2017 6th International Symposium on Advanced Control of Industrial Processes (AdCONIP)

28 – 31 May 2017
Taipei
Howard International House

Hosted by
Petrochemical Industry Research Center
Department of Chemical Engineering
College of Engineering
National Taiwan University

AdCONIP Series

Kumamoto (2002)	Seoul (2005)	Jasper (2008)
Hangzhou (2011)	Hiroshima (2014)	Taipei (2017)

Welcome to AdCONIP 2017

On behalf of the **International Program Committee** (**IPC**) and **National Organizing Committee** (**NOC**), we would like to warmly welcome you to ***2017 6th International Symposium on Advanced Control of Industrial Processes*** (***AdCONIP***). We are delighted to have you here in Taipei to share your experiences and to contribute to the theory and practice of advanced control for industry.

AdCONIP is a triennial international symposium bringing together researchers and practitioners to discuss recent developments in advanced control and their applications in industry. ***AdCONIP 2017*** is the sixth symposium following previous events at Kumamoto (2002), Seoul (2005), Jasper (2008), Hangzhou (2011), and Hiroshima (2014).

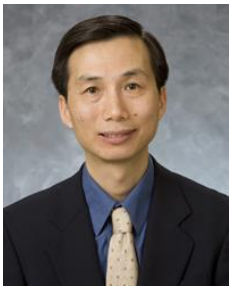
Based on a rigorous review process, the International Program Committee selected 110 papers for presentation (64 regular papers, 6 keynote papers, and 40 invited session papers). The program consists of 6 regular sessions, 7 invited sessions, 1 poster session, 6 keynote sessions, and 4 plenary sessions. There are four invited keynote speakers and 2 selected from the contributions. Each morning starts with a plenary talk. Each day 3 keynotes are delivered in parallel in the early afternoon. Another plenary talk is scheduled at the end of each day. The regular and invited sessions are split into four parallel tracks on Monday and three on Tuesday. A poster session will be held on Monday afternoon before the second plenary talk.

The program is also complemented by a preconference workshop on process data analytics taking place on Sunday, May 28. The social program consists of the Welcome Reception on Sunday evening, the Conference Banquet on Monday evening, the Closing Ceremony on Tuesday, and an optional free half-day tour to the National Palace Museum on Wednesday.

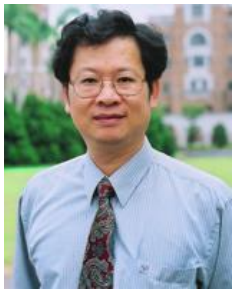
The excellence of the program would not be possible without the tremendous contributions of the **NOC** and **IPC** members, secretaries, invited session organizers, associate editors who organized review of the papers, and all the reviewers. We would also like to acknowledge the generous support from the conference sponsors.

Please do not hesitate to stop at the conference registration desk or contact any volunteer if you have questions or need help. We hope you will enjoy your stay in Taipei.

Best Regards,



Biao Huang
IPC Chair



Cheng-Liang Chen
NOC Chair

Welcome to Taipei

Taipei, the largest city in **Taiwan**, is situated in the north of the island near the confluence of the Keelung and Xindian rivers. With 2.7 million people living within the city and more than seven million living in the greater metropolitan area, Taipei ranks among the 50 most populous metropolitan regions in the world.

Popular attractions in Taipei include the National Palace Museum, which boasts a collection of nearly 700,000 imperial artifacts and artworks spanning nearly 8,000 years of Chinese history; Taipei 101, the tallest skyscraper in Taiwan and once the tallest building in the world, which offers panoramic views of the city from its observation deck on the 89th floor; and the Chiang Kai-shek Memorial Hall, a monument to the former leader. Additional information about tourist attractions in Taipei is available from the website of the Taipei City Department of Information and Tourism: https://www.travel.taipei.

