we address two time-scale systems and we investigate whether it is possible to synthesize a stabilizing event-triggered controller based only on an approximate model of the slow dynamics given by singular perturbation theory, when the fast one is stable. We highlight specific challenges which arise with the event-triggered implementation: the state of the fast model experiences jumps at transmissions which induces non-trivial difficulties for the stability analysis and the Zeno phenomenon may occur due to the fact that we neglect the fast dynamics. We describe the overall problem as a hybrid singularly perturbed system. We first provide a necessary condition on the triggering condition to avoid the Zeno phenomenon. Afterwards, we propose two strategies which respectively use a dead-zone and a clock variable and which ensure different asymptotic stability properties. The existence of a minimum inter-transmission interval is guaranteed. Our results are illustrated by a physical example.

ThA2	Room C102

Electrical and Mechanical Systems (Regular Session)

Chair: Dochain, Denis	Univ. Catholique de Louvain
Co-Chair: Munoz-Arias, Mauricio	Univ. of Groningen

10:00-10:20	ThA2.1

Robustness Analysis of a Position Observer for Surface--Mount Permanent Magnet Synchronous Motors Vis-A-Vis Rotor Saliency, pp. 359-364

Pillai, Harish	Indian Inst. of Tech. Bombay
Ortega, Romeo	Supelec
Hernandez, Michael	Schneider Electric
Devos, Thomas	Schneider Electric
Malrait, Francois	Schneider Toshiba Inverter

A gradient descent--based nonlinear observer for surface--mount permanent magnet synchronous motors (PMSMs) with remarkable stability properties was recently proposed in [7]. A key assumption for the derivation of the observer is the absence of rotor saliency, which is the case in surface--mount PMSMs. A question of great practical interest is to assess the performance of the observer in the presence of saliency. This is the topic of study of the present paper. It is shown that the robustness of the observer is fully determined by the sinusoidal steady--state values of the currents, providing some guidelines for the selection of their reference values to ensure good position estimation.

10:20-10:40	ThA2.2

Nonlinear Control for Bidirectional Power Converter in a Dc Microgrid, pp. 365-370

Lenz Cesar, Eduardo	Federal Univ. of Santa Catarina
Pagano, Daniel Juan	Federal Univ. of Santa Catarina

Some comparative studies of several nonlinear control techniques applied to dc-dc power converters are developed in this paper, like for instance the Immersion & Invariance, Passivity-Based Control, Feedback Linearization and the Sliding-Mode Control. All these different control strategies are used to drive dc-dc power converters in a dc microgrid. The load, modeled as a Constant Power Load type, is also a major issue of this paper.

10:40-11:00	ThA2.3

Voltage Balancing in Five-Level Diode-Clamped Power Converters, pp. 371-376

Umbría Jiménez, Francisco	Univ. of Seville
Gomez-Estern, Fabio	Univ. De Sevilla
Gordillo, Francisco	Univ. de Sevilla
Salas Gómez, Francisco	Escuela Superior de Ingenieros. Univ. de Sevilla

This paper addresses the voltage imbalance problem of the dc-link capacitors in multilevel power converters. Considering the five-level diode-clamped converter, a mathematical analysis of the capacitor voltage difference dynamics is carried out. It leads to a new problem statement that relates the voltage balancing objective to a problem of ensuring the practical stability of a nonlinear system in the presence of disturbances. Then, exploiting the properties and knowledge of the disturbance patterns, a novel and simple controller is presented. Simulation results are included to validate the performance of the proposed controller.

11:00-11:20	ThA2.4

A Globally Exponentially Stable Tracking Controller for Mechanical Systems with Friction Using Position Feedback, pp. 377-382

Romero Velazquez, José Guadalupe	Lab. des Signaux et Systèmes, CNRS–SUPELEC
Ortega, Romeo	Supelec

A solution to the problem of global exponential tracking without velocity measurement of mechanical systems with friction and possibly unbounded inertia matrix is given in the paper. The proposed controller is obtained combining a new full--information passivity--based controller with a new immersion and invariance observer. The resulting closed--loop system has, in some suitably defined coordinates, a port--Hamiltonian structure with a desired energy function and a uniformly positive definite damping matrix. In this way, global exponential tracking of position and velocity for all desired reference trajectories is ensured.

11:20-11:40	ThA2.5

Force Control of a Class of Standard Mechanical Systems in the Port-Hamiltonian Framework, pp. 383-388

Munoz-Arias, Mauricio	Univ. of Groningen
Scherpen, Jacquelien M.A.	Univ. of Groningen
Dirksz, Daniel A.	INCAS3

This work is devoted to a force control strategy of a class of standard mechanical systems in the port-Hamiltonian framework. First, a coordinate transformation is applied to equivalently describe the original port-Hamiltonian system in a port-Hamiltonian form which has a constant mass-inertia matrix in the Hamiltonian. Then, we show how to derive an extended port-Hamiltonian system with structure preservation which can be used for force control purposes. Furthermore, we prove that the closed-loop system is asymptotically stable via a Lyapunov candidate function. Finally, experiments results are provided to show the advantages of the force control strategy in presence of external forces.

11:40-12:00	ThA2.6

A Thermodynamic Approach to the Passive Boundary Control of Tubular Reactors, pp. 389-394

Hoang, Ngoc Ha	Univ. of Tech. (VNU-HCM, Vietnam) and Univ. Bern
Dochain, Denis	Univ. Catholique de Louvain

This paper proposes a thermodynamics based approach for the boundary control of distributed single phase reactive systems in one spatial dimension. More precisely, this approach is motivated by the so-called thermodynamic availability directly derived from the concavity of the entropy function for homogeneous mixtures. On this basis, a general connection to the boundary control is developed for the case of tubular chemical reactors by selecting an appropriate input-output pair. In this control framework, we shall show that to be (strictly) passive, a necessary and sucient condition for the dissipation that is strongly related to the transport phenomena and chemical reaction has to be fullled. Consequently, a proportional boundary feedback control law globally stabilizes the reactor at a desired stationary prole. For a simple study without convection, the dissipation condition holds thanks to the irreversible entropy production.

ThA3	Room C103

Distributed Parameters and Heterogeneous Systems
(Regular Session)

Chair: Matignon, Denis	ISAE
Co-Chair: Palis, Stefan	Univ. Magdeburg

10:00-10:20	ThA3.1

State Reconstruction of a Model of Microalgae Growth Based on One Continuous-Time and One Discrete-Time Measurements, pp. 395-400

Rehak, Branislav	Inst. of Information Theory and Automation, Acad. ofScienc
Papacek, Stepan	Univ. of South Bohemia

An observer for the reconstruction of the state of the phenomenological two time-scale model of the microalgae growth, so-called photosynthetic factory model formally described as a bilinear system, is designed. Three states of the model form the probability vector and while one of the states is measurable in real time the second is available only in integrated quantities. The observer designed here uses both information channels to increase precision of the reconstruction. The results are demonstrated on simulations.

10:20-10:40	ThA3.2

Moment Matching for Nonlinear Port Hamiltonian and Gradient Systems, pp. 401-405

Ionescu, Tudor Corneliu	Imperial Coll. London
Astolfi, Alessandro	Imperial Col. London & Univ. of Rome Tor Vergata

The problem of moment matching with preservation of port Hamiltonian and gradient structure is studied. Based on the time-domain approach to linear moment matching, we characterize the (subset of) port Hamiltonian/gradient

models from the set of parameterized models that match the moments of a given port Hamiltonian/gradient system, at a set of finite points.

10:40-11:00 ThA3.3

Adaptice Discrepancy Based Control of Continuous Fluidized Bed Spray Granulation with Internal Classification, pp. 406-411

Palis, Stefan	Univ. Magdeburg
Bück, Andreas	Otto von Guericke Univ. Magdeburg
Kienle, Achim	Univ. Magdeburg

This paper is concerned with adaptive stabilization of open loop unstable fluidized bed spray granulation with internal product classification by means of nonlinear feedback control. Since the process model is represented by a nonlinear partial integro-differential equation, direct stabilization of the particle size distribution in a L_p or $L_{\∞}$ norm is difficult. To overcome this problem a stability notion using two generalized distance measures, the discrepancies, is used. It is shown that the adaptive version of the resulting discrepancy based control law is able to cope with uncertainties present in industrial applications.

11:00-11:20 ThA3.4

A Fractional Burgers Equation Arising in Nonlinear Acoustics: Theory and Numerics, pp. 412-417

Le Gorrec, Yann	FEMTO-ST, ENSMM
Lombard, Bruno	Lab. de Mécanique et d'Acoustique, CNRS
Matignon, Denis	ISAE

The study of a fractional Burgers equation arising in nonlinear acoustics is presented. The motivation comes from an elementary model of shock waves in brass wind instruments, that proves useful in musical acoustics. Such a model results from the coupling of a conservative nonlinear system with a dissipative term; here the dissipation is represented by a fractional derivative in time, for which equivalent diffusive representations can be efficiently used: in a first part, strong solutions, weak solutions and energy balances are examined. In a second part, ad hoc numerical schemes are derived, in order to capture all the physical phenomena at stake in the original model, and to get rid, as far as possible, of the spurious numerical effects which are highly undesirable: to this end, conservative schemes for hyperbolic conservation laws, diffusive realizations for the fractional derivatives and integrals, and splitting of the two are being used.

11:20-11:40 ThA3.5

Stabilisation of a Nonlinear Flexible Beam in Port-Hamiltonian Form, pp. 418-423

Macchelli, Alessandro	Univ. of Bologna - Italy

The aim of this paper is to present a simple extension of the theory of linear, distributed, port-Hamiltonian systems to the nonlinear scenario. More precisely, an algebraic nonlinear skew-symmetric term has now been included in the PDE. It is then shown that the system can be equivalently written in terms of the scattering variables, and that these variables are strictly related with the Riemann invariants that appear in quasi-linear hyperbolic PDEs. For this class of PDEs, several results about the existence of solutions, and asymptotic stability of equilibria have already been presented in literature. Here, these results have been extended and applied within the port-Hamiltonian framework, where are suitable of a nice physical interpretation. The final scope is the boundary asymptotic stabilisation of a nonlinear flexible beam with a free-end, and full actuation on the other side.

