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Book of Abstracts of 2015 Australian Control Conference

Technical Program for Thursday November 5, 2015

ThAO	Theatre 4
Process Control Session (Invited Session)	
Chair: Bao, Jie	The Univ. of New South Wales
Organizer: Bao, Jie	The Univ. of New South Wales

09:10-09:30 ThAO.1

Monitoring and Diagnosis of PI Controllers (I), pp. 1-5

Shahni, Farzam — Univ. of Auckland, Auckland

Yu, Wei — The Univ. of Auckland

Young, Brent — The Univ. of Auckland

A PI controller is one of the most widespread controller types used in industry. If the structure and order of a controller is restricted (e.g. a PI controller as is the case in this paper), this may cause worse output variance as compared to the minimum variance (MV) benchmark. Finding the best achievable performance boundary for this controller is a challenging task as it leads to a non-convex optimization problem. This paper presents a fast, simple and comparably accurate method of estimating the PI performance boundary. The proposed method finds the minimum output variance with a PI controller (PIMOV), and this is then used to obtain an accurate PI trade-off curve for a SISO system which can be used in monitoring and diagnosis. A Full theoretical analysis is presented, and a simulation study is performed for the assessments using the Matlab optimization toolbox. Several simulation examples are incorporated to show the usefulness of the proposed algorithm.

09:30-09:50 ThAO.2

The Global Enterprise and Process Control (I), pp. 6-11

Lees, Michael — Carlton & United Breweries

The manufacturing industry has continued to evolve since its inception. There have been many different areas of focus and paradigms during this journey of improvement. Globalisation, particularly in the form of acquisition and integration of disparate manufacturing plants, has presented an interesting set of challenges and opportunities for plant and process control. This paper looks at the impact of this type of globalisation on process & plant control. The examples and insights that are presented are based on observations and experiences within the global brewing industry. Process control is a popular field of research and is relevant to a significant portion of the manufacturing industries. The insights into the context and basis for emerging control requirements is of use to researchers interested in industry relevant aspects of this field.

09:50-10:10 ThAO.3

Industry Standard Models for Design / Discussion of Manufacturing Systems (I), pp. 12-15

Hood, Gavan — Simul-Tech. Pty Ltd

The American National Standards Institute (ANSI) / International Society of Automation (ISA) and International Electrotechnical Commission (IEC) are groups of industry professionals committed to the improvement of design, automation and control systems management across manufacturing and critical infrastructure. ISA / IEC concepts are embodied in many of the current control system products available today and are leveraged by many global manufacturers. This paper illustrates how two ISA standards can be used as valuable frameworks for the design and discussion of modern batch, discrete and continuous automation systems that integrate equipment, control and higher level business processes to produce a range of products.

10:10-10:30 ThAO.4

Distributed Plantwide Process Control Based on Dissipativity (I), pp. 16-20

Bao, Jie — The Univ. of New South Wales

Wang, Ruigang — Univ. of New South Wales

This paper presents some recent results on distributed plantwide control based on the concept of dissipativity. The plantwide process is modelled as a network of process units interconnected with physical mass and energy flows. By using dynamic supply rates, the plantwide stability and performance conditions transformed into the dissipativity conditions that each controller needs to satisfy. Developments in plantwide operability analysis, distributed model predictive control, analysis of multi-time scale plantwide process dynamics and their extensions to nonlinear systems are discussed.

ThB1	G17_Foyer
Interactive Session I (Nonlinear Systems and Control I) (Interactive Session)	
Chair: Tan, Ying	The Univ. of Melbourne

10:30-12:30 ThB1.1

Sliding Mode Control for Tracking of Nonholonomic Wheeled Mobile Robots, pp. 21-26

Kigezi, Tom — Kiira Motors Corp

Stancu, Alexandru — Univ. Pol. De Catalunya (UPC)

Mugabi, Edgar — Kiira Motors Project

Paul Isaac, Musasizi — Kiira Motors Project

A chatter-free sliding mode controller employing only conventional sliding surfaces is proposed for trajectory tracking of a nonholonomic wheeled mobile robot. In one sliding surface, nonlinear state variable coupling is avoided by linearly combining two indirectly controlled states into a single aggregate variable. This greatly simplifies analysis compared to the case of sophisticated sliding surfaces. The derived control signals are in form of their respective time derivatives. Thus, upon integration, continuous control action is actually produced, yielding significant chatter reduction. Rigorous stability proofs as well as validation simulation results are presented.

10:30-12:30 ThB1.2

On Positive Output Controllability and Cable Driven Parallel Manipulators, pp. 27-32

Eden, Jonathan — The Univ. of Melbourne

Lau, Darwin — Chinese Univ. of Hong Kong

Tan, Ying — The Univ. of Melbourne

Oetomo, Denny — Univ. of Melbourne

This paper introduces a new concept: the positive output controllability for a multi-link cable driven parallel manipulator (CDPM). This class of mechanism is characterised by the use of cable actuation which is constrained to be non-negative at all times. For simplicity, a linear-time-invariant system (LTI) is considered, which corresponds to the local behavior of the CDPMs around an particular equilibrium. A necessary and sufficient condition is provided to ensure that a LTI system is positive output

controllable. The obtained results are verified by using a simulation example of a 2-link CDPM.

10:30-12:30 ThB1.3

Exponential Stability of Multiple Equilibria for Memristive Cohen-Grossberg Neural Networks with Non-Monotonic Activation Functions, pp. 33-38

Nie, Xiaobing — Southeast Univ
Zheng, Wei Xing — Univ. of Western Sydney

This paper is concerned with the problem of exponential stability of multiple equilibria for memristive Cohen-Grossberg neural networks with non-monotonic piecewise linear activation functions. First, the fixed point theorem and nonsmooth analysis theory are applied to develop some sufficient conditions under which n-dimensional memristive Cohen-Grossberg neural networks with non-monotonic activation functions are ensured to have 5^n equilibrium points. Then, with the aid of the theories of set-valued maps and differential inclusions, the exponential stability is proved for 3^n equilibrium points out of those 5^n equilibrium points. The importance of the multistability results obtained in this paper lies in that the use of the proposed non-monotonic activation functions can increase the storage capacity of the corresponding neural networks considerably.

10:30-12:30 ThB1.4

A Discrete-Time Strong Implication-Form Lyapunov Function for ISS Systems with Respect to Positive Semidefinite Measurement Functions, pp. 39-42

Tran, Duc N. — Univ. of Newcastle
Kellett, Chris — Univ. of Newcastle
Dower, Peter M. — The Univ. of Melbourne

In this paper, we study the notion of ISS with respect to two measurement functions for discrete-time systems. In particular, we present a strong ISS-Lyapunov function result for the case where two measurement functions are identical. We then present and discuss the challenge of extending this result to the case where two measurement functions are not necessarily identical.

10:30-12:30 ThB1.5

Moment Convergence in a Class of Singularly Perturbed Stochastic Differential Equations, pp. 43-48

Herath, Narmada — Massachusetts Inst. of Tech
Del Vecchio, Domitilla — Univ. of Michigan

We consider a class of singularly perturbed stochastic differential equations with linear drift and nonlinear diffusion terms. We obtain a reduced-order model that approximates the slow variable dynamics of the original system when the singular perturbation parameter $epsilon$ is small. In our previous work, it was shown that, on a finite time interval, the first and the second moments of the slow variable dynamics of the original system are within an $O(epsilon)$-neighborhood of the first and the second moments of the reduced-order system. In this paper, we extend this result to show that all moments of the slow variable dynamics of the original system are within an $O(epsilon)$-neighborhood of the moments of the reduced-order system. We illustrate the application of this approach on a biomolecular system modeled by the chemical Langevin equation.