Transportation in Taipei is very convenient with a modern subway system covering most of the city. Taxis can be hailed directly on the street in most locations. Transportation to and from the Taiwan Taoyuan International Airport is also convenient with the recent completion of the Taoyuan Airport Access rapid transit line. Additional information about travel to and from the airport and within Taipei is also available on the internet: https://www.travel.taipei/en/information/trafficlist

The National Organizing Committee (NOC) sincerely welcomes you to Taipei. We hope you enjoy your visit.

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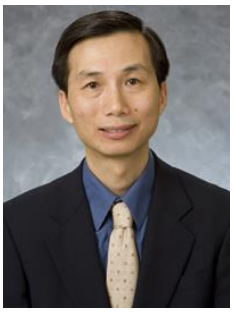

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Shoukat Choudhury	BGD	Ikuro Mizumoto	JPN
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Chang Jun Lee	KOR	Quanxiong Zhu	CHN
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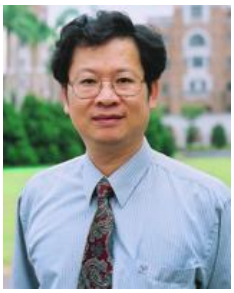
National Organizing Committee



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National Taiwan University

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Wei Wu	National Cheng-Kung University
Yuan Yao	National Tsinghua University

Plenary Talk 1

Richard D. Braatz

Advanced Control of Pharmaceutical Crystallization

Monday May 29, 2017
09:30 – 10:20
1F Conference Room

Crystallization from solution is widely used industrial process for purification, especially in the pharmaceutical industry in which most drugs undergo multiple crystallizations during the manufacturing of the final drug product. Modern control system technologies have reduced the time required to develop robust, scalable, and reliable crystallization processes; enabled the robust isolation of metastable and stable crystal forms; and enabled the removal or simplification of post-crystallization processing—with associated increases in productivity, product quality, and product consistency.

The lecture will describe advances in the control of pharmaceutical crystallization processes, which include (1) an automated procedure that designs nearly optimal batch control policies, (2) a nonlinear feedback control design provably robust to large variations in the crystallization kinetics, (3) the incorporation of process intensification strategies, which employ micromixers, ultrasonic irradiation, and multiphase flow instabilities to enhance actuation or improve spatiotemporal dynamics. Experimental results will be presented with improved control of molecular purity, crystal structure, and particle size distribution.

Richard D. Braatz is the Edwin R. Gilliland Professor at the Massachusetts Institute of Technology (MIT) where he does research in control theory and its application to advanced manufacturing. He received an MS and PhD from the California Institute of Technology and was the Millennium Chair and Professor at the University of Illinois at Urbana-Champaign and a Visiting Scholar at Harvard University before moving to MIT. He has consulted or collaborated with more than 20 companies including United Technologies Corporation, IBM, Novartis, and Merck. Honors include the Donald P. Eckman Award from the American Automatic Control Council, the Antonio Ruberti Young Researcher Prize, and the IEEE Control Systems Society Transition to Practice Award. He is a Fellow of IEEE and IFAC.

Plenary Talk 2

Sigurd Skogestad

Economic Plantwide Control

Monday May 29, 2017
16:50 – 17:40
1F Conference Room

A chemical plant may have thousands of measurements and control loops. By the term *plantwide control* it is not meant the tuning and behavior of each of these loops, but rather the control philosophy of the overall plant with emphasis on the structural decisions. In practice, the control system is usually divided into several layers, separated by time scale: scheduling (weeks), site-wide optimization (day), local optimization (hour), supervisory and economic control (minutes) and regulatory control (seconds). Such a hierarchical (cascade) decomposition with layers operating on different time scale is used in the control of all real (complex) systems including biological systems and airplanes, so the issues in this section are not limited to process control. In the talk the most important issues are discussed, especially related to the choice of “self-optimizing” variables that provide the link the control layers. Examples are given for optimal operation of a runner and distillation columns.