11:40-12:00 ThA3.6

Analysis of Critical Phenomenon on Gossip Protocol Using Back-Ultradiscritization, pp. 424-429

Ishikawa, Tetsuya	Tokyo Inst. of Tech.
Hayakawa, Tomohisa	Tokyo Inst. of Tech.

Critical probability of a cellular automaton is investigated via a novel approach of back-ultradiscretization. Specifically, back-ultradiscretization of a gossip protocol provides a conservative yet analytical lower bound, which is usually hard to be evaluated in the form of cellular automata. Comparison of theoretical and numerical values are provided for several representative grids to evaluate efficacy of the proposed approach.

ThSPS1 Room A001

Quantum Reservoir Engineering and Single Qubit Cooling (Semi-Plenary Session)

Chair: Sepulchre, Rodolphe J. — Univ. de Liege

13:20-14:20 ThSPS1.1

Quantum Reservoir Engineering and Single Qubit Cooling, pp. 430-435

Mirrahimi, Mazyar	INRIA Rocquencourt
Leghtas, Zaki	INRIA, MINES ParisTech
Vool, Uri	Yale Univ.

Stabilizing a quantum system in a desired state has important implications in quantum information science. In control engineering, stabilization is usually achieved by the use of feedback. The closed-loop control paradigm consists of measuring the system in a non-destructive manner, analyzing in real-time the measurement output to estimate the dynamical state and finally, calculating a feedback law to stabilize the desired state. However, the rather short dynamical time-scales of most quantum systems impose important limitations on the complexity of real-time output signal analysis and retroaction. An alternative control approach for quantum state stabilization, bypassing a real-time analysis of output signal, is called reservoir engineering.

In this paper, we start with a general description of quantum reservoir engineering. We then apply this method to stabilize the ground state (lowest energy state) of a single two-level quantum system. Applying the averaging theorem and some simple Lyapunov techniques, we prove the convergence of our proposed scheme. This scheme has recently been successfully implemented on a superconducting qubit and has led to a fast and reliable reset protocol for these qubits.

ThSPS2 Room A002

Recursive RANSAC: Multiple Signal Estimation with

Outliers (Semi-Plenary Session)

Chair: Allgower, Frank — Univ. of Stuttgart

13:20-14:20 — ThSPS2.1

Recursive RANSAC: Multiple Signal Estimation with Outliers, pp. 436-441

Niedfeldt, Peter — BYU
Beard, Randy — Brigham Young Univ.

The random sample consensus (RANSAC) algorithm is frequently used in computer vision to estimate the parameters of a signal in the presence of noisy and even spurious observations called gross errors. Instead of just one signal, we desire to estimate the parameters of multiple signals, where at each time step a set of observations of generated from the underlying signals and gross errors are received. In this paper, we develop the recursive RANSAC (RRANSAC) algorithm to solve the inherent data association problem and recursively estimate the parameters of multiple signals without prior knowledge of the number of true signals. We compare the performance of RRANSAC with several existing algorithms, and also demonstrate the capabilities of RRANSAC in an aerial geolocation problem.

ThB1 — Room C101

Observer Design (Regular Session)

Chair: Kang, Wei — Naval Postgraduate School

Co-Chair: Andrieu, Vincent — Univ. de Lyon1

14:30-14:50 — ThB1.1

A Note on Observability Canonical Forms for Nonlinear Systems, pp. 442-444

Astolfi, Daniele — Univ. of Bologna
Praly, Laurent — Ec. des Mines
Marconi, Lorenzo — Univ. di Bologna

For nonlinear systems affine in the input with state x in R^n, input u in R and output y in R, it is a well-known fact that, if the function mapping (x, u, ..., u^(n-1)) into (u, ..., u^(n-1),y, ..., y^(n-1)) is an injective immersion, then the system can be locally transformed into an observability normal form with a triangular structure appropriate for a high-gain observer. In this technical note we extend this result to the case of systems not necessarily affine in the input and such that the injectivity condition holds for the function mapping (x, u, ..., u^(p-1)) into (u, ..., u^(p-1),y, ..., y^(p-1)) with p >= n. The forced uncertain harmonic oscillator is taken as elementary example to illustrate the theory.

14:50-15:10 — ThB1.2

Continuous Discrete Observer with Updated Sampling Period, pp. 445-450

Andrieu, Vincent — Univ. de Lyon1
Nadri, Madiha — Univ. Claude Bernard Lyon 1
Serres, Ulysse — Univ. of Lyon 1
Vivalda, Jean-Claude — INRIA Nancy Grand Est & Univ. de Lorraine

This paper deals with the design of high gain observers for a class of continuous dynamical systems with discrete-time measurements. Indeed, different approaches based on high gain techniques have been followed in the literature to tackle this problem. Contrary to these works, the measurement sampling time is considered to be variable. Moreover, the new idea of the proposed work is to synthesize an observer requiring the less knowledge as possible from the output measurements. This is done by using an updated sampling time observer. Under the global Lipschitz assumption, the asymptotic convergence of the observation error is established. As an application of this approach, an estimation problem of state of an academic bioprocess is studied, and its simulation results are discussed.

15:10-15:30 — ThB1.3

Partial Observability and Its Consistency for Linear PDEs, pp. 451-456

Kang, Wei — Naval Postgraduate School
Xu, Liang — Naval Res. Lab.

In this paper, a quantitative measure of partial observability is definition for PDEs. The quantity is proved to be consistent in well-posed approximation schemes. A first order approximation of an unobservability index using empirical gramian is introduced. For linear systems with full state observability, the empirical gramian is equivalent to the observability gramian in control theory. The consistency theorem is exemplified using a Burgers' equation.

15:30-15:50 — ThB1.4

Interval State Estimation for Uncertain Nonlinear Systems, pp. 457-462

Zheng, Gang — INRIA Lille-Nord Europe
Efimov, Denis — INRIA - LNE
Perruquetti, Wilfrid — Ec. Centrale de Lille

The objective of this work is to develop some design methods of interval observers for a class of nonlinear continuous-time systems. It is assumed that the estimated system can be represented as a superposition of the nominal subsystem (belonged to the class of uniformly observable systems) and a Lipschitz nonlinear perturbation vanishing at the origin. Then it is shown there exists an interval observer for the system that estimates the set of admissible values for the state consistent with the output measurements. An example of the observer application is given with computer simulation results.

15:50-16:10 — ThB1.5

On the Existence of Unknown Input Observers for State Affine Systems up to Output Injection, pp. 463-468

Sahnoun, Mariem — Univ. Claude Bernard Lyon 1
Hammouri, Hassan — Univ. Claude Bernard

In this paper, the design of an unknown input observer is considered. The main contribution consists in the obtention of a sufficient condition to design an observer which estimates a part of the state independently of the knowledge of some inputs. Based on the geometric appraoch, a sufficient condition for the existence of an unknown input observer for state affine systems up to output injection is given. This approach is illustrated in a numerical example.

ThB2	Room C102
Vehicles Control and Mechatronics (Regular Session)	

Chair: Boehme, Thomas Juergen — iav automotive engineering
Co-Chair: Jauberthie, Carine — LAAS-CNRS

14:30-14:50 ThB2.1

Optimal Control with Input Constraints Applied to Internal Combustion Engine Test Benches, pp. 469-474

Passenbrunner, Thomas Ernst — Johannes Kepler Univ. Linz
Sassano, Mario — Imperial Coll. London
del Re, Luigi — Johannes Kepler Univ.

Optimal control of nonlinear systems provides a major challenge in control engineering. Constraints on the input signals are common to many real-world applications and render the problem to be tackled even more complicated. This paper proposes a method to map the input constraints by nonlinear functions to the state equations of the system, afterwards an approximation of the solution of the resulting optimization problem is calculated by means of a dynamic extension to the state of the system. The approach is applied in the control of test benches for internal combustion engines, where speed and torque references need to be tracked at the crankshaft of the engine. Simulation results using a high-quality simulator, also regarding effects that have not been included in the model for controller design, show the performance of the proposed approach.

14:50-15:10 ThB2.2

Optimal Input Design for a Nonlinear Dynamical Uncertain Aerospace System, pp. 475-480

Jauberthie, Carine — LAAS-CNRS
Chanthery, Elodie — Univ. of Toulouse, INSA

An optimal input design technique for aircraft uncertain parameter estimation is presented in this paper. The original idea is the combining of a dynamic programming method and interval analysis for the optimal input synthesis. This approach does not imply the estimation of a nominal value for parameter and allows to include realistic practical constraints on the input and output variables. The precise description of the approach is followed by an application in aerospace sciences.

15:10-15:30 ThB2.3

Calibration of Parallel Hybrid Vehicles Based on Hybrid Optimal Control Theory, pp. 481-486

Schori, Markus — Univ. of Rostock
Boehme, Thomas Juergen — iav automotive engineering
Frank, Benjamin — IAV GmbH
Schultalbers, Matthias — IAV GmbH, Ingenieurgesellschaft Auto und Verkehr

Most energy management systems for hybrid electric vehicles rely on information stored in lookup tables, to define the current mode of operation under certain circumstances. In this paper it is demonstrated how the theory of hybrid optimal control can be used to calculate an initial parameter set for the calibration of parallel hybrid electric vehicles. After solving a hybrid optimal control problem for the fuel optimal operation of the vehicle, taking into account continuous as well as discrete dynamics, the results can be used to automatically calculate lookup-tables for optimal gear shifts, optimal torque-split between motor/generator and internal combustion engine and the determination of the drive mode (electric or hybrid mode). The algorithms proposed are easy in their application and can be used for other hybrid vehicle configurations as well and therefore constitute a valuable tool for the initial calibration.

15:30-15:50 ThB2.4

A New Extension of the L1 Adaptive Controller to Drastically Reduce the Tracking Time Lags, pp. 487-492

Maalouf, Divine — LIRMM
Chemori, Ahmed — UM2
creuze, vincent — CNRS / Univ. Montpellier II

The L1 adaptive control scheme has proven its effectiveness and robustness in various fields thanks to its particular architecture where robustness and adaptation are decoupled. It was though noted that whenever the trajectory is varying, an inherent lag is present compared to other adaptive schemes due to the presence of a filter in the control architecture. To achieve a better tracking, we propose extending the architecture of the L1 controller by augmenting it with a control input that could take the form of a nonlinear proportional or a proportional integral term. The extended scheme is validated through simulations via an illustrative example as well as experimental results performed on an underwater vehicle.