ThB2 G17_Foyer

Interactive Session I (Robust Control I) (Interactive Session)

Chair: Tan, Ying — The Univ. of Melbourne

10:30-12:30 ThB2.1

Model Free Adaptive Robust Control Based on GIMC Structure for Nonlinear Discrete-Time System, pp. 49-54

Zhao, Shulong — School of Mechanics and Automation, National Univ. of Defen
Wang, Xiangke — School of Mechanics and Automation, National Univ. of Defen
Zhang, Daibing — School of Mechanics and Automation, National Univ. of Defen
Shen, Lincheng — National Univ. of Defense Tech

In this paper, a novel model free adaptive robust control (MFARC) algorithm is proposed to adaptive and robust control for a class of complex and uncertain nonlinear systems, which is considered to have random noise and disturbances in the input and output data. It is shown that general inner model control (GIMC) structure can be used to overcome the trade-off that performance and robustness of controller are both taking into account. Meanwhile, model free adaptive control is employed to guarantee the performance of nominal controller with disturbance or uncertainty, where the detailed analytical models are difficult to obtain. The unique feature of this paper is that we explicitly combine data driven control technique and GIMC structure to design controller directly to omit the drawback of model linearization with dynamical uncertainties and disturbances. Simulation results show the effectiveness and applicability of the proposed control law.

10:30-12:30 ThB2.2

Repetitive Disturbance Observer-Based Control for an Active Magnetic Bearing System, pp. 55-60

Noshadi, Amin — Victoria Univ
SHI, JUAN — Victoria Univ
Lee, Wee Sit — Victoria Univ
Shi, Peng — The Univ. of Adelaide
Kalam, Akhtar — Victoria Univ

Vibrations with time-varying frequencies significantly affect the performance of active magnetic bearing systems at high rotational speeds. It is well-known that these vibrations manifest as harmonic forces with frequencies synchronous to the rotor speed. It is important to attenuate these vibrations, as they may lead to system instability. This paper presents a hybrid control scheme comprising of an outer-loop H_∞ controller and an inner-loop repetitive disturbance observer-based controller for the robust stabilization of a laboratory active magnetic bearing system while reducing the vibrations caused by the rotor mass-imbalance. The stability analysis of the presented hybrid control scheme (H_∞-RDOBC) is provided, and its effectiveness is verified via simulation studies and real-time experiments on a laboratory active magnetic bearing setup.

10:30-12:30 ThB2.3

Trajectory Planning and Execution Using Robust Funnels, pp. 61-64

Shekhar, Rohan Chandra — The Univ. of Melbourne
Kearney, Michael — The Univ. of Queensland
Shames, Iman — Univ. of Melbourne
Manzie, Chris — The Univ. of Melbourne

This paper presents a new robust path planning and execution methodology for constrained linear systems, using reachable sequences of sets denoted funnels. Constraint tightening is used to guarantee the existence of a combined feedforward and affine disturbance-feedback policy to guide the system trajectory from anywhere within a set of initial states to a target set, through a sequence of intermediate sets forming the cross-section of the funnel. It is shown how the sets can be placed to guarantee robust obstacle avoidance for a known bounded disturbance. Numerical simulations are used to demonstrate the approach on a simple unmanned aerial vehicle model.

10:30-12:30 ThB2.4

A New Fundamental Solution for Differential Riccati Equations Arising in L2-Gain Analysis, pp. 65-68

Dower, Peter M. Univ. of Melbourne

Zhang, Huan The Univ. of Melbourne

A new fundamental solution for a class of differential Riccati equations (DREs), developed via max-plus and semiconvex analysis, is summarized. An algorithm for its application in the computation of particular solutions of DREs is elucidated, followed by its illustration in a numerical example.

10:30-12:30 ThB2.5

Robust Overlapping Output Feedback Control Design in Uncertain Systems with Unknown Uncertainty Bounds, pp. 69-74

Ahmadi, Adel The Univ. of Melbourne

Aldeen, Mohammad Univ. of Melbourne

Abdolmaleki, Mohammad Univ. of Melbourne

This paper deals with stabilisability of overlapping uncertain linear systems with fixed modes by overlapping static output feedback controllers. The uncertainties are assumed to be time-varying and norm-bounded. The fixed modes arise from natural changes in the physical system parameters due to operational conditions. The approach used in this paper is based on the inclusion principle where the system is first expanded into a weakly interconnected system that preserves all of the properties of the original system. Then, an Iterative Linear Matrix Inequality (ILMI) algorithm is proposed to find (i) the maximum upper bounds on the 2-norm of the uncertainties such that the uncertain expanded system is robustly stabilisable with a decentralised static output feedback control, and (ii) a robust decentralised guaranteed static output feedback cost controller for the expanded system. Finally, both the robust decentralised controller and the upper bounds are contracted to a robust overlapping guaranteed cost controller and upper bounds on the uncertainties of the original system, respectively. A numerical example is provided to illustrate the design approach.

ThB3 G17_Foyer

Interactive Session I (Estimation) (Interactive Session)

Chair: Tan, Ying The Univ. of Melbourne

10:30-12:30 ThB3.1

Filter Design for Decentralized State Estimation in Sensor Networks, pp. 75-80

Leong, Alex Univ. of Melbourne

Nair, Girish N. Univ. of Melbourne

This paper considers decentralized state estimation with sensors exchanging information with its nearest neighbours. Under the constraint that sensors can only exchange information with its neighbours once at each discrete time instant, a lower bound on the achievable performance is derived. For networks with cycles, it is not known if the lower bound can be achieved. An approach that forms weighted combinations of local estimates is proposed, which can get very close to the lower bound when the filter gains and weights are appropriately optimized. A suboptimal way of designing the filter gains and weights, which can be computed using information available within a sensor's local neighbourhood, is also considered.

10:30-12:30 ThB3.2

Friction Compensation in a Pneumatic Actuator Using Recursive Least Square Algorithm, pp. 81-86

Kosari, Hamed Khaje Nasir Toosi Univ. of Tech

Moosavian, S. Ali A. Department of Mechanical Engineering, K.N.Toosi Univ. of Te

For many years pneumatic actuators have had a significant role as a technology in many applications. But nonlinearities such as air compressibility and friction make pneumatic systems difficult to apply in accurate control strategies. In this paper, pneumatic cylinder actuator system has been modeled considering a nonlinear friction characteristic. Since the unknown friction parameters cannot be directly measured, an indirect method is utilized, in this paper, for estimating them. Parameter estimation is performed by using the appropriate algorithm beside the real data acquired from experimental setup. The result reveals very good convergence. The developed model is then used for simulation studies, and comparison of the experiment and simulation results exhibit very good agreement between them.

10:30-12:30 ThB3.3

Detection and Estimation of Icing in Unmanned Aerial Vehicles Using a Bank of Unknown Input Observers, pp. 87-92

Seron, Maria M. The Univ. of Newcastle

Johansen, Tor Arne Norweigian Univ. of Sci. & Tech

De Dona, Jose The Univ. of Newcastle

Cristofaro, Andrea Norwegian Univ. of Science and Tech

Icing is regarded as a severe structural alteration affecting unmanned aerial vehicles (UAVs), since ice accretion on wings and control surfaces modifies the aircraft shape resulting in altered controllability and performance of the vehicle. We study the problem of detection of icing and estimation of its `severity' factor in longitudinal control of UAVs. We propose to employ a bank of unknown input observers (UIOs), each designed to match a model of the aircraft under a particular level of icing taken from a quantisation of the icing's severity factor range of variation. The UIO design exploits the change in equilibrium conditions, caused by the icing effect, to identify a direction in the observer estimation error space that allows for aircraft icing detection and estimation. By selecting at each time the observer from the bank that yields the smallest value of a suitable residual signal, the icing severity factor can be estimated with an accuracy that is inversely proportional to the size of the quantisation level.

10:30-12:30 ThB3.4

Weyl Variations and Local Sufficiency of Linear Observers in the Mean Square Optimal Coherent Quantum Filtering Problem, pp. 93-98

Vladimirov, Igor UNSW Canberra

This paper is concerned with the coherent quantum filtering (CQF) problem, where a quantum observer is cascaded in a measurement-free fashion with a linear quantum plant so as to minimize a mean square error of estimating the plant variables of interest. Both systems are governed by Markovian Hudson-Parthasarathy quantum stochastic differential equations driven by bosonic fields in vacuum state. These quantum dynamics are specified by the Hamiltonians and system-field coupling operators. We apply a recently proposed transverse Hamiltonian variational method to the development of first-order necessary conditions of optimality for the CQF problem in a larger class of observers. The latter is obtained by perturbing the Hamiltonian and system-field coupling operators of a linear coherent quantum observer along linear combinations of unitary Weyl operators, whose role here resembles that of the needle variations in the Pontryagin minimum principle. We show that if the observer is a stationary point of the performance functional in the class of linear observers, then it is also a stationary point with respect to the Weyl variations in the larger class of nonlinear observers.