Sigurd Skogestad is a professor in chemical engineering at NTNU. He worked in industry (Norsk Hydro) from 1980 to 1983 in the areas of process design and simulation. Moving to the US, he received the Ph.D. degree from the California Institute of Technology in 1987. He is a worldwide expert in the area of process control with about 150 journal publications and a current H factor of 28 (2009). He is the principal author together with Ian Postlethwaite of the very popular book "Multivariable feedback control" published by Wiley in 1996 (first edition) and 2005 (second edition). The goal of his research is to develop simple yet rigorous methods to solve problems of engineering significance, including biological problems. Research interests include the use of feedback as a tool to (1) reduce uncertainty (including robust control), (2) change the system dynamics (including stabilization), and (3) generally make the system more well-behaved (including self-optimizing control).

Plenary Talk 3

Jia-Yushi Yen

Corneal Biomechanical Model and Intraocular Pressure Measurement

Tuesday May 30, 2017
09:00 – 09:50
1F Conference Room

This talk introduces the research effort in NTU to directly extract the corneal Young's modulus *in vivo* using the Scheimpflug imaging technique. An eye ball model was developed to describe the corneal behavior under the impinging air puff to compare with the data extracted by the image processing tool from the Scheimpflug image of the Corvis® ST. The data from 536 right eyes of 536 healthy subjects were analyzed. The IOP is directly affected by the patients' Young's modulus. The mean Young's moduli of right eyes and left eyes were not statistically different. The Corvis® ST parameters such as the CCT was weakly correlated with the IOP and the Young's modulus. Univariate analysis shows weak correlations between the Young's modulus and the age, the IOP, the CCT, and the DA. Analysis results show that the estimated Young's modulus does not change significantly between the two eyes, but slightly decrease in elder group, weakly correlated with the age, the IOP, the CCT, the DA, and the A1T. Without the Young's modulus correction, the IOP reading can be seriously misleading.

Professor Jia-Yush Yen received his Ph.D degree in Mechanical Engineering from University of California, Berkeley in 1989. He then joined the Mechanical Engineering faculty of National Taiwan University where he served as the Department Chair for three years and the director of the Tjing-Ling Industrial Research Institute for four years. Currently, he also serves as the Dean of the College of Engineering. Prof. Yen served as the Chair of the Automation Area for the National Science Council for three years. He is the Secretary General of the Institute of Engineering Education Taiwan. He served as the President of the Chinese Institute of Automation Engineers (CIAE) for four years. He is the fellow of ASME, Chinese Society of Mechanical Eng., and CIAE. Dr. Yen received many awards, among them the Outstanding Research Award from the Taiwan National Science Council (now the Ministry of Science and Technology) which is awarded only to the topmost researchers in their area. Dr. Yen also received numerous compliments from the government for his public service. He had also served as a consultant for many companies and institutes. His research interests are in the areas of mechatronic systems, computer peripherals, and nano-manipulations.

Plenary Talk 4

Jay H. Lee

Mathematical Programming and Dynamic Programming: How they can be combined for further use in planning, scheduling and control of multi-scale stochastic energy systems

Tuesday May 30, 2017
15:40 – 16:30
1F Conference Room

Mathematical programming has been an important pillar of the process systems engineering discipline and has provided useful tools for making optimal decisions in many process design, operation planning/scheduling, and control problems. Dynamic programming has been the foundation of many classical optimal control methods, especially those addressing stochastic systems like the linear quadratic Gaussian method. In this talk, we will review how they have supported each other in the development of theories and tools for optimal control. This will be followed by a discussion on their shortcomings as individual methods for addressing multi-scale, stochastic decision and control problems and how they may be combined in a complementary manner to provide more general and powerful methods for solving such problems. Examples of multiple timescale planning and scheduling problems in electric power grid operation will be presented to highlight the issues and illustrate the roles of the two respective approaches.