15:50-16:10 ThB2.5

Flatness Based Control of a Gantry Crane, pp. 493-498

Kolar, Bernd — Johannes Kepler Univ. Linz
Schlacher, Kurt — Johannes Kepler Univ. Linz

This contribution deals with flatness based control of a laboratory model of a gantry crane. The mechanical model has 3DOFs, where a trolley can be moved on a rail, the load is fixed at the end of a rope and can be lifted or lowered by coiling or uncoiling this rope on a cylinder. Under the assumption that the rope is always stretched, the underactuated system is not input to state linearisable but it is flat with the coordinates of the load as flat output. Since the flat output coincides with the variables to be controlled, a flatness based design for trajectory tracking and stabilisation is indicated. The design of the tracking control is accomplished in two steps. First, the system is exactly linearised by a quasi-static state feedback. Subsequently, for the linear system a feedback with integral parts is designed such that the motion of the load is stabilised about the reference trajectories. Moreover, the control law is extended by terms which approximately compensate for the friction occurring at the gantry crane. Finally, the setting of the controller parameters is discussed and measurement results are presented, which demonstrate an excellent tracking behaviour and disturbance attenuation.

ThB3	Room C103
Geometric and Algebraic Methods (Regular Session)	
Chair: Sekiguchi, Kazuma	Tokyo City Univ.
Co-Chair: Respondek, Witold	Inst. National des Sciences Appliquees

14:30-14:50 ThB3.1

Flatness of Two-Input Control-Affine Systems Linearizable Via One-Fold Prolongation, pp. 499-504

Nicolau, Florentina — INSA - Rouen
Respondek, Witold — INSA - Rouen

We study flatness of two-input control-affine systems, defined on an n-dimensional state-space. We give a complete geometric characterization of systems that become static feedback linearizable after a one-fold prolongation of a suitably chosen control. They form a particular class of flat systems: they are of differential weight n+3. We provide a system of first order PDE's to be solved in order to find all minimal flat outputs. We illustrate our results by two examples: the induction motor and the polymerization reactor.

14:50-15:10 ThB3.2

Covariant Differentiation of a Map in the Context of Geometric Optimal Control, pp. 505-511

Saccon, Alessandro — Eindhoven Univ. of Tech.
Hauser, John — Univ. of Colorado at Boulder
Aguiar, A. Pedro — Faculty of Engineering, Univ. of Porto (FEUP)

This paper provides a detailed discussion of the second covariant derivative of a map and its role in the Lie group projection operator approach (a direct method for solving continuous time optimal control problems).

We begin by briefly describing the iterative geometric optimal control algorithm and summarize the general expressions involved. Particular emphasis is placed on the expressions related to the search direction subproblem, writing them in a new compact form by using a new operator notation.

Next, we show that the covariant derivative of a map between manifolds endowed with affine connections plays a key role in obtaining the required local quadratic approximations for the Lie group projection operator approach.

We present a new result for computing an approximation of the parallel displacement associated with an affine connection which is an affine combination of two (or more) connections. As a corollary, an extremely useful approximation of the parallel displacement relative to the Cartan-Schouten (0) connection on Lie groups is obtained.

15:10-15:30 ThB3.3

Feedback Classification of Invariant Control Systems on Three-Dimensional Lie Groups, pp. 512-517

Biggs, Rory — Rhodes Univ.
Remsing, Claudiu C. — Rhodes Univ.

We consider left-invariant control affine systems evolving on Lie groups. In this context, feedback equivalence specializes to detached feedback equivalence. We characterize (local) detached feedback equivalence in a simple algebraic manner. We then classify all (full-rank) systems evolving on three-dimensional Lie groups. A representative is identified for each equivalence class. Systems on the Heisenberg group, the Euclidean group, and orthogonal group are treated in full, as typical examples. In these three cases, simple algebraic characterizations of the equivalence classes are also exhibited. A few remarks conclude the paper.

15:30-15:50 ThB3.4

When Is a Lagrangian Control System with Virtual Holonomic Constraints Lagrangian?, pp. 518-523

Mohammadi, Alireza — Univ. of Toronto
Maggiore, Manfredi — Univ. of Toronto
Consolini, Luca — Univ. of Parma

This paper investigates a class of Lagrangian control systems with n degrees-of-freedom (DOF) and $n-1$ actuators, assuming that $n-1$ virtual holonomic constraints have been enforced via feedback, and a basic regularity condition holds. The reduced dynamics of such systems are described by a second-order unforced differential equation. We present necessary and sufficient conditions under which the reduced dynamics are those of a mechanical system with one DOF and, more generally, under which they have a Lagrangian structure.

15:50-16:10 ThB3.5

The Minimal Time-Varying Realization of a Nonlinear Time-Invariant System, pp. 524-529

Kotta, Ülle — Inst. of Cybernetics at TUT
Moog, Claude — CNRS
Tõnso, Maris — Inst. of Cybernetics at Tallinn Univ. ofTechnology

The state realization is called minimal if it is either accessible and observable or its state dimension is minimal. In the linear case those two definitions are equivalent, but not for nonlinear time-invariant systems. It is shown that definitions remain equivalent in case one is searching for minimal realization in a larger class of nonlinear time-varying systems. First, nonlinear realization theory is recasted for time-varying nonlinear systems. A necessary and sufficient realizability condition is given in terms of integrability of certain subspace. The mathematical tools used for this purpose are the algebraic approach of differential forms and the theory of the skew polynomial rings; these tools are again extended from time-invariant to time-varying systems.

16:10-16:30 ThB3.6

On Multi Time-Scale Form of Nonlinear Systems, pp. 530-535

Sekiguchi, Kazuma — Tokyo City Univ.
Sampei, Mitsuji — Tokyo Inst. of Tech.

In general, controller is designed with respect to one time scale. Time-state control form divides a system into virtual time control part and state control part, and the system is linearized based on two time scales; real and virtual time scales. This paper claims that handling of time scales for a control system should be more flexible, and introduces a multi time-scale transformation as a generalization of time

scale transformation. As an example, a mechanical system is linearized under two virtual time scales.

ThC1	Room C101
Invariant Sets for Systems (Regular Session)	
Chair: Colonius, Fritz	Univ. of Augsburg
Co-Chair: Heath, William Paul	Univ. of Manchester

17:00-17:20 ThC1.1

Controllability Properties in Safe Regions, pp. 536-539

Colonius, Fritz — Univ. of Augsburg

For nonlinear control systems in discrete time, the global controllability structure within a safe region of the state space is analyzed. The main results characterize those safe regions, where every point can be steered into a relatively invariant subset of complete approximate controllability. Furthermore, for parameter dependent systems, loss of invariance is analyzed.

17:20-17:40 ThC1.2

Inner Approximations of the Region of Attraction for Polynomial Dynamical Systems, pp. 540-545

Korda, Milan — École Pol. fédérale de Lausanne

Henrion, Didier — LAAS-CNRS, Univ. Toulouse

Jones, Colin, N — Ec. Pol. Federale de Lausanne (EPFL)

In a previous work we developed a convex infinite dimensional linear programming (LP) approach to approximating the region of attraction (ROA) of polynomial dynamical systems subject to compact basic semialgebraic state constraints. Finite dimensional relaxations to the infinite-dimensional LP lead to a truncated moment problem in the primal and a polynomial sum-of-squares problem in the dual. This primal-dual linear matrix inequality (LMI) problem can be solved numerically with standard semidefinite programming solvers, producing a hierarchy of outer (i.e. exterior) approximations of the ROA by polynomial sublevel sets, with a guarantee of almost uniform and set-wise convergence. In this companion paper, we show that our approach is flexible enough to be modified so as to generate a hierarchy of polynomial inner (i.e., interior) approximations of the ROA with similar convergence guarantees.

17:40-18:00 ThC1.3

Saddle Point Seeking for Convex Optimization Problems, pp. 546-551

Dürr, Hans-Bernd — Univ. of Stuttgart

Zeng, Chen — Univ. of Stuttgart

Ebenbauer, Christian — Stuttgart Univ.

In this paper, we consider convex optimization problems with constraints. By combining the idea of a Lie bracket approximation for extremum seeking systems and saddle point algorithms, we propose a feedback which steers a single-integrator system to the set of saddle point of the Lagrangian associated to the convex optimization problem. We prove practical uniform asymptotic stability of the set of saddle points for the extremum seeking system for strictly convex as well as linear programs. Using a numerical example we illustrate how the approach can be used in distributed optimization problems.

18:00-18:20 ThC1.4

Convex Synthesis of Multivariable Static Discrete-Time Anti-Windup Via the Jury-Lee Criterion, pp. 552-557

Ahmad, Nur Syazreen — Univ. Sains Malaysia

Heath, William Paul — Univ. of Manchester

Due to its ease of application, the circle criterion has been widely used to guarantee the stability of many anti-windup schemes. While the Popov criterion gives less conservative results, it has been conjectured in the literature that it cannot be used for convex anti-windup synthesis. This paper shows that the conjecture does not necessarily apply in the discrete-time setting. We show how the search for optimal parameters corresponding to the Jury-Lee criterion (a discrete counterpart of the Popov criterion) can be formulated as a convex search via a linear matrix inequality (LMI). The result is then extended to two existing multivariable static anti-windup schemes with stable open-loop plants. Two numerical examples of multivariable anti-windup controller synthesis are provided, and it is shown that in both cases the synthesis using the Jury-Lee criterion can allow better performance than existing methods which use the circle criterion alone.

18:20-18:40 ThC1.5

Positive Definiteness of Generalized Homogeneous Functions, pp. 558-563

Nakamura, Hisakazu — Tokyo Univ. of Science

To identify positive definiteness of functions are important in control theory. However, there does not exist a method to identify the positive definiteness of homogeneous systems with dilation. In this paper, we consider Lipschitz continuous homogeneous functions with dilations. For the functions, we propose a new method to identify the positive definiteness of the functions. Moreover, we apply our proposed method to an optimal homogeneous finite-time control problem. We confirm the effectiveness of the proposed method through the example.