10:30-12:30 ThB3.5

MIMO Control of the Cutting System for Trench Cutter Based on

Disturbance Observer, pp. 99-104

Tian, Qiyan	Zhejiang Univ
Wei, Jianhua	Zhejiang Univ
Guo, Kai	Zhejiang Univ
Fang, Jinhui	Zhejiang Univ

In this paper, a novel cutting system of trench cutter (TC) is proposed and the simultaneous control of cutting velocity and supply pressure for the cutting system is presented. The cutting velocity and supply pressure control performance of the cutting system is subjected to the unknown load characteristics of rock or soil and time-varying operating conditions due to the particular characteristics of TC. Therefore, the control performance is significantly affected by the unknown time-varying load flow and load torque acting on the actuator. To improve the cutting velocity and supply pressure tracking performances in the presence of unknown time-varying disturbances, a disturbance observer is proposed to estimate the disturbances acting on the actuator. Based on the estimation, a MIMO nonlinear tracking controller is designed in this paper. Simulations are conducted on a co-simulation platform with the proposed controller under different operating conditions. The simulation results demonstrate that the proposed controller gives a superior and robust cutting velocity and supply pressure tracking performance.

ThCO — Theatre 3

Quantum Control (Invited Session)

Chair: Dong, Daoyi	UNSW
Organizer: Dong, Daoyi	UNSW

14:30-14:50 — ThCO.1

A Possible Implementation of a Direct Coupling Coherent Quantum Observer (I), pp. 105-107

Petersen, Ian R.	Australian Defence Force Acad
Huntington, Elanor H.	Univ. of New South Wales, Canberra

This paper considers the problem of implementing a previously proposed direct coupling quantum observer for a closed linear quantum system. This observer is shown to be able to estimate some but not all of the plant variables in a time averaged sense. The paper proposes a possible experimental implementation of the observer plant system using a non-degenerate parametric amplifier.

14:50-15:10 — ThCO.2

Manipulation of Molecular Vibrational Motions Via Pure Rotational Excitations (I), pp. 108-110

Shu, Chuancun	The Univ. of New South Wales Canberra
Henriksen, Niels E.	Tech. Univ. of Denmark

The coupling between different molecular degrees of freedom plays a decisive role in many quantum phenomena, including electron transfer and energy redistribution. Here, we demonstrate a quantum-mechanical time-dependent simulation to explore how a vibrational motion in a molecule can be affected via the rotation-vibration coupling. Our simulations show that a slow (compared to the vibrational period) rotational excitation leads to a smooth increase in the bond length whereas a fast rotational excitation leads to a non-stationary vibrational motion.

15:10-15:30 — ThCO.3

Fault Tolerant Design of Quantum Filter for a Class of Open Quantum Systems with Photon Counting Measurement (I), pp. 111-114

Gao, Qing	Univ. of New South Wales
Dong, Daoyi	UNSW
Petersen, Ian R.	Australian Defence Force Acad

In [Q. Gao, D. Dong, and I. R. Petersen, ``Fault tolerant quantum filtering and fault detection for quantum systems,'' arXiv:1504.06780 [math-ph], 2015], a quantum-classical probability space model has been proposed to solve the problem of fault tolerant quantum filtering and fault detection for a class of laser-atom open quantum systems subject to stochastic faults and under homodyne detection. This paper further investigates the case when performing photo counting measurements on the laser field.

15:30-15:50 — ThCO.4

Quantum Observers for Dissipative Interacting Qubits in a Common Environment (I), pp. 115-119

Miao, Zibo	The Univ. of Melbourne
Pan, Yu	Australian National Univ
James, Matthew R.	Australian National Univ

We previously developed coherent quantum observers for linear and bilinear quantum plants corresponding to open harmonic oscillators and finite level systems quantum respectively. In this paper we consider the case where two XY-coupled qubits are interacting with a common environment, and a class of coherent quantum observers is designed aimed at tracking variables characterising the two qubits including dipole-dipole product terms in the sense of mean values. The quantum observers proposed here have the potential to be employed in coherent feedback control design involving coupling between qubits.

ThD1 — G17_Foyer

Interactive Session II (Nonlinear Systems and Control II) (Interactive Session)

Chair: Dower, Peter M.	Univ. of Melbourne

15:50-17:50 — ThD1.1

Consensus Analysis of Double Integrator Agents with Persistent Interaction Graphs, pp. 120-125

Roy Chowdhury, Nilanjan	IIT Bombay
Sukumar, Srikant	IIT Bombay

This article proposes a technique to compute convergence rate to consensus for multi-agent systems with double integrator agent dynamics interacting via time-varying, undirected and persistent communication graphs. Existing results provide control laws guaranteeing asymptotic convergence to consensus but no practically computable estimate of the convergence rate. We introduce a novel analysis technique relying on classical notions of persistent of excitation (PE) to establish the convergence rate of a mildly modified double integrator consensus law. A transformation is utilized to convert the consensus problem into a stabilization one on which an amalgamation of the Lyapunov function approach and persistence of excitation (PE) results are applied. As in the case of single integrator agents [1], a saturation in the convergence rate is observed.

15:50-17:50 — ThD1.2

A Small-Gain Feedback Interconnection for Bilinear Systems, pp. 126-130

Dower, Peter M.	Univ. of Melbourne
Kellett, Chris	Univ. of Newcastle

Recently it has been shown that general bilinear systems satisfy a nonlinear L2-gain property, which is a qualitatively equivalent special case of the more general integral input-to-state stability (iISS) property. By exploiting a small-gain theorem that attends this

nonlinear L2-gain property, a nontrivial example of a feedback interconnection for general bilinear systems is constructed that preserves this nonlinear L2-gain property, and hence iISS, in closed loop.

15:50-17:50 ThD1.3

Minimum Phase Characterization for Nonlinear Systems with Periodic Trajectories Using Differential Dissipativity, pp. 131-133

Wang, Ruigang — Univ. of New South Wales

Bao, Jie — The Univ. of New South Wales

The minimum phase property is usually defined for the zero dynamics for an equilibrium point, which is asymptotically stable under the zero output constraint. In this paper, it is extended to a more general form -- periodic trajectories. The zero displacement dynamics is introduced to describe the constrained dynamics with respect to periodic output trajectories. A differential dissipation inequality is derived to characterized the minimum phase property. In this approach, the prior knowledge on neither the periodic trajectories nor the explicit solutions of the zero dynamics is required.

15:50-17:50 ThD1.4

Dissipativity Analysis of Discrete-Time Delayed Neural Networks, pp. 134-137

Feng, Zhiguang — The Univ. of Hong Kong

Zheng, Wei Xing — Univ. of Western Sydney

The objective of this paper to analyze dissipativity of discrete-time neural networks with time-varying delay. The main idea is to introduce the concept of extended dissipativity for discrete-time neural networks with a view to unifying several performance measures such as the H_{infty} performance, passivity, l_{2}-l_{infty} performance and dissipativity. The reciprocally convex approach together with a Lyapunov function involving a triple-summable term is applied to develop the extended dissipativity criterion for discrete-time neural networks with time-varying delay. In addition, the new criterion also ensures the stability of the neural networks. The improved results are validated through a numerical example in comparison with the existing results.

15:50-17:50 ThD1.5

Design of Decentrailized Block Backstepping Controllers for Perturbed Large-Scale Systems to Achieve Asymptotic Stability, pp. 138-143

Cheng, Chih-Chiang — National Sun Yat-Sen Univ

Chiang, Yu-Chi — Department of Electrical Engineering, National Sun Yat-Sen Univ

Wu, Min-Yan — Department of Electrical Engineering, National Sun Yat-Sen Univ

A design methodology of decentralized adaptive block backstepping controller is proposed in this paper for a class of large-scale systems with interconnections to solve regulation problems. The perturbation estimation mechanism is employed in the proposed control scheme so that the derivatives of virtual input functions do not need to be computed directly, and the upper bounds of perturbation estimation errors are not required to be known in advance. The proposed robust controller with adaptive mechanisms embedded is designed in accordance with the last block by using Lyapunov stability theorem, so that the upper bounds of interconnections as well as perturbations are not required to be known either. Furthermore, the dynamic equations of each subsystem do not need to strictly satisfy the block strict feedback form, and the resultant controlled system can achieve asymptotic stability. A numerical example is given for demonstrating the feasibility of the proposed control scheme.