ThC2	Room C102
Reliable Methods for Control, State Estimation and Parameter Identification of Uncertain Dynamic Systems II (Invited Session)	
Chair: Ramdani, Nacim	Univ. d'Orléans
Co-Chair: Rauh, Andreas	Univ. of Rostock
Organizer: Rauh, Andreas	Univ. of Rostock
Organizer: Ramdani, Nacim	Univ. d'Orléans

17:00-17:20 ThC2.1

Uses of GPU Powered Interval Optimization for Parameter Identification in the Context of SO Fuel Cells (I), pp. 564-569

Kiel, Stefan — Univ. of Duisburg-Essen

Auer, Ekaterina — Univ. of Duisburg-Essen

Rauh, Andreas — Univ. of Rostock

In this paper, we discuss parameter identification for models based on ordinary differential equations in the context of solid oxide fuel cells. In this case, verified methods (e.g. interval analysis), which provide a guarantee of correctness for the computed result, can be of great help for dealing with the appearing uncertainty and for devising accurate control strategies. Moreover, interval arithmetic can be used to discard infeasible areas of parameter space in a natural way and so to improve the results of traditional numerical algorithms. We describe a simulation environment interfacing different verified and floating point based approaches and show how the interchangeability between different techniques enhances parameter identification. Additionally, we give details on possible parallelization of our version of the global interval optimization algorithm on the CPU and the GPU. The applicability of the method and the features of the environment are demonstrated with the help of different fuel cell models.

17:20-17:40 ThC2.2

Optimization-Based Domain Reduction in Guaranteed Parameter Estimation of Nonlinear Dynamic Systems (I), pp. 570-575

Paulen, Radoslav — Tech. Univ. Dortmund.
Villanueva, Mario E. — Imperial Coll. London
Chachuat, Benoit — Imperial Coll. London

This paper is concerned with guaranteed parameter estimation in nonlinear dynamic systems in a context of bounded measurement error. The problem consists of finding -- or approximating as closely as possible -- the set of all possible parameter values such that the predicted outputs match the corresponding measurements within prescribed error bounds. An exhaustive search procedure is applied, whereby the parameter set is successively partitioned into smaller boxes and exclusion tests are performed to eliminate some of these boxes, until a prespecified threshold on the approximation level is met. In order to enhance the convergence of this procedure, we investigate the use of optimization-based domain reduction techniques for tightening the parameter boxes before partitioning. We construct such bound-reduction problems as linear programs from the polyhedral relaxation of Taylor models of the predicted outputs. When applied to a simple case study, the proposed approach is found to reduce the computational burden significantly, both in terms of CPU time and number of iterations.

17:40-18:00 ThC2.3

Verified Stability Analysis for Interval-Based Sliding Mode and Predictive Control Procedures with Applications to High-Temperature Fuel Cell Systems (I), pp. 576-581

Rauh, Andreas — Univ. of Rostock
Senkel, Luise — Univ. of Rostock, Chair of Mechatronics
Kersten, Julia — Univ. of Rostock, Chair of Mechatronics
Aschemann, Harald — Univ. of Rostock

In previous work, control-oriented models have been derived for solid oxide high-temperature fuel cell systems. In these models, interval variables have been used to describe uncertainty due to a limited knowledge about system parameters and to handle effects of electric load variations on the temperature distribution in the fuel cell stack module as well as bounded measurement uncertainty. To deal with these types of uncertainty both in the design of robust controllers and during their online usage, interval techniques can be employed successfully. These control procedures make use of the basic principles of either sliding mode control or predictive control. The corresponding algorithms and the prerequisites for their real-time capable implementation using software libraries for interval arithmetic and algorithmic differentiation are described in this paper. Experimental results show the efficiency of these control laws for a fuel cell test rig that is available at the Chair of Mechatronics at the University of Rostock.

18:00-18:20 ThC2.4

Lyapunov Function Synthesis Using Handelman Representations (I), pp. 582-587

Sankaranarayanan, Sriram — Univ. of Colorado
Chen, Xin — RWTH Aachen Univ.
Abraham, Erika — RWTH Aachen Univ.

We investigate linear programming relaxations to synthesize Lyapunov functions that establish the stability of a given system over a bounded region. In particular, we attempt to discover functions that are more readily useful inside symbolic verification tools for proving the correctness of control systems. Our approach searches for a Lyapunov function, given a parametric form with unknown coefficients, by constructing a system of linear inequality constraints over the unknown parameters. We examine two complementary ideas for the linear programming relaxation, including interval evaluation of the polynomial form and "Handelman representations" for positive polynomials over polyhedral sets.

Our approach is implemented as part of a branch-and-relax scheme for discovering Lyapunov functions. We evaluate our approach using a prototype implementation, comparing it with techniques based on Sum-of-Squares (SOS) programming. A comparison with SOSTOOLS is carried out over a set of benchmarks gathered from the related work. The evaluation suggests that our approach using Simplex is generally fast, and discovers Lyapunov functions that are simpler and easy to check. They are suitable for use inside symbolic formal verification tools for reasoning about continuous systems.

18:20-18:40 ThC2.5

Control of Nonlinear Systems Using Multiple Model Black-Box Identification, pp. 588-593

Kolyubin, Sergey — St. Petersburg NRU ITMO
Efimov, Denis — INRIA - LNE
Nikiforov, Vladimir O. — St. State Univ. of Information Tech. Mechanicsand Optics
Bobtsov, Alexey — Sainr Petersburg National Res. Univ. of ITMO

The paper is devoted to development of control algorithms for nonlinear parametrically uncertain systems. Original system dynamics is approximated by a set of local NARX models combined by a special mixing rule. Algorithm for local models' parameters estimation and structure adjustment has been developed. Proposed approach

allows straightforward designing of the combined feedforward/feedback controller.

ThC3	Room C103
Algebraic Methods (Regular Session)	
Chair: Bacciotti, Andrea	Pol. Di Torino
Co-Chair: Kotta, Ülle	Inst. of Cybernetics at TUT

17:00-17:20 ThC3.1

On Flatness of Discrete-Time Nonlinear Systems, pp. 594-599

Kaldmäe, Arvo — Inst. of Cybernetics at TUT
Kotta, Ülle — Inst. of Cybernetics at TUT

The paper addresses the problem of dynamic feedback linearization of discrete-time nonlinear control systems. Analogously to the continuous-time case, necessary and sufficient conditions for flatness property are obtained and showed to be equivalent to previously known results on feedback linearizability by endogenous dynamic feedback. An example is added to illustrate the results.

17:20-17:40 ThC3.2

Learning Time Optimal Control of Smart Actuators with Unknown Friction, pp. 600-605

Trogmann, Hannes — Johannes Kepler Univ. Linz
Colaneri, Patrizio — Pol. di Milano
del Re, Luigi — Johannes Kepler Univ.

Active valves are most effective tools to control gas flow in compressors if fast transitions between the open mode and closed mode are needed. Unfortunately, an accurate model including several nonlinear effects and in particular the resistance and gas flow forces is not available, and this prevents the use of standard model based approaches for time optimal control. However, the repetitive nature of the operation of valves suggests the use of learning methods to track a reference in spite of the insufficient information on the control behavior, thus shifting the problem from the search of the time optimal control to the search of the reference corresponding to its solution. To this end, in this paper, a previously proposed algorithm for the iterative determination of the fastest feasible trajectory is analyzed in terms of convergence conditions and applied to the valve model.

17:40-18:00 ThC3.3

Definition of Eigenvalues for a Nonlinear System, pp. 606-611

Halas, Miroslav — Slovak Univ. of Tech.
Moog, Claude — CNRS

In this paper the concept of eigenvalues and eigenvectors of nonlinear systems, both continuous- and discrete-time, is suggested. It represents a generalization of the concept known from linear control theory. Some basic properties, like invariance of eigenvalues under a (nonlinear) change of coordinates, possibility to transform the system to the diagonal form and, respectively, to the feedforward form are then shown.

18:00-18:20 ThC3.4

Observability Analysis of Nonlinear Systems Using Pseudo-Linear Transformation, pp. 612-617

Kawano, Yu — Osaka Univ.
Ohtsuka, Toshiyuki — Osaka Univ.

In the linear control theory, the observability Popov-Belevitch-Hautus (PBH) test plays an important role in studying observability along with the observability rank condition and observability Gramian. The observability rank condition and observability Gramian have been extended to nonlinear systems and have found applications in the analysis of nonlinear systems. On the other hand, there is no observability criterion for nonlinear systems corresponding to the PBH test. In this study, we generalize the observability PBH test for nonlinear systems using pseudo-linear transformation.

18:20-18:40 ThC3.5

A Remark about Linear Switched Systems in the Plane, pp. 618-622

Bacciotti, Andrea — Pol. Di Torino

In this note we prove that if a switched system ${cal F}$ formed by a pair of linear vector fields of R^2 is asymptotically controllable, then the discrete time operator associated to ${cal F}$ admits at least one real eigenvalue $lambda$, with $|lambda|<1$. For the particular case at hand, this is an improvement of previous existing results.

FrPL1	Rooms A001/A002
Observers for Kinematic Systems with Symmetry (Plenary Session)	
Chair: Marconi, Lorenzo	Univ. di Bologna

09:00-10:00 FrPL1.1

Observers for Kinematic Systems with Symmetry, pp. 623-639

Mahony, Robert — Australian National Univ.
Trumpf, Jochen — The Australian National Univ.
Hamel, Tarek — Univ. de Nice Sophia Antipolis

This paper considers the design of nonlinear state observers for finite-dimensional equivariant kinematics of mechanical systems. The observer design problem is approached by lifting the system kinematics onto the symmetry group and designing an observer for the lifted system. Two particular classes of lifted systems are identified, which we term type I and type II systems, that correspond to common configurations of sensor suites for mobile robotics applications. We consider type I systems in detail and define an error signal on the symmetry group using the group structure. We propose an observer structure with a pre-observer or internal model augmented by an equivariant innovation term that leads to autonomous error evolution. A control Lyapunov function construction is used to design the observer innovation that both ensures the required equivariance, and leads to strong convergence properties of the observer error dynamics.