ThD2 G17_Foyer

Interactive Session II (Robust Control II) (Interactive Session)

Chair: Dower, Peter M. — Univ. of Melbourne

15:50-17:50 ThD2.1

Conditions for Simultaneous Decentralized Integral Controllability, pp. 144-147

Su, Steven Weidong — Univ. of Tech. Sydney

Tuan, Hoang — Univ. of Tech. Sydney

Chen, weidong — Shanghai Jiao Tong Univ

Nguyen, Hung T. — Univ. of Tech. Sydney

Celler, Branko — Univ. of Western Sydney

This paper explores the designing of a decentralized integral controller to simultaneously ensure closed loop decentralized unconditional stability for a set of multi-variable models. If such a controller exists, then the set of models is considered as Simultaneously Decentralized Integral Controllable (SDIC). We provide an sufficient SDIC condition under which an approach is given to simultaneously achieve closed loop decentralized unconditional stability.

15:50-17:50 ThD2.2

On Virtual Actuators for LPV Systems under Errors in the Measurement of the Varying Parameter, pp. 148-152

Nazari, Raheleh — Univ. of Newcastle

Seron, Maria M. — The Univ. of Newcastle

De Dona, Jose — The Univ. of Newcastle

This paper is concerned with linear parameter varying (LPV) fault tolerant control (FTC) systems reconfigured using virtual actuators. Most works dealing with FTC of LPV systems in general, and in particular using virtual actuators, assume perfect knowledge of the 'varying parameter' of the LPV system description at all times. In this paper, for LPV systems with convex polytopic modelling description, we derive conditions for closed-loop stability of the overall virtual-actuator based FTC system when the varying parameter is not exactly known but measured with bounded errors.

15:50-17:50 ThD2.3

Robust Eigenvalue Assignment Via Particle Swarm Optmization Methods, pp. 153-157

Mahdizadeh, Amin — Univ. of Melbourne

Schmid, Robert — Univ. of Melbourne

We consider the classic problem of robust pole assignment for a linear time invariant plant with state feedback. We employ a parametric formula for the pole placing feedback matrix and implement a particle swarm optimization to seek a gain matrix that will achieve a robust pole assignment, by minimizing the sensitivity of the eigenvalues to uncertainties in the matrices. The performance of the algorithm is compared against several alternative methods from the recent literature.

15:50-17:50 ThD2.4

Radial Basis Function Neural Network Based Rudder Roll Stabilization for Ship Sailing in Waves, pp. 158-163

Wang, Yuanyuan — National Centre for Maritime Engineering and Hydrodynamics, Austr

Nguyen, Hung Duc — National Centre for Maritime Engineering and Hydrodynamics, Aust

Chai, Shuhong — National Centre for Maritime Engineering and Hydrodynamics, Aust
Khan, Faisal — National Centre for Maritime Engineering and Hydrodynamics, Aust

This paper presents a rudder-roll stabilization system utilizing Radial Basis Function neural network (RBFNN) for course keeping and roll damping. Roll motion of a vessel sailing under severe weather conditions has adverse effects on crews' health, cargoes and safety, thus it must be damped as much as possible. A new control algorithm for both course keeping and roll damping is proposed based on the RBFNNs. In order to realize the proposed rudder roll stabilization system, a nonlinear mathematical model of a container vessel with effects of wave disturbance is used to simulate the proposed rudder roll stabilization system which consists of two controllers implemented in parallel, one is the autopilot for course keeping and the other is roll damping controller. The performance and robustness of the proposed control system is investigated by taking consideration of the effects of external disturbance. The simulation studies are designed to verify the improved performance of the proposed rudder roll stabilization system and to validate its efficiency of course keeping and roll motion reduction.

15:50-17:50 ThD2.5

Nonsingular Fast Terminal Sliding Mode Control Approach to Front Wheel Subsystem of Steer-By-Wire System, pp. 164-169

Mousavinejad, Iman (Eman) — Griffith Univ
Zhu, Yong — Griffith Univ
Vlacic, Ljubo — Griffith Univ

The steer-by-wire (SbW) system, in which the conventional mechanical linkage between the steering wheel and the front wheel is removed, is capable to act as an actuator for the active front steering system enhancing vehicle handling performance and safety. Several control strategies have been investigated to control the front wheel subsystem, which is the main part of the SbW system, and improve the steering response of SbW in the presence of system uncertainties and external disturbance; however, improvement of the controller transient response is not considered in most of these control strategies. In this paper a nonsingular fast terminal sliding mode (NFTSM) control method for the front wheel subsystem is first established. The NFTSM technique aims to provide a fast transient response for the front wheel tracking controller in the existence of system uncertainties and disturbance including the tire self-aligning torque, Coulomb friction torque and variation of road condition. Simulation results confirm that the proposed nonsingular fast terminal sliding mode controller not only has strong robustness against uncertainties but also improves the transient response of the tracking controller.

ThD3 G17_Foyer

Interactive Session II (Fault Detection) (Interactive Session)

Chair: Dower, Peter M. — Univ. of Melbourne

15:50-17:50 ThD3.1

Set-Membership Filtering Approach for Fault Detection of Systems with Unknown-But-Bounded Noises, pp. 170-175

Zhang, Yilian — Shanghai Maritime Univ
Qiu, Quanwei — East China Univ. of Science and Tech
Yang, Fuwen — Griffith Univ
Han, Qing-Long — Griffith Univ
Vlacic, Ljubo — Griffith Univ
Lu, Junwei — Griffith Univ

In this paper, a fault detection problem is considered for a class of systems with unknown-but-bounded noises by set-membership filtering approach. The measurement and the process noises are both considered as unknown-but-bounded. Two ellipsoidal sets, which are one-step-ahead prediction ellipsoid and estimation ellipsoid, are proposed for the state estimation. The fault signal is detected by intersecting the two ellipsoids to check whether the intersection set is empty or not. Recursive algorithms for calculating the two ellipsoids and for detecting whether the fault occurs in the system are developed. Simulation results are provided to illustrate the effectiveness of the proposed method.

15:50-17:50 ThD3.2

Sensor Fault Detectability Analysis for Discrete LTI Systems. a Positive Invariance Based Approach, pp. 176-181

Kodakkadan, Abid Rahman — CentraleSupelec
Reppa, Vasso — Supelec
Olaru, Sorin — SUPELEC

The paper considers the abnormal functioning of sensors (measurement channels) deployed for monitoring and control of discrete linear time invariant systems affected by additive uncertainties. The main objective is to analyze the sensor fault detectability via a robust positive invariance based technique. The analysis relies on the categorization of detectable faults and leads to certain conditions for guaranteed non-detectability, guaranteed detectability and implicit detectability.

15:50-17:50 ThD3.3

Actuator and Sensor Fault Detection and Diagnosis of Quadrotor Based on Two-Stage Kalman Filter, pp. 182-187

Moghadam, Majid — Istanbul Tech. Univ
caliskan, fikret — ITU

This paper addresses the problem of sensor and actuator fault detection and diagnosis (FDD) of an unmanned quadrotor helicopter in the presence of the observation and process noises. To this end a Two-Stage Kalman Filter (TSKF) to detect, isolate and identify faults is used. Sensor faults are assumed to be bias faults and actuator faults are modeled as a loss of effectiveness in the propellers. Also a discrete-time Linear Quadratic Regulator (LQR) controller is used to make the system response to follow a desired trajectory.

15:50-17:50 ThD3.4

Model Based Fault Detection Using Unknown Input Observer State Dependent H∞ Filter, pp. 188-193

Wahab, Hamimi — Univ. of Strathclyde
Katebi, M. R. — Univ. of Strathclyde
Hannan, M.A — Univ. Kebangsaan Malaysia

This paper presents an approach for robust fault detection (FD) for discrete-time non-linear systems by employing a modified version of the unknown input observer (UIO) to form a nonlinear stochastic observer using state dependent H∞ filter (SDHF). The new Nonlinear UIO-SDHF structure for detecting faults in the presence of external disturbances and uncertainties are applied to a nonlinear biological process. Simulation results are given to show the effectiveness of the approach to discriminate disturbance and detect sensor and actuator faults.