FrA1	Room C101
Robustness and Performance (Regular Session)	
Chair: Biannic, Jean-Marc	ONERA
Co-Chair: Georges, Didier	Grenoble Inst. of Tech. - ENSE3

10:30-10:50 FrA1.1

H-Infinity Filter Design for Nonlinear Quadratic Systems, pp. 640-645

Lacerda, Márcio J. — Univ. of Campinas
Tarbouriech, Sophie — LAAS-CNRS
Garcia, Germain — LAAS-CNRS
Peres, Pedro L. D. — Univ. of Campinas

This paper is concerned with the problem of H-infinity filtering for continuous-time nonlinear quadratic systems. The aim is to design a full order dynamic filter that can also contain quadratic terms. The strategy relies on the use of a quadratic Lyapunov function and an inequality condition that assures an H-infinity performance bound for the augmented quadratic system, composed by the original system and the filter to be designed, in a regional (local) context. Then, by using the Finsler's lemma, an enlarged parameter space is created, where the Lyapunov matrix appears separated from the system matrices. Imposing structural constraints to the decision variables, theoretical conditions, which can be treated as linear matrix inequality conditions by fixing a grid on a scalar parameter, can be derived for the filter design. As illustrated by numerical experiments, the proposed conditions can improve the H-infinity performance provided by linear filters by including the quadratic terms in the filter dynamics.

10:50-11:10 FrA1.2

Limit-Cycles Prevention Via Multiple Hinfinity Constraints with an Application to Anti-Windup Design, pp. 646-651

Biannic, Jean-Marc — ONERA

Rate and magnitude control limitations are often responsible for the apparition of undesired limit cycles in the resulting nonlinear closed-loop system. Based on the well-known describing function approach, it is shown in this paper that such limit cycles can be avoided as soon as multiple Hinfinity constraints are simultaneously satisfied by appropriately chosen linear interconnections. This result is then used to design anti-windup compensators.

11:10-11:30 FrA1.3

Energy-Peak Evaluation of Nonlinear Control Systems under Neglected Dynamics, pp. 652-657

Leite, Valter J. S. — CEFET/MG - Campus Div.
Tarbouriech, Sophie — LAAS-CNRS
Garcia, Germain — LAAS-CNRS

The main objective in this paper is to investigate the robust performance degradation for a class of nonlinear systems due to some dynamics that are not taken into account during the controller design stage. This is usually the case in practical applications where a simplified (nonlinear) model is used to design the controller. Therefore, it is expected some performance degradation in the application of such a controller due to the presence of the neglected dynamics. With this purpose, some convex conditions for stability analysis and energy-peak evaluation of nonlinear control systems are given. It is supposed that the nonlinear functions present in the model are subject to bounded uncertainties and that both the simplified model and the neglected dynamics model are affected by polytopic uncertainties. The theoretical conditions providing stability and energy-peak bound on the regulated output of the system despite the presence of uncertainties associated with the nonlinear functions are obtained by means of a parameter dependent Lyapunov function. The proposal is illustrated by numerical examples.

11:30-11:50 FrA1.4

Locally Optimal Controllers for Some Nonlinear Systems, pp. 658-663

Benachour, Sofiane — LAGEP, Univ. de Lyon
Andrieu, Vincent — Univ. de Lyon1

In this paper we consider the problem of global asymptotic stabilization with prescribed local behavior. We show that this problem can formulated in terms of control Lyapunov functions. Moreover, we show that if the local control law has been synthesized employing a LQ approach, then the associated Lyapunov function can be seen has the value function of an optimal problem with some specific properties. We illustrate these result on two specific classes of systems: backstepping and feedforward systems. Finally, we show how this framework can be employed when considering an orbital transfer problem.

11:50-12:10 FrA1.5

Nonlinear Robust and Optimal Control Via Proper

Orthogonal Decomposition, pp. 664-669

Georges, Didier — Grenoble Inst. of Tech. - ENSE3

In this paper, a methodology based on proper orthogonal decomposition (POD) for computing approximate closed-loop optimal or robust control laws for finite-dimensional nonlinear systems is proposed. The solution can be obtained on any arbitrary domain of the state space represented by a multidimensional grid. The method only requires the computation of a limited number of well-conditioned two-point boundary value problems and a simple backwards integration of a reduced model of the Hamilton-Jacobi-Bellman or Hamilton-Jacobi- Isaacs equation associated to the control problem. Two illustrative examples demonstrate the effectiveness of the approach.

FrA2	Room C102
Observer and Applications (Regular Session)	

Chair: Besancon, Gildas — Ense3, Grenoble INP

Co-Chair: Aranda-Bricaire, Eduardo — CINVESTAV

10:30-10:50 — FrA2.1

Input Selection in Observer Design for Non-Uniformly Observable Systems, pp. 670-675

Besancon, Gildas — Ense3, Grenoble INP

Rubio Scola, Ignacio — Control Systems Department, Gipsa-Lab.

Georges, Didier — Grenoble Inst. of Tech. - ENSE3

In this paper the problem of inputs in observer design for systems which are not uniformly observable is considered. It is emphasized how it amounts to a control problem, which can be solved in a general way by some appropriate optimization approach. This is illustrated on the basis of a quite general Kalman-like observer form - possibly with high gain, as well as related simulation results on an application example.

10:50-11:10 — FrA2.2

Nonlinear Observer Normal Form with Output Injection and Extended Dynamic, pp. 676-681

Tami, Ramdane — ENSI de Bourge

Boutat, Driss — Ensi de Bourges

Zheng, Gang — INRIA Lille-Nord Europe

This paper presents a new extended output depending nonlinear observer normal form. A sufficient geometrical conditions that guarantee a change of coordinates allowing the transformation of a given nonlinear dynamical system into the proposed observer form are given. Throughout this work, it will be showed that, unlike to the existing observer normal forms, this new form enables to design an observer for the Susceptible, Exposed, Infected, and Recovered (SEIR) model of population under an infectious disease.

11:10-11:30 — FrA2.3

Trajectory Tracking for a Group of Unicycle-Type Robots Using an Attitude Observer, pp. 682-687

González-Sierra, Jaime — CINVESTAV

Aranda-Bricaire, Eduardo — CINVESTAV

Rodriguez-Cortes, Hugo — Northeastern Univ.

Santiaguillo-Salinas, Jesús — CINVESTAV

The trajectory tracking problem for a group of unicycle-type robots is addressed and solved by means of a partial state feedback strategy based on the leader-followers scheme using an observer to estimate the orientation angle of each mobile robot. The control law is based on an extended kinematic model where the output function to be controlled is the mid-point of the wheels axis of each robot. This choice leads to an ill defined control law when the robot is at rest. To avoid such a singularity, a complementary control law is enabled when the linear velocity of each robot is close to zero. It is shown that the combination of a classical dynamic full information controller with an exponentially convergent vehicle attitude observer yields an asymptotically stable closed-loop system. Real-time experiments show the performance of the proposed control scheme.

11:30-11:50 — FrA2.4

Nonlinear Observer Normal Forms for Some Predator-Prey Models, pp. 688-693

Boutat, Driss — Ensi de Bourges

Saif, Mehrdad — Simon Fraser Univ.

This paper considers the nonlinear observer normal forms and their application in an ecological Predator-Prey system. These forms allow for the design of robust observers for Predator-Prey models where full measurement is not available. Thus, from a measured population of one specie (prey or predator), one can estimate the population that is not directly measured.

11:50-12:10 — FrA2.5

Approximation of Reachability Sets for Nonlinear Unicycle Control System Using the Comparison Principle, pp. 694-698

Sinyakov, Vladimir — Moscow M.V. Lomonosov State Univ.

Roublev, Ilya — Moscow M.V.Lomonosov State Univ.

In this paper the application of the comparison principle for Hamilton-Jacobi equations to a particular nonlinear control system is discussed. Two classes of approximations of the reachability sets for this system are constructed. Numerical examples of the reachability set approximations and the solutions to control synthesis problem are given to illustrate the proposed approach.

FrA3	Room C103
Delay Systems (Regular Session)	

Chair: Baras, John S. — Univ. of Maryland

Co-Chair: Hetel, Laurentiu — CNRS

10:30-10:50 — FrA3.1

The Popov Criterion for Consensus between Delayed Agents, pp. 699-704

Proskurnikov, Anton — St.-Petersburg State Univ.

We consider consensus algorithms for multi-agent

networks with high-order and delayed dynamics of agents. The topology is assumed to be fixed and undirected, however the couplings may be nonlinear and uncertain, we assume only the symmetry condition to be valid. We obtain conditions of stability for such algorithms that are similar in spirit to the celebrated Popov criterion for the stability of Lurie systems.

10:50-11:10 FrA3.2

Prediction of Partially Synchronous Regimes of Delay-Coupled Nonlinear Oscillators, pp. 705-710

Unal, Hakki Ulas — Anadolu Univ.
Michiels, Wim — K.U. Leuven

We present an approach which allows to accurately predict both the occurrence and type of partially synchronous regimes of delay-coupled non-linear oscillators. Unlike the conventional approach, we build on an analysis of the stability properties of the synchronized equilibrium in the (coupling gain, delay) parameter space. As partially synchronous regimes are closely related to the presence of invariant manifolds, we first present necessary and sufficient conditions for the existence of forward invariant sets. Next, from the existence of these invariant sets and from the characterization of solutions in the unstable manifold of the synchronized equilibrium, we predict which (gain,delay) parameters may result in fully/partially synchronous behavior. We illustrate the approach by means of a network of delay coupled Hindmarsh-Rose neurons.

11:10-11:30 FrA3.3

On the Convergence Rate of Non-Linear Consensus Networks with Delays, pp. 711-716

Somarakis, Christoforos — Univ. of Maryland, Coll. Park
Baras, John S. — Univ. of Maryland

We consider a generic non-linear consensus model and prove convergence results to a common value together with prescribed rate of convergence. Instead of a Lyapunov approach, we consider a functional metric space and make a Fixed point theory argument using contraction mappings. We are restricted to the case of static networks.