15:50-17:50 ThD3.5

Functional Observer-Based Fault Detection of Time-Delay Systems Via an LMI Approach, pp. 194-199

Manh Tran, Hieu — Deakin Univ
Trinh, Hieu — Deakin Univ
Phan, T. Nam — Quynhon Univ

This paper presents a novel residual generator that uses minimum-order functional observers to trigger actuator and component faults in time-delay systems. We first present a fault detection scheme and derive existence conditions of the residual generator and functional observer. The observer and residual parameters are then systematically determined via solving some coupled generalized Sylvester matrix equations. To deal with the time-delay issue, a stabilizability condition expressed in terms of linear matrix inequality (LMI) is derived to ensure the time-delay observer error system converges to zero with a prescribed convergence rate. Our design approach has the advantage that the designed fault detection scheme has lower order than existing results in the literature. Two numerical examples are given to illustrate the effectiveness of our results.

FrAO Theatre 4

Oral Session (Control Applications I) (Regular Session)

Chair: Seron, Maria M. The Univ. of Newcastle

09:00-09:15 FrAO.1

Modelling Voltage-Demand Relationship on Power Distribution Grid for Distributed Demand Management, pp. 200-205

xia, lu The Univ. of Melbourne
Alpcan, Tansu The Univ. of Melbourne
Mareels, Iven The Univ. of Melbourne
Brazil, Marcus Univ. of Melbourne
de Hoog, Julian IBM Res. Australia
Thomas, Doreen Univ. of Melbourne

Most existing demand response or management algorithms require a dedicated communication infrastructure to coordinate actions of electricity users. However, the necessary communication infrastructures may not be available in many low-voltage (LV) networks around the world. On the other hand, implicit information on the state of the network is readily available at all times via measurements. In this paper we propose a stochastic modelling approach to estimate aggregate network demand from local voltage measurements at each household using a gamma distribution. The model suggests a linear relationship between the expected value of network demand and voltages at households in the network. We propose a set of illustrative distributed demand control algorithms that allow making decisions based on local information only. Depending on the nature of different appliances, the algorithms either shift the entire demand block to another time (for deferable loads such as driers) or alter the consumption rate of an appliance continuously (for granular loads such as electric vehicles). We illustrate via simulations that the stochastic model captures the actual relationship between voltage and demand. The resulting demand management algorithms are efficient in reducing demand peaks without reducing the overall consumption. Moreover, the lack of explicit communication requirements makes the algorithms scalable and readily applicable to most LV networks.

09:15-09:30 FrAO.2

Internal Model Control for High-Speed Spiral Scan AFM, pp. 206-209

Bazaei, Ali Univ. of Newcastle
Yong, Yuen Univ. of Newcastle
Moheimani, S.O. Reza Univ. of Newcastle

We report on a novel application of internal model control for accurate tracking of a high speed spiral trajectory in scanning probe microscopy. With a closed-loop bandwidth of only 1 kHz, we achieved tracking errors as low as 0.31% of the scan diameter and an ultra-video frame rate of 37.5 frames per second (FPS) for a high pitch spiral trajectory generated by amplitude modulation of 3 kHz sinusoids.

09:30-09:45 FrAO.3

Nonlinear Model Predictive Control Approach for Structural Load Mitigation of Wind Turbines in Presence of Wind Measurement Uncertainties, pp. 210-214

Mohammadalipour Tofighi, Elham Univ. of Newcastle
Faulwasser, Timm Ec. Pol. Fédérale De Lausanne
Kellett, Chris Univ. of Newcastle

In this paper the design of nonlinear model predictive control (NMPC) for multi-mega watt wind turbines is addressed. In an attempt to minimize energy production costs, we propose an NMPC scheme to maximize the wind energy harvest while mitigating structural loads. The proposed controller relies on noisy look-ahead wind field information obtained via LIDAR measurements. By means of simulations we demonstrate the advantages of the proposed NMPC approach.

09:45-10:00 FrAO.4

Regions of Attraction to Ultimate Bound Sets for Inverter-Based Microgrids with Decentralised Frequency Control Loops, pp. 215-220

Heidari, Rahmat Univ. of Newcastle
Seron, Maria M. The Univ. of Newcastle
Braslavsky, Julio H. Commonwealth Scientific and Industrial Res. Organisation

In this paper we study frequency stabilisation in inverter-based microgrid systems with primary droop controller and decentralised secondary control strategy. For the microgrid with any configuration of inverter buses, we establish conditions for trajectory ultimate boundedness and derive an explicit description of an estimate of the region of attraction to the ultimate bound set.

FrB1 G17_Foyer

Interactive Session III (Distributed Systems I) (Interactive Session)

Chair: Yang, Fuwen Griffith Univ

10:00-12:00 FrB1.1

Data-Driven Subspace-Based Distributed Control and Its Algorithmic Convergence, pp. 221-224

Chen, Jianmin China Ship Develop and Design Center
Zhu, Jun China Ship Develop and Design Center
Qiu, Quanwei East China Univ. of Science and Tech
Yang, Fuwen Griffith Univ
Han, Qing-Long Griffith Univ
Vlacic, Ljubo Griffith Univ
Lu, Junwei Griffith Univ

This paper proposed a new data-driven subspace-based distributed control strategy based on Nash optimality. The distributed controller of each subsystem exchange the input-output information with other subsystems by networks. Communication among the controllers is helped to make each controller work in coordination with the others. In this way, the control performance of each subsystem is improved by considering the interactions among subsystems. An iteration algorithm is utilized to achieve the Nash equilibrium. The computational convergence of the algorithm is discussed. Simulations on a radial distribution power system network would provided to verify the validness of the proposed control strategy.

10:00-12:00 FrB1.2

An Improved Droop Control Scheme for Islanded Microgrids, pp. 225-229

Azim, Md. Imran The Univ. of New South Wales, Canberra
Hossain, Md. Jahangir Griffith Univ
Rafi, Fida Griffith Univ
Pota, Hemanshu R. Univ. of New South Wales

This paper proposes an improved droop control algorithm to ensure the proportional load distribution among multiple parallel inverter-sourced generators in a microgrid, operating in an islanded mode. The improvement is done by including derivative term in the

conventional droop control scheme so that the oscillatory modes of the controller can be damped and better dynamic performance is achieved. The proposed controller is a two steps decentralized tunable controller; in which control gains are scheduled via small-signal stability analysis of the microgrid study system, consisting of three inverter-interfaced distributed-generation (DG) units and one static load. The performance of the proposed control method is verified by implementing it under diverse operating conditions and desired damped responses are obtained in all cases that can be seen from simulations.

10:00-12:00 FrB1.3

AIMD in a Discrete Time Implementation or with a Non-Constant Shared Resource, pp. 230-235

Stuedli, Sonja	The Univ. of Newcastle
Middleton, Richard H.	The Univ. of Newcastle
Braslavsky, Julio H.	Commonwealth Scientific and Industrial Res. Organisation
Shorten, Robert	IBM Res

The additive increase multiplicative decrease (AIMD) algorithm, that is commonly used for congestion avoidance in communication networks, has recently been suggested in other fields such as load management in electric power networks. As for congestion avoidance, in such systems a large number of agents are required to share a given resource. In recent work by Shorten, Wirth and Leith on congestion control in networking a stochastic model has been developed to analyse AIMD algorithms. However, the analysis assumes a continuous implementation of the algorithm and a constant available resource. These assumptions are no longer useful if the AIMD algorithm is applied in fields such as load management in electric power networks, where a discrete implementation is often required, and the available resource shared may be inherently variable. In this paper we develop a disturbed AIMD model based on the model introduced by Shorten et al. that includes discrete time implementation and time varying resource availability. Further, we use that model to bound the influence of these disturbances, caused by either a discrete implementation or small variations in the available resource.