11:30-11:50 FrA3.4

Sampled-Data Control of LTI Systems with Relays: A Convex Optimization Approach, pp. 717-722

Hetel, Laurentiu — CNRS
Fridman, Emilia — Tel-Aviv Univ.
Floquet, Thierry — CNRS

We consider a generalized class of relay controllers where the system input may take values in a finite set of constant vectors. A simple continuous-time design method is proposed for linear time invariant (LTI) systems. Furthermore, it is used in the sampled-data case in order to guarantee (locally) the practical stabilization to a bounded ellipsoid containing the origin. The sampling intervals may be unknown and time-varying in a given interval. Simple linear matrix inequalities (LMIs) conditions are proposed for checking (local) practical stability.

11:50-12:10 FrA3.5

Control of a Nonlinear Ice Cream Crystallization Process, pp. 723-728

Casenave, Céline — INRA
Dochain, Denis — Univ. Catholique de Louvain
alvarez, Graciela — IRSTEA
Arellano, Marcela — IRSTEA
Benkhelifa, Hayat — AgroParisTech
Leducq, Denis — IRSTEA

In the ice cream industry, the type of final desired product (large cartons (sqrounds) or ice creams on a stick) determine the viscosity at which the ice cream has to be produced. One of the objectives of the ice cream crystallization processes is therefore to produce an ice cream of specified viscosity. In this paper, a nonlinear control strategy is proposed for the control of the viscosity of the ice cream in a continuous crystallizer. It has been designed on the basis of a reduced order model obtained by application of the method of moments, on a population balance equation describing the evolution of the crystal size distribution. The control strategy is based on a linearizing control law coupled with a Smith predictor to account for the measurement delay. It has been validated on a pilot plant located at IRSTEA (Antony, France).

FrSPS1 Room A001

Utility of Iiss in Composing Lyapunov Functions for Interconnections (Semi-Plenary Session)

Chair: Tarbouriech, Sophie — LAAS-CNRS

13:20-14:20 FrSPS1.1

Utility of Iiss in Composing Lyapunov Functions for Interconnections, pp. 729-736

Ito, Hiroshi — Kyushu Inst. of Tech.

Decomposition of a system into smaller components sometimes allows us to analyze and design the system effectively based on properties of the components. The notion of input-to-state stability (ISS) has been widely used to characterize components that refuse linear-like properties. It is, however, still restrictive, and it cannot cover a lot of saturation mechanisms which often arise in practical systems. The notion of integral input-to-state stability (iISS) is a way to remove the limitation of ISS. This paper collects and illustrates some recent advances in the framework of iISS that allows us to broaden the class of nonlinearities we can address in analysis and design of interconnected systems by making use of Lyapunov functions.

FrSPS2 Room A002

A Control Theoretic Framework for the Analysis and Design of Biological Networks (Semi-Plenary Session)

Chair: Gouze, Jean-Luc — INRIA

13:20-14:20 FrSPS2.1

A Control Theoretic Framework for the Analysis and Design of Biological Networks, pp. 737-742

Del Vecchio, Domitilla — MIT

Control theory has been instrumental for the analysis and design of a number of engineering systems, including aerospace and transportation systems, robotics and

intelligent machines, manufacturing chains, electrical, power, and information networks. In the past several years, the ability of de novo creating biomolecular systems and of measuring key physical quantities has come to a point in which quantitative analysis and design of biological networks is now possible. While a modular approach to analyze and design networked dynamical systems has proven critical in most control theory applications, it is still subject of intense debate whether a modular approach is viable in biomolecular networks. The dynamics of these networks are highly nonlinear and therefore addressing this question requires the use of tools from nonlinear control theory. In this talk, we present a theoretical framework to quantify the extent of modularity in biomolecular networks and to establish modular analysis and design techniques. Specifically, we address the fundamental question of modularity by demonstrating that impedance-like effects are found in biomolecular systems, just like in many engineering systems. These effects, which we call retroactivity, can be severe and alter the behavior of a module upon interconnection, undermining modular behavior. Leveraging nonlinear model reduction tools, we show how one can determine interconnection rules that account for retroactivity by calculating equivalent network descriptions, just like Thevenin's theorem does for linear electrical circuits. By merging disturbance rejection and singular perturbation techniques for nonlinear systems, we further provide an approach that exploits the distinctive structure of biomolecular networks to design biomolecular insulating amplifiers. These devices buffer systems from retroactivity and restore modular behavior, allowing a bottom-up approach to creating synthetic biological circuits. We provide experimental demonstrations of our theory and illustrate concrete biological realizations of insulating amplifiers in living cells.

FrB1	Room C101
Networks and Detection (Regular Session)	

Chair: Acho, Leonardo	EUETIB-Univ. Pol. of Catalunya
Co-Chair: Proskurnikov, Anton	St.-Petersburg State Univ.

14:30-14:50 FrB1.1

The Circle Criterion for Synchronization in Nonlinearly Coupled Networks, pp. 743-748

Proskurnikov, Anton — St.-Petersburg State Univ.

The problem of synchronization (consensus) in nonlinearly coupled network is addressed. The agents of the network are assumed to identical and linear, however, they may have arbitrary order and be unstable. The interaction topology may switch and the couplings are uncertain, assumed only to satisfy conventional quadratic constraints. We offer easily verifiable synchronization criteria, based on the Kalman-Yakubovich-Popov lemma and extending a number of known result for agents with special dynamics. Those criteria are close in spirit to the celebrated circle criterion for the stability of Lurie systems.

14:50-15:10 FrB1.2

Practical and Robust Synchronization of Systems with Additive Linear Uncertainties, pp. 749-754

Montenbruck, Jan Maximilian — Univ. of Stuttgart
Seyboth, Georg S. — Univ. of Stuttgart
Allgower, Frank — Univ. of Stuttgart

We investigate the synchronization of systems with additive uncertainties. In doing so, we establish a setup of diffusively coupled nonlinear systems that are perturbed by unknown linear functions, each. By assuming bounded solutions of the nominal uncoupled systems, we derive sufficient conditions for boundedness of the solutions of the coupled systems with uncertainties. Next, using the QUAD condition, we derive conditions for the synchronization error to remain bounded. Subsequently, we investigate the impact of the coupling strength on this bound and find that the bound can be made arbitrarily small for sufficiently large gains, thus establishing criteria for practical synchronization. Finally, we consider classes of uncertainties which consist of matrices whose maximal singular value is smaller than a specific value and show practical synchronization for all uncertainties belonging to that class. Therefore, we establish conditions for robust synchronization with respect to such a class. Our theoretical results are validated with a numerical example composed of perturbed Van der Pol oscillators.

15:10-15:30 FrB1.3

A Chaotic Secure Communication Scheme Based on Duffing Oscillators and Frequency Estimation, pp. 755-760

Zapateiro, Mauricio — Univ. Pol. de Catalunya
Vidal, Yolanda — Univ. Pol. de Catalunya
Acho, Leonardo — EUETIB-Univ. Pol. of Catalunya

This work presents a new technique to securely transmit and retrieve a message signal via chaotic systems. In our system, a two-valued message signal modulates the frequency of a Duffing oscillator sinusoidal term. An observer is used in the receiver side to retrieve the sinusoidal signal that contains the message and a novel frequency estimator is then used to reproduce an approximated estimation of the message signal. The performance of the system is analyzed by means of numerical simulations performed in Matlab.

15:30-15:50 FrB1.4

A Cluster Control of Nonlinear Network Systems with External Inputs, pp. 761-766

Ryono, Koki — Tokyo Metropolitan Univ.
Oguchi, Toshiki — Tokyo Metropolitan Univ.

In this paper, we consider the synchronization problem in networks of identical nonlinear systems with delayed couplings and external inputs. We show that the existence of external inputs can generate partial synchronization in networks and the synchronization pattern based on the notion of equitable partitions. Some illustrated examples with numerical simulation are given to verify the validity of the result obtained in this paper. The result indicates that synchronization patterns can be controlled by applying external inputs.

15:50-16:10 FrB1.5

Outlier Detection for Polynomial Systems Using Semidefinite Relaxations, pp. 767-772

Borchers, Steffen	Max Planck Inst. for dynamics of complex Tech. systems
Findeisen, Rolf	Otto-von-Guericke-Univ. Magdeburg

Outlier detection and analysis is a primary step in modelling towards obtaining unbiased estimates, model validation, and coherent analysis, because outliers may contain valuable information or lead to falsely rejecting hypotheses. In this work, we describe approaches for detecting outliers in measurements due to time-dependent and possibly non-homogeneously distributed measurement uncertainties within a set-membership setting. We propose a combinatorial outlier detection approach based on a rigorous invalidity criterion using semidefinite programming relaxations. To overcome combinatorial complexity issues, we furthermore propose a reachability-based approach to identify outlier candidates, which can be easily verified thereafter.

16:10-16:30 FrB1.6

Chaotic Behavior of the Folding Map on the Equilateral Triangle, pp. 773-778

Ishikawa, Tetsuya	Tokyo Inst. of Tech.
Hayakawa, Tomohisa	Tokyo Inst. of Tech.

In recent years, it becomes important to understand chaotic behaviors in order to analyze nonlinear dynamics because chaotic behavior can be observed in many models in the field of physics, biology, and so on. To understand chaotic behaviors, investigating mechanisms of chaos is necessary and it is meaningful to study simple models that shows chaotic behaviors. In this paper, we propose an extremely simple triangle folding map and show that the map has k-periodic points for any integer k, and show the map has sensitivity to initial conditions. Finally, we discuss the connection with the Sierpinski gasket and construct similar types of fractal geometry.

FrB2	Room C102
Robotic and Mechanical Control (Regular Session)	
Chair: Perruquetti, Wilfrid	Ec. Centrale de Lille
Co-Chair: Ishikawa, Masato	Osaka Univ.