10:00-12:00 FrB1.4

Displacement-Based Formation Tracking Control of Multi-Agent with Size Scaling, pp. 236-240

Wu, Zixing	Nanjing Univ. of Science and Tech. Nanjing, China
Sun, Jinsheng	Nanjing Univ. of Science and Tech. Nanjing, China
Wang, Ximing	Nanjing Univ. of Science and Tech. Nanjing, China

In this paper, we propose a formation control algorithm for multi-agent systems to achieve prospected formation shape and track reference trajectory. We assume the description of formation and reference velocity is known to all agents. For second-order dynamics, we present a strategy that allows all agents to maneuver to desired scaled formation during tacking leader's movements. Finally, simulation results show that the proposed displacement-based formation tracking strategies are effective.

10:00-12:00 FrB1.5

Rigid Formation Control Systems Modelled by Double Integrators: System Dynamics and Convergence Analysis, pp. 241-246

Sun, Zhiyong	The Australian National Univ
Anderson, Brian D.O.	Australian National Univ

In this paper we study rigid formation control systems modelled by double integrators. Two kinds of double-integrator formation systems are considered, namely, the formation stabilization system and the flocking control system. Certain novel observations on the null space and eigenvalues of the system Jacobian matrix will be provided, which reveal important properties of system dynamics and the associated convergence results. We also establish some links between single-integrator formation systems and double-integrator formation systems via a parameterized Hamiltonian system, which further provide stability criteria for different equilibria in double-integrator formation systems by using available results in single-integrator formation systems.

FrB2 G17_Foyer

Interactive Session III (Model Predictive Control) (Interactive Session)

Chair: Yang, Fuwen Griffith Univ

10:00-12:00 FrB2.1

Towards Systematic Design of MPC to Achieve Time Domain Specifications, pp. 247-252

Gowri Sankar, Gokul Siva Sankar	The Univ. of Melbourne
Moase, William	The Univ. of Melbourne
Shekhar, Rohan Chandra	The Univ. of Melbourne
Broomhead, Timothy James	The Univ. of Melbourne
Manzie, Chris	The Univ. of Melbourne

This paper presents a systematic design procedure for obtaining a model predictive controller (MPC), encompassed within standard MPC formulations for constrained linear systems to achieve desired output transient responses. The proposed formulation provides a way of overcoming the complexity involved in tuning MPC controllers to accomplish certain output response characteristics. Exponential envelopes are introduced and the outputs are constrained to remain within the envelopes forming the key tuning parameters in meeting the time domain specifications. The key feature of this controller compared to the standard MPC controllers, is the reduced number of effective tuning parameters. Moreover, closed loop stability is guaranteed under standard assumptions. The systematic tuning procedure of the proposed controller is illustrated on a numerical simulation of a double mass-spring-damper system with time domain requirements on the output.

10:00-12:00 FrB2.2

Periodic Economic Model Predictive Control with Bounded-State Stability, pp. 253-258

Tran-Cao, Tri	Nanyang Tech. Univ

This paper presents an economic model predictive control (EMPC) scheme for nonlinear affine systems employing the quadratic dissipativity constraint (QDC) previously introduced. The vector fields are included in the supply rate such that a dissipative condition based on linear matrix inequality (LMI) is rendered for nonlinear systems. Both storage function and supply rate are periodic and parameterized in this formulation. The closed-loop system stability is obtained as a result of having the QDC as an enforced stability constraint to the EMPC optimization. This is a constraint with respect to the current-time control vector. In finding a stability condition suitable for systems that may not operate at the optimal steady state with EMPC, we have chosen the bounded-state stability (BSS) and derive a stabilizability condition with QDC in the discrete-time domain. The BSS is characterized by a non-monotonically decreasing storage function and the boundedness property of Lagrange stability.

10:00-12:00 FrB2.3

A Real-Time Pricing Scheme for Residential Energy Systems Using a Market Maker, pp. 259-262

Braun, Philipp	Univ. of Bayreuth
Gruene, Lars	Univ. of Bayreuth
Kellett, Chris	Univ. of Newcastle

Weller, Steven — Univ. of Newcastle
Worthmann, Karl — Tech. Univ. Ilmenau

Voltage rise is an undesirable side-effect of solar photovoltaic (PV) generation, arising from the flow of surplus electrical power back into the grid when PV generation exceeds local demand. Customers deploying residential-scale battery storage are likely to further exacerbate voltage rise problems for electrical utilities unless the charge/discharge schedules of batteries are appropriately coordinated. In this paper, we present a real-time pricing mechanism for use in a network of distributed residential energy systems (RESs), each employing solar PV generation and battery storage. The pricing mechanism proposed in this paper is based on a Market Maker algorithm in which predicted power profiles and real-time pricing information is iteratively exchanged between a central entity and each of the RESs. The Market Maker formulation presented in this paper is shown via simulation studies to converge to a fixed price vector, thereby reducing the price volatility observed in an earlier formulation, while achieving the same reduction in power usage variability as a centralised model predictive control (MPC) scheme presented previously.

10:00-12:00 FrB2.4

An Improved Controller Design for Reducing Errors in AFM Imaging, pp. 263-268

Rana, Md. Sohel — The Univ. of New South Wales, Canberra
Pota, Hemanshu R. — Univ. of New South Wales
Petersen, Ian R. — Australian Defence Force Acad

In this article, the design and implementation of a multi-input multi-output (MIMO) model predictive control (MPC) framework for reducing errors in images scanned by an atomic force microscope (AFM) is presented. To improve the damping capability of the proposed control framework, it is augmented with a damping compensator. The MIMO form of this control framework compensates the tilted natures of the scanned images by compensating the cross-coupling effect while its augmented damping compensator reduces the vibration effect by improving damping in the resonant mode of the AFM's piezoelectric tube scanner (PTS). Experimental results using the existing AFM proportional integral (PI) controller and single-input single-output (SISO) MPC are also presented to show the effectiveness of the MIMO MPC controller. This paper is an extension of an authors' earlier published work.

FrB3 — G17_Foyer

Interactive Session III (Modelling and Identification) (Interactive Session)

Chair: Yang, Fuwen — Griffith Univ

10:00-12:00 FrB3.1

Steady-State and Transient Dynamic Behavior of Simple Climate Models for Application in Integrated Assessment Models, pp. 269-273

Hafeez, Salman — Univ. of Newcastle
Weller, Steven — Univ. of Newcastle
Kellett, Chris — Univ. of Newcastle

We characterize the steady-state and transient dynamic behavior of a suite of twelve linear time-invariant (LTI) climate models capturing the response of global mean surface temperature to net radiative forcing. The LTI models considered here have previously been obtained by system identification experiments with data derived from the Coupled Model Intercomparison Project phase 3 (CMIP3), and have subsequently been applied in integrated assessment models (IAMs) of climate–economy based on the solution of a finite-horizon nonlinear optimal control problem, where atmosphere– ocean general circulation models (AOGCMs) of the climate are computationally prohibitive. In this paper, we compute the equilibrium climate sensitivity (ECS) and transient climate response (TCR) for each of the twelve LTI climate models in the model suite, and compare the values so obtained with previously published values of ECS and TCR for these CMIP3 models. The results of this paper confirm the suitability of simple LTI climate models in IAMs, and validate the robustness of conclusions drawn from the application of such models in integrated climate–economy assessments.

10:00-12:00 FrB3.2

Cross Gramian Based Time Interval Model Reduction, pp. 274-276

Jazlan, Ahmad — Univ. of Western Australia
Sreeram, Victor — Univ. of Western Australia
Togneri, Roberto — Univ. of Western Australia

This paper presents the development of new Sylvester equations for both continuous and discrete time linear SISO and symmetric MIMO systems in order to obtain the time interval cross gramian matrices which have time interval controllability and observability information contained in a single matrix. Numerical examples are provided to demonstrate the computational efficiency of the proposed method which requires computing only the time interval cross gramian compared to existing techniques which require the computation of both time interval controllability and observability gramians simultaneously.