14:30-14:50 FrB2.1

Comparison of Cascaded Backstepping Control Approaches with Hysteresis Compensation for a Linear Axis with Pneumatic Muscles, pp. 779-784

Schindele, Dominik	Univ. of Rostock
Aschemann, Harald	Univ. of Rostock

This paper presents two control approaches for a linear axis with pneumatic muscles. Its guided carriage is driven by a nonlinear drive system consisting of two pulley tackles with pneumatic muscle actuators arranged at both sides. This innovative drive concept allows for an increased workspace as well as higher carriage velocities as compared to a direct actuation. Both proposed control schemes have a cascaded structure, where the control design is based on backstepping techniques. Hysteresis in the force characteristic of the pneumatic muscles is considered by an asymmetric shifted Prandtl-Ishlinskii model, while remaining uncertainties are compensated using an adaptive backstepping strategy. The main difference between both approaches is the usage of either the internal muscle pressures or the muscle forces as controlled variables of the inner control loops. Both control approaches have been implemented on a test-rig and show an excellent closed-loop performance.

14:50-15:10 FrB2.2

Spatio-Temporal Symmetries in Control Systems: An Application to Formation Control, pp. 785-790

Consolini, Luca	Univ. of Parma
Tosques, Mario	Univ. of Parma

With the aim of addressing the stabilization problem of periodic trajectories in systems composed of identical interconnected subsystems, we introduce the class of "spatio-temporally symmetric" nonlinear systems. We address in detail the linear, time-varying case and present conditions for the synthesis of a static and a dynamic stabilizing controller. We show that linear spatio-temporally symmetric systems can be reduced to hybrid systems, described by a periodic linear system with periodic state jumps. As an application example, we present the stabilization of a formation of unicycle robots in cyclic pursuit.

15:10-15:30 FrB2.3

Modeling and Control of Casterboard Robot, pp. 791-796

Kinugasa, Kazuki	Osaka Univ.
Ishikawa, Masato	Osaka Univ.
Sugimoto, Yasuhiro	Osaka Univ.
Osuka, Koichi	Osaka Univ.

In this paper, we propose a robotic model of casterboard, which is a commercial variant of skateboard with twistable footplates and passive inclined caster wheels.We then derive its mathematical model in the form of nonlinear state equation; this system is of much interest from both mechanical and control points of view as a new challenging example of nonholonomic mechanics. Based on the observation on preceding works concerning locomotion control for nonholonomic systems, we propose a locomotion control method with sinusoidal periodic control to realize forwarding and turning locomotion. The proposed idea is examined by simulations and physical experiments using the prototype robot developed by the authors. Moreover, we also examine the influences on the driving of the robot of parameter in the sinusoidal reference signals.

15:30-15:50 FrB2.4

Identification of Different Types of Non-Holonomic Mobile Robots, pp. 797-802

Ma, Yingchong	Ec. Centrale de Lille
Zheng, Gang	INRIA Lille-Nord Europe
Perruquetti, Wilfrid	Ec. Centrale de Lille

This paper presents the real-time identification of different types of non-holonomic mobile robot systems. Since the robot type is unknown, the robot systems are formulated as a witched singular nonlinear system, and the problem becomes the real-time identification of the switching signal, and then the existence of the input-output functions and the distinguishability of the system are studied. We show in the simulations that the technique is implemented easily and effectively, and it is robust to the noises as well.

15:50-16:10 FrB2.5

Collision Avoidance in Formation Control Using Discontinuous Vector Fields, pp. 803-808

Hernández-Martínez, Eduardo Gamaliel — Univ. Iberoamericana
Aranda-Bricaire, Eduardo — CINVESTAV

This paper presents a novel collision avoidance approach in formation control for Multi-agent Robots. The control strategy consists in the mix of attractive vector elds and repulsive vector elds based on a scaled unstable focus centered at the position of another robot, instead of the vector elds obtained from the negative gradient of repulsive potential functions. The analysis of the closed-loop system is presented for the case of two point robots. After that, a modication of the composite vector eld is proposed adding a discontinuity in order to avoid the undesired equilibria of the system. Real-time experiments using unicycle-type robots show that the control strategy exhibits good performance.

16:10-16:30 FrB2.6

Local Finite-Time Stability and Stabilization Analysis of Interconnected Systems, pp. 809-814

Zoghlami, Naim — Univ. of Evry
Beji, Lotfi — Univ. of Evry
Mlayeh, Rhouma — Pol. School of Tunisia
Abichou, Azgal — Tunisia Pol. School

Interconnection is omnipresent in a system through the state variables and induced for multi-system interaction and shared tasks. Typically, the example of multi-agent coordination was studied as an interconnected system. The paper deals with the finite-time stability problem of a general form of interconnection presented as a perturbation term. Sufficient conditions for finite-time stability are derived. A second interest is given to the interaction of multiple controlled autonomous systems, and where the multi-system control-input is established both for finite-time stabilization. As an example of application, the finite-time tracking problem of four unicycles is studied.

FrB3 Room C103

Model Predictive Control (Regular Session)

Chair: Findeisen, Rolf — Otto-von-Guericke-Univ. Magdeburg

Co-Chair: Andrieu, Vincent — Univ. de Lyon1

14:30-14:50 FrB3.1

Stability of NMPC with Cyclic Horizons, pp. 815-820

Koegel, Markus J. — Otto-von-Guericke-Univ. Magdeburg
Findeisen, Rolf — Otto-von-Guericke-Univ. Magdeburg

In this paper we present stability conditions for nonlinear model predictive control with cyclically varying horizons. Starting from a maximum horizon length, the horizon is reduced by one at each sampling time until a minimum horizon length is reached, at which the horizon is increased to the maximum length. The approach allows to utilize shapes and structures in the terminal constraints, which can otherwise not be handled. Examples are terminal boxconstraints, where the terminal set cannot be rendered invariant, or quadratic terminal regions and penalties of diagonal structure. Such constraints are for example of advantage for distributed predictive control problems. To underline the applicability, the approach is used to control a four tank system.

14:50-15:10 FrB3.2

Dual Adaptive Control for Non-Minimum Phase Systems with Functional Uncertainties, pp. 821-826

Kral, Ladislav — Univ. of West Bohemia
Simandl, Miroslav — Univ. of West Bohemia

A dual control for a nonlinear system with non-minimum phase based on the bicriterial approach is proposed and discussed. A particular class of the nonlinear input/output recursive model is composed of linear and nonlinear blocks, the latter being implemented with a multi-layered perceptron neural network. The unknown parameters of the model are estimated in real-time by the extended Kalman filter. The chosen nonlinear model with the affine structure in inputs together with the certainty equivalence principle utilization allow to obtain an analytical solution to control based on generalised minimum variance method. Behaviour of the system based on the enforcement of the certainty equivalence can negatively be affected, especially in a presence of disturbances and functional uncertainties. For that, the control action is enhanced about dual property based on the bicriterial approach that uses two separate criteria to introduce one of the opposing aspects between estimation and control.

15:10-15:30 FrB3.3

Differentiation Tool Efficiency Comparison for Nonlinear Model Predictive Control Applied to Oil Gathering Systems, pp. 827-832

Codas, Andrés — NTNU
Aguiar, Marco Aurélio — Univ. Federal de Santa Catarina
Nalum, Konstantin — NTNU
Foss, Bjarne — Norwegian Univ. of Science & Tech.

This paper presents a comparison of gradient computation techniques required to solve a single-shooting formulation of nonlinear model predictive control (NMPC) problems. An oil production system with network structure is considered as test instance. The structure of the network is exploited to improve computational efficiency. Exact gradient sensitivity calculation methods (forward and adjoint) are compared along with the finite difference approximation. Forward and Reverse automatic differentiation for calculating Jacobians are also compared along with the finite difference approximation counterpart. Since there is a trade off involving accuracy and speed when calculating these gradients, the best combination of tools is case dependent and it is determined by the analyses of performance indexes arising when solving specific NMPC problems. A hybrid approach combining finite difference Jacobian calculations with adjoint sensitivity calculations gave the best performance for our test problems.

15:30-15:50	FrB3.4

Optimal Control of Digital Hydraulic Drives Using Mixed-Integer Quadratic Programming, pp. 833-838

Sniegucki, Mateusz	Bosch Rexroth AG, Tech. Univ. Darmstadt
Gottfried, Markus	Bosch Rexroth AG
Klingauf, Uwe	Tech. Univ. Darmstadt

Control of dynamical systems gets considerably harder with an increasing number of control variables. Especially when the control variables are restricted to integer values, the solution is of combinatorial complexity. An example of such systems are Digital Hydraulic Drives, where several cylinders contribute to the output torque independently. In this work we present an optimal control approach for torque control of Digital Hydraulic Drives using Mixed-Integer Quadratic Programming in a Model Predictive Control framework. The nonlinear behavior and discrete valued inputs resulting from the use of on-off valves, are accommodated in the control model using a Mixed Logical Dynamical System representation. With the presented approach, optimal switching sequences for the electrical valves are computed that produce the desired torque trajectory with fast tracking and minimal ripple, while keeping switching events at a minimum and respecting physical system constraints.

15:50-16:10	FrB3.5

A Robust Receding Horizon Control Approach to Artificial Glucose Control for Type 1 Diabetes, pp. 839-844

Penet, Maxime	Supelec
Gueguen, Herve	SUPELEC
Belmiloudi, Aziz	INSA de Rennes

The problem of controlling the blood glucose value of a patient suffering from type 1 diabetes is considered. The proposed strategy consists in designing a robust nonlinear model predictive controller based on a minimal nonlinear model. The various uncertainties and disturbances are introduced through the use of a variational model. The control problem is then expressed as a constrained game type minimax optimization problem. The choice of a final cost which ensures good stability properties are detailed. The performances of the controller are exemplified on a virtual testing platform showing its good properties.

16:10-16:30	FrB3.6

Neuro-Fuzzy Modified Smith Predictor for IPDT and FOPDT Processes Control, pp. 845-850

Chen, Hao	Glyndwr Univ.
Zouaoui, Zoubir	Glyndwr Univ.
Chen, Zheng	Glyndwr Univ.

In this paper, intelligent control approaches are introduced to overcome the problems highlighted in the standard Smith predictor (SP). First, in order to overcome the steady state error in the Integrator Plus Dead Time (IPDT) process control due to disturbance loading, a new fuzzy logic control based SP is developed by intentionally introducing a model mismatch to improve the system performance in terms of disturbance rejection and robustness to process modelling errors. In addition, for the First Order Plus Dead Time (FOPDT) process control, a Smith predictor based neural network control scheme is proposed to deal with the process modelling errors and proved to provide a significantly improved robustness. The neural network (NN) was designed to work with different types of modelling errors. Simulation results show that this NN approach provides excellent performance in terms of robustness to modelling errors and high adaptability to the control of both IPDT and FOPDT processes.

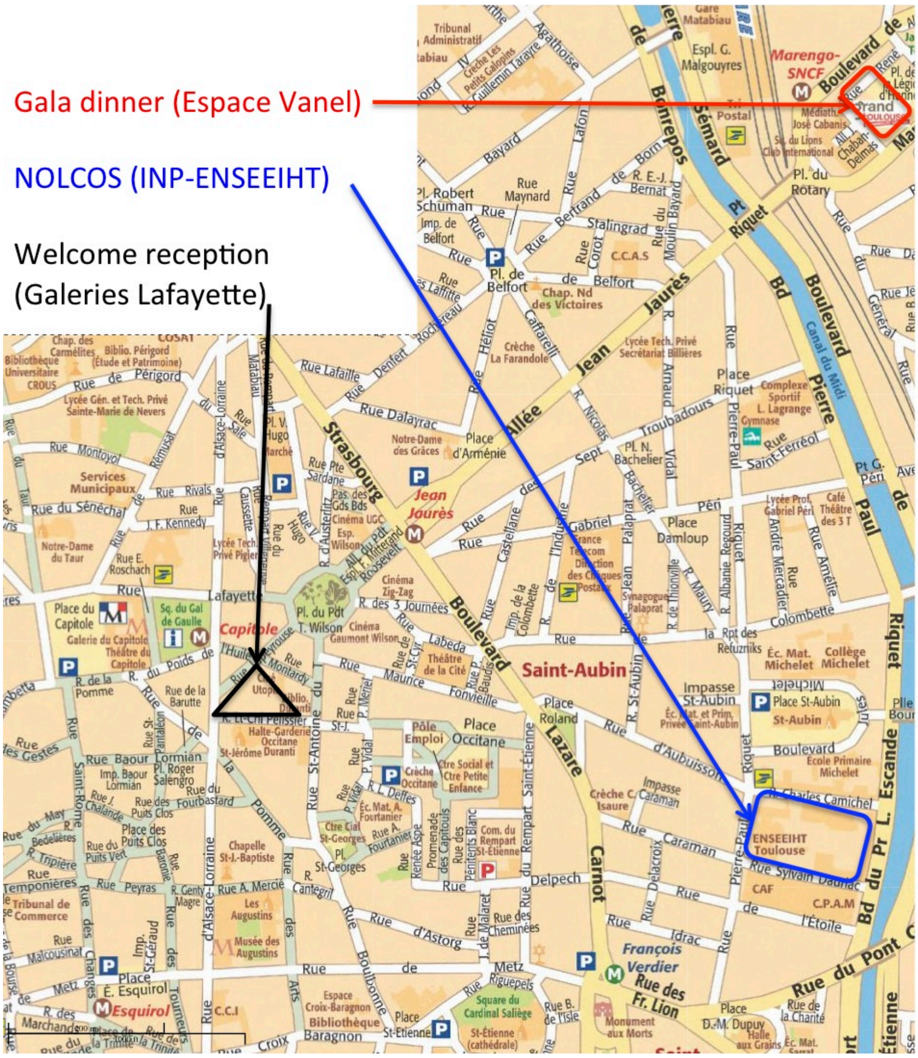
Author Index

Keyword Index

General Information

Conference Venue

The Tutorials (September 3) and the Symposium (September 4-6) are held at the Engineering School INP-ENSEEIHT of University of Toulouse. The main entrance of the Engineering School is Rue Camichel. A secondary entrance, direct to the building of the Symposium is Rue Riquet. The conference venue is located within walking distance from the city center (about 10-15 min from Capitole Square).



Registration Desk

During the Symposium a registration desk, in the main hall of the conference building of INP-ENSEEIHT, is organized in order to support participants with local information and logistic matters.

Registration desk opening hours
Tuesday, September 3, 2013 8h00-17h30
Wednesday, September 4, 2013 8h00-19h00

Thursday, September 5, 2013	8h00-19h00
Friday, September 6, 2013	8h30-17h00

A "light" registration desk is also opened at the Welcome Reception: 18h00-19h30

Coffee Breaks and Lunches

Coffee breaks and lunches for the three days of the Symposium are included in the registration fees. Coffee breaks are localized in the main hall of the conference building. Lunches are located in Room A003.

Internet Access

Wireless access to Internet is available in all the conference rooms for all registered participants. Detailed instructions to log in are provided in the Symposium bag.

Information for Chairpersons and Speakers

Chairpersons and speakers are requested to contact the registration desk before the start of their session to receive an updated schedule if necessary. Detailed instructions for Chairs and Co-Chairs are provided in the Symposium bag. All the rooms are equipped with video projectors and black boards. Speakers are kindly requested to use their laptop for presentation. PCs are not available in the rooms. Speakers who need a laptop for their presentation are required to ask the registration desk in advance.
Speakers are required to contact the chairs at least 10 minutes before the start of the session and test their laptop in advance. In each room an assistant is available to support speakers in case of technical problems.

Plenary and semi-plenary speakers
The plenary and semi-plenary sessions last one hour each. Plenary and semi-plenary speakers are kindly requested to arrange their presentations in order to keep about 10 minutes for final questions/comments.

Regular/Invited session speakers
The time slot for presentations of regular and invited papers is 20 minutes. Speakers are kindly requested to arrange their presentations to keep few minutes for final questions/comments.

Weather

September is most certainly the best time of the year to visit Toulouse, when temperatures are agreeably warm and ideal for sightseeing. The average daily temperature should be around 20°C, typically varying from 14°C to 25°C.

Welcome Reception

A welcome reception is organized on the roofs of Toulouse, at Galeries Lafayette, sixth (top) floor, Tuesday, September 3, from 18h30 to 20h00.
Address:

GALERIES LAFAYETTE TOULOUSE LAPEYROUSE

4-8 Rue Lapeyrouse
31000 TOULOUSE

Associated to the invitation, a discount flyer (10% + tax refund) for the Galeries Lafayette is offered to every foreign participant, with validity for all the conference duration.

BANQUET

The Gala Dinner takes place on Thursday, September 5, in Toulouse downtown, at Espace Vanel, at 19h30. Espace Vanel is located at the top of the José-Cabanis multimedia library, place Marengo, 10 minutes walking distance from the conference location and Capitole Square. The Gala Dinner is included in all registration fees. Additional tickets to the Gala Dinner can be purchased at the registration desk during the Symposium in the limit of available places.

FAREWELL PARTY

At the end of the sessions a Farewell party will take place to say goodbye to friends and colleagues. It will be held in the main hall of the conference building. The farewell party is included in the registration fees.

AIRBUS VISIT

With the Airbus A380 tour, the "super jumbo" reveals all its secrets... The visit is organized on September 3, just after the Tutorial session, and before the Welcome Reception. Only pre-registered participants can access the site, as Airbus security policy imposes to provide information prior to the visit.

Program

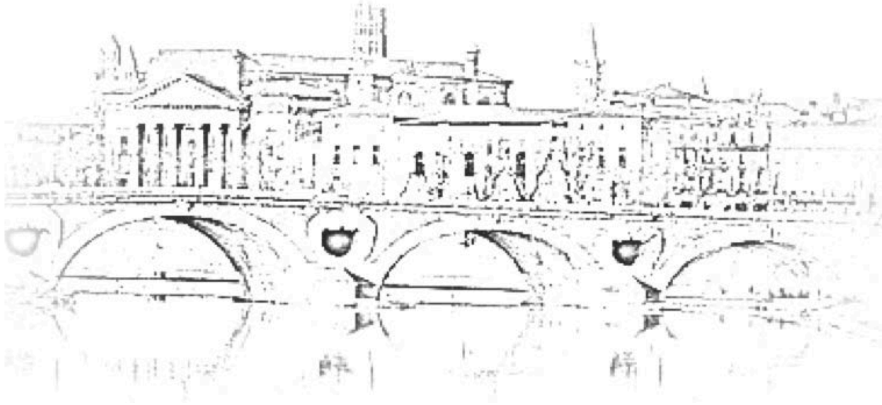
- 15h15: Departure of the bus from the conference location
- 16h15: Airbus visit (1h30)
- 18h00: Departure of the bus from Airbus
- 18h30: Back to city center (close to the Welcome Reception location)

TOULOUSE CITY

With its characteristic architecture, the city of Toulouse has earned the nickname "ville rose" or "pink city" due to the color of the local building material traditionally used - terra cotta bricks. Its other nickname is the "city of violets". There is a brotherhood of violets in Toulouse, as there was large-scale production of this flower here. The Violet is one of the prizes awarded by the Academy of Floral Games in Toulouse.

Hosting in particular Airbus, Toulouse is now one of Europe's high-tech cities with a large number of cutting-edge businesses in the aeronautic, IT and spatial industries, as well as many research institutes. It is an important university town with prestigious cultural centers such as its conference center, José-Cabanis multimedia library, Zénith concert hall, Abattoirs museum of modern and contemporary art, Cité de l'Espace Space Park and Toulouse National Theatre (TNT).

Toulouse is undergoing rapid demographic expansion, the fastest-growing in France and, for agglomerations with more than 850,000 inhabitants, even in Europe. It is considered one of the largest intermediate European cities along with Lyon, Marseille, Florence, Hamburg and Zurich.



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The material submitted for presentation at an IFAC meeting (Congress, Symposium, Conference, Workshop) must be original, not published or being considered elsewhere. All papers accepted for presentation will appear in the Preprints of the meeting and will be distributed to the participants. Papers duly presented at the IFAC Congress, Symposia, Conferences and Workshops will be hosted on-line on the IFAC-PapersOnLine.net website. The presented papers will be further screened for possible publication in the IFAC Journals (Automatica, Control Engineering Practice, Annual Reviews in Control, Journal of Process Control, Engineering Applications of Artificial Intelligence, and Mechatronics), or in IFAC affiliated journals. All papers presented will be recorded as an IFAC Publication.

NOLCOS 2013