10:00-12:00 FrB3.3

A Combined Use of the Adaptive Inverse Plant Modeling and Iterative Learning Control Strategy for Service Load Simulations, pp. 277-282

Moten, Sikandar — KU Leuven
Pipeleers, Goele — KU Leuven
Desmet, Wim — KU Leuven, Department of Mechanical Engineering, Div. of PMA
Swevers, Jan — KU Leuven

Service load simulation is a crucial step in the design and development cycle of automotive vehicles. The objective of these tests is to reproduce acquired road load data in lab environment typically on a vibration test rig. This research proposes an algorithm for load data replication that makes use of adaptive inverse plant modeling (AIPM) and iterative learning control (ILC) techniques. The validation of the proposed approach is done through simulation using the single-input single-output (SISO) linear and non-linear test rig models. It is shown that both the tracking accuracy and convergence behavior are improved compared to an existing state of the art time waveform replication (TWR) method. Moreover, the LDR approach utilizes a time domain iterative control law and requires minimal processing time in between trials to update the drive signals for reproducing the load data in contrast to existing approach.

10:00-12:00 FrB3.4

Modeling and Attitude Control for Solar Sail Based on Gimbal Boom, pp. 283-287

Wu, Liping — Nanjing Univ. of Science and Tech
Guo, Yu — Nanjing Univ. of Science and Tech
Yu, Zhen — Nanjing Univ. of Science and Tech
Xu, Yi — Nanjing Univ. of Science and Tech

Solar sail is a new type of spacecraft with propellantless propulsion, whose flight greatly depends on its attitude. The purpose of this paper is to present an attitude control strategy for solar sail using a gimbal boom as actuator. Focusing on the large scale but light weight flexible sail structure, a reduced rigid-flexible coupling model is established including the dynamics of actuator. Based on the proposed nonlinear model, a LQR control law is designed to accomplish a pitch axis reorientation control with a permitted control torque which is limited to actuator. In addition, to deal with the vibrations induced by attitude maneuver, a path planning technique is proposed combined with the feedback control law to improve the performance of the control system. The numerical simulation results demonstrate the effectiveness of the proposed algorithms.

FrCO	Theatre 3
Oral Session (Control Applications II) (Regular Session)	
Chair: Lees, Michael	Carlton & United Breweries

14:00-14:15 FrCO.1

Cement Rotary Kiln: Constraints Handling and Optimization Via Model Predictive Control Techniques, pp. 288-293

Zanoli, Silvia Maria — Univ. Pol. Delle Marche
Pepe, Crescenzo — Univ. Pol. Delle Marche
Rocchi, Matteo — Univ. Pol. Delle Marche

In this work an Advanced Process Control approach aimed to the control and the optimization of a cement rotary kiln is proposed. Model Predictive Control techniques have been adopted for the controller and a system architecture based on two optimization layers is proposed. A suitable design of each layer and their interaction policy allowed to improve control performances and to meet possibly variable economic goals. Simulation results show the effectiveness of the adopted control architecture and optimization problem formulation. Results of practical implementation of the proposed controller on a cement rotary kiln unit confirm the improvement of the performances in terms of energy efficiency, product quality and environmental impact when compared to the previous control system.

14:15-14:30 FrCO.2

Sensor Reintegration in the Fault Tolerant Control of Linear Parameter Varying Systems, pp. 294-299

McCloy, Ryan Josef — Univ. of Newcastle
De Dona, Jose — The Univ. of Newcastle
Seron, Maria M. — The Univ. of Newcastle

In this paper, we present a fault tolerant control (FTC) scheme for linear parameter varying systems that utilises multiple sensor switching to compensate for sensor faults. The closed-loop scheme consists of an estimator-based feedback tracking controller and sensor-estimate switching strategy which allows for the recovery of faulty sensors. The switching mechanism tracks the transitions from faulty to healthy behaviour by means of set separation and pre-computed transition times. The selected sensor-estimate pairing is then reconfigured based on available healthy sensors. Under the proposed scheme, preservation of closed-loop system boundedness is guaranteed for a wide range of sensor fault situations. An example is presented to illustrate the performance of the FTC strategy.

14:30-14:45 FrCO.3

Transversal Surface Wave Control by Gain Switching Iterative Learning Improving Research on Active Turbulent Flow Control, pp. 300-305

Dueck, Marcel — Res. Center Juelich GmbH
Abel, Dirk — RWTH Aachen Univ
van Waasen, Stefan — Res. Center Juelich GmbH
Schiek, Michael — Res. Center Juelich GmbH

Active turbulent flow control for friction drag reduction at high Reynolds numbers ($mathbf{Re > 10^4}$) on transportation systems such as airplanes is investigated. The drag reduction is based on transversal surface waves effecting the turbulent boundary layer. For this wave parameter studies are performed in subsonic wind tunnel experiments using an in house developed electromagnetic actuation system for flexible generation of sinusoidal surface waves with amplitudes between $mathbf{50}$ and $mathbf{500mu m}$. To ensure an amplitude accuracy better than 5% and a real-time parameter switching we evaluated a gain switching iterative learning control for the transversal surface waves. This approach enables efficient and reliable wind tunnel experiments investigating active turbulent flow control.

14:45-15:00 FrCO.4

PID Controller Design for Industrial Beer Filtration, pp. 306-311

Lees, Michael — Carlton & United Breweries
Wang, Liuping — RMIT Univ

This paper investigates the optimization and control of a beer filtration process via closed-loop PID control. The authors' previous work has found that the beer filtration process changes in both dynamics and steady-state gain, resulting in different linear models obtained at different operational times. This paper addresses the issue of multiple linear models for a plant by taking the average of their frequency responses to obtain a single set of frequency response data. It also proposes to use a PID controller design technique based on two frequency response data points. The PID controller is then validated using Nyquist loci for measuring gain and phase margins. Closed-loop control simulations that mimic the filtration process have been used to demonstrate the feasibility of maintaining the desired operating conditions of the filtration process by manipulating the system input.

FrD1	G17_Foyer
Interactive Session IV (Distributed Systems II) (Interactive Session)	
Chair: Nazarathy, Yoni	The Univ. of Queensland

15:00-16:30 FrD1.1

Decentralized Coherent Quantum Control Design for Translation Invariant Linear Quantum Stochastic Networks with Direct Coupling, pp. 312-317

Khodaparastsichani, Arash — UNSW Canberra at Australian Defence Force Acad
Vladimirov, Igor — UNSW Canberra
Petersen, Ian R. — Australian Defence Force Acad

This paper is concerned with coherent quantum control design for translation invariant networks of identical quantum stochastic systems subjected to external quantum noise. The network is modelled as an open quantum harmonic oscillator and is governed by a set of linear quantum stochastic differential equations. The dynamic variables of this quantum plant satisfy the canonical commutation relations. Similar large-scale systems can be found, for example, in quantum metamaterials and optical lattices. The problem under consideration is to design a stabilizing decentralized coherent quantum controller in the form of another translation

invariant quantum system, directly coupled to the plant, so as to minimize a weighted mean square functional of the dynamic variables of the interconnected networks. We consider this problem in the thermodynamic limit of infinite network size and present first-order necessary conditions for optimality of the controller.

15:00-16:30 FrD1.2

Distributed Formation Control with Limited Sensing Ranges and Scalability, pp. 318-321

Yu, Hongjun — Univ. of Adelaide
Shi, Peng — The Univ. of Adelaide
Lim, Cheng-Chew — Univ. of Adelaide

This paper is concerned with the formation control and stability analysis for a team of robots when the size is variable, the individual sensing range is limited and no data communication is assumed among the robots. The concept of triangle displacement based formation is established to make the formation scalable. In the control strategy, the predefined formation is first partially reached but it is subject to potential collisions. Then, a protocol is proposed to eliminate all collisions while maintaining connectivity. Subsequently, a novel controller is designed and a coordination protocol is developed. Analysis is made on simulation examples to demonstrate the performance and merits of the proposed techniques.

15:00-16:30 FrD1.3

Two Targets Tracking Over Heterogeneous Sensor Networks with Random Network Topologies, pp. 322-326

Ge, Xiaohua — Central Queensland Univ
Han, Qing-Long — Griffith Univ
Vlacic, Ljubo — Griffith Univ

This paper is concerned with the problem of two targets tracking over sensor networks. A heterogeneous sensor network framework in considered, in which two types of sensors are employed (denoted as x-type and y-type sensors, respectively). Sensors with x-type can only measure information from target x, while sensors with y-type can only measure information from target y. Sensors update their tracking estimations by using only local information collected from neighboring ones. The network topology is random and governed by a continuous-time Markov process, whose states represent possible modes of interaction topologies of sensors. To solve the two targets tracking problem, a novel distributed tracking protocol in the form of consensus-based estimators is delicately developed. Then, tracking performance analysis against the effects of random network topologies is carried out as well as a criterion for designing desired tracking protocol parameters is derived such that the two targets tracking can be achieved. A numerical example is given to demonstrate the effectiveness of the proposed theoretical results.

15:00-16:30 FrD1.4

Distributed Negotiation for Scheduling Smart Appliances, pp. 327-330

Farokhi, Farhad — The Univ. of Melbourne
Cantoni, Michael — Univ. of Melbourne

A framework is presented for scheduling smart appliances based on electricity prices and constraints, such as timing of service, delays between phases of operation and working regimes, and maximum permissible power consumption. We use game theory to construct a distributed algorithm for negotiating the optimal schedule for the appliances.

FrD2 G17_Foyer

Interactive Session IV (Motion Control; Stochastic Control; Linear Systems; Filters and Filtering) (Interactive Session)

Chair: Nazarathy, Yoni — The Univ. of Queensland

15:00-16:30 FrD2.1

Modeling and Measurement Algorithm of Hexapod Platform Sensor Using Inverse Kinematics, pp. 331-335

Shi, Hongliang — The Ohio State Univ
Duan, Xuechao — Xidian Univ
She, Yu — The Ohio State Univ

This paper covers the design of a series of hexapod platform sensors and an inverse kinematics based measurement algorithm. Hexapod platforms are widely used as the motion positioning devices with 6 degrees of freedom (DOF). In this paper, we convert the positioning stages to the platform sensors to determine the motion errors of a target positioning device by measuring the length changes of the struts and the displacements of the bottom stages. Based on the geometric layout and the topology, the inverse kinematic models are built for the platforms to establish the relationship of the motion of the top platform and the changes of the struts and the marks on the bottom stages. Based on the kinematic model, a measurement algorithm is proposed for the devices.

15:00-16:30 FrD2.2

Towards the Development of Numerical Procedure for Control of Connected Markov Chains, pp. 336-341

Miller, Alexander — Inst. for Information Transmission Problems, RAS
Miller, Boris — Inst. for Information Transmission Problems RAS and Monash U
Popov, Alexey — Inst. for Information Transmission Problems of the Russian A
Stepanyan, Karen — Inst. for Information Transmission Problems

The system of controlled time-inhomogeneous Markov chains (MCs) is considered. The principal problem related to this kind of systems and could be called as the "curse of dimension" appears as a necessity of solving a system of ordinary differential equations of high dimension. Moreover, even the software development for such systems is a serious issue since these equations are linked and the standard parallelization approaches in existing software packages are not very effective. Meanwhile, we noticed that the minimization procedure needed for the right-hand side (RHS) of this system may be easily parallelized by independent minimization in each equation. As an example we consider the management of linked dams under non-stationary seasonally changing random inflows/outflows and customers' demands. The current state of each dam is described by the state of continuous-time MC corresponding to the water level. So the state of the dams system is represented in tensor form. The connection of MCs is a result of the controlled flow between dams. The aim of the control is to maintain the required water levels on the weather conditions and to satisfy the customers' demands. The general approach is based on the solution of Bellman type equation in tensor form. This equation may be reduced to the system of ordinary differential equations. We suggest here the automatic procedure for the generation of this system and also the approach to the minimization of the RHS.

15:00-16:30 FrD2.3

The Challenge of Stabilizing Control for Queueing Systems with Unobservable Server States, pp. 342-347

Nazarathy, Yoni	The Univ. of Queensland
Taimre, Thomas	School of Mathematics and Physics, the Univ. of Queensland,
Asanjarani, Azam	The Univ. of Queensland
Kuhn, Julia	The Univ. of Queensland
Patch, Brendan	The Univ. of Queensland and Univ. of Amsterdam
Vuorinen, Aapeli	The Univ. of Queensland, Australia

We address the problem of stabilizing control for complex queueing systems where servers follow unobservable Markovian environments. The controller needs to assign servers to queues without full information about the servers' states. A control challenge is to devise a policy that matches servers to queues in a way that takes state estimates into account and updates these estimates in the best way possible. Maximally attainable stability regions are non-trivial.

We present the model, the control problem, and some preliminary methods for analysis and control. We illustrate basic phenomena and then focus on the simplest possible model having a single queue, a fixed state server, and a two state server. For this case, we begin analysis of a partially observable Markov decision process (POMDP) hinting at some structural properties. We also show how to use a quasi-birth--death (QBD) process for analysis and control.

15:00-16:30 FrD2.4

Reduction of Discrete Interval Systems through Fuzzy-C Means Clustering with Dominant Pole Retention, pp. 348-353

Gupta, Neeraj	Motilal Nehru National Inst. of Tech. Allahabad (India
Narain, Anirudha	Motilal Nehru National Inst. of Tech. Allahabad (India

the work carried out here, introduces an improved mixed method for order reduction of interval systems based on Fuzzy C-Means (FCM) clustering algorithm along with Padé Approximation method. In proposed technique for a given interval system the reduced order denominator is constructed through FCM clustering using dominant pole approach. The added impact of these two approaches tries to capture the most of essential characteristics of original higher order system. The reduced order model numerator is approximated using Padé approximation with determination of optimized ‘r' time moments of the higher order interval system belonging to its reduced order system, here ‘r' is the order of reduced order interval system (ROIS).

15:00-16:30 FrD2.5

Geometric Structure and Properties of LTI Systems in the Controller Canonical Form, pp. 354-359

Kazantzidou, Christina	Curtin Univ
Ntogramatzidis, Lorenzo	Curtin Univ
Vardulakis, Antonis	Aristotle Univ. of Thessaloniki
Garone, Emanuele	Univ. Libre De Bruxelles

In this paper we analyse the geometric properties of systems in the controller canonical form. We show that using a technique based on the calculation of null-spaces of the Rosenbrock system matrix pencil facilitates the computation of the fundamental geometric subspaces for such systems. It is also shown how this geometric analysis can be exploited to derive necessary and sufficient conditions for the solution of the global monotonic tracking control problem solely in terms of the problem data.

15:00-16:30 FrD2.6

Particle Filter Based Scale Adaptive Compressive Tracking, pp. 360-365

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Compressive Tracking is a very popular vision tracking method based on Compressive Sensing theory. In the Compressive Tracking, the measurement matrix is used to transform the image patch to a feature vector and plays a fundamental role in the tracking procedure. However, based on our analysis the traditional way of constructing the measurement matrix has intrinsic problems. In this paper, we propose a loop-blocked matrix which can extract more complete and discriminative information than the original one. In order to make our method robust to scale variation, a scale adaptive window model is also developed and its parameters are estimated by the particle filter. Regarding to the issue of occlusion, a forgetting model is proposed to improve the tracking robustness, especially when complete occlusion happens or the occlusion lasts too long. Experiments show that our algorithm has good adaption to the scale changes of the target in the image and good robustness to occlusion.

15:00-16:30 FrD2.7

Elevator Absolute Landing Position Sensor Using Infrared Interrupter and MEMS Accelerometer, pp. 366-370

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Absolute encoder is a common solution to detect the position of elevator cabin in a reliable way, yet it require extra cabling and chain to accomplish the work. The installation and maintenance cost is the main trade-off. However, absolute position is only required by certain cases such as re-leveling. This is a situation where loading of the elevator cabin changes makes the elevator steel rope extends. The worst situation for a high-rise building may have more than 10 mm shifting in the elevator cabin platform. Such an offset between the cabin platform and floor level can stumble passenger boarding or disembarking. In this proposed design, a linear position sensor detecting the position of landing zone vane is targeted to provide position sensing resolution up to 0.01 mm with maximum of 1mm error, using traditional infrared interrupter and new MEMS accelerometer. The device can help to improve motion control of the elevator with its high resolution and high accuracy to prevent position overshooting and steady state error. Kalman filter is employed to fusion the detected position and acceleration signal and outputting a clean and reliable position reading to the elevator motion control system.