Jay H. Lee obtained his B.S. degree in Chemical Engineering from the University of Washington, Seattle, in 1986, and his Ph.D. degree in Chemical Engineering from California Institute of Technology, Pasadena, in 1991. From 1991 to 1998, he was with the Department of Chemical Engineering at Auburn University, AL, as an Assistant Professor and an Associate Professor. From 1998-2000, he was with School of Chemical Engineering at Purdue University, West Lafayette, and then with the School of Chemical Engineering at Georgia Institute of Technology, Atlanta from 2000-2010. Since 2010, he is with the Chemical and Biomolecular Engineering Department at Korea Advanced Institute of Science and Technology (KAIST), where he was the department head from 2010-2015. He is currently a Professor and Director of the Saud Aramco-KAIST CO_2 Management Center there. He has held visiting appointments at E. I. Du Pont de Numours, Wilmington, in 1994 and at Seoul National University, Seoul, Korea, in 1997. He was a recipient of the National Science Foundation's Young Investigator Award in 1993 and was elected as an IEEE Fellow and an IFAC (International Federation of Automatic Control) Fellow in 2011 and AIChE Fellow in 2013. He was also the recipient of the 2013 *Computing in Chemical Engineering* Award given by the AIChE's CAST Division and the 2016 Roger Sargent Lecturer at Imperial College, UK. He is currently an Editor of *Computers and Chemical Engineering* and also the chair of *IFAC Technical Committee on Chemical Process Control*. He has published over 150 manuscripts in SCI journals with more than 10500 Google Scholar citations (H-index of 46). His research interests are in the areas of system identification, state estimation, robust control, model predictive control and approximate dynamic programming with applications to energy systems, bio-refinery, and CO_2 capture/conversion systems.

Keynote Speech 1

Martin Guay

Adaptive Gain Nonlinear Observer Design Techniques

Monday May 29, 2017
13:40 – 14:10
1F Conference Room

In this study, two novel observer design techniques are proposed in which the observer gain is computed in real-time using online gain updates. First, an adaptive Luenberger observer is proposed. The approach borrows from the application of Chandrasekhar-type algorithms that are amenable to the design of an adaptive gain approach to the design of Luenberger observer. Second, an extremum-seeking control based observer is proposed. This approach provides an effective unstructured approach to compute observer gains for a general class of detectable nonlinear systems. Both approaches avoid the need for the computation of a solution of a Riccati equation or its nonlinear counterpart.

Keynote Speech 2

Yujia Fu* and Huizhong Yang

Simultaneous Estimation of the Number of Principal Components and Kernel Parameter in KPCA

Monday May 29, 2017
13:40 – 14:10
ROOM 101

This article proposed a novel method to determine the number of principal components and the optimal values of tuning factors for kernel principal component models. Existing work predominantly relies on ad-hoc rules or cross-validatory approaches to estimate. To guarantee statistical independence, the proposed technique incorporates a two-fold cross-validatory approach by omitting one variable in turn, which is predicted by the remaining ones. For these regressions, the number of principal components varies. This finally yields an optimum selection for the parameters, which application and the analysis of recorded industrial data from a glass melter process confirm.

Keynote Speech 3

Yucai Zhu

System Identification:
New Developments of the Asymptotic Theory and Method

Monday May 29, 2017
13:40 – 14:10
ROOM 103

The so-called asymptotic theory of Ljung (1985) gives an error description of the identified black-box model in the frequency domain. Based on the theory the asymptotic method of identification has been developed and applied successively in industrial MPC control and PID tuning. In this work, new results that extend the asymptotic theory and method will be presented: (1) an asymptotically globally convergent Box-Jenkins model estimation algorithm; (2) errors-in-variables model identification; and (3) accurate model identification using over-sampling scheme.

Keynote Speech 4

M. Tajammal munir, Isuru Sampath Bandara Abeykoon Udugama, Ira Boiarkina, Wei Yu, Brent Young*

Beyond the Theory - How Can Academia Contribute to the Advanced Process Control of Industrial Processes?

Tuesday May 30, 2017
13:10 – 13:40
1F Conference Room

This paper discusses the role of academia in contributing to the advanced process control of industrial processes. We first review the current maturity of process control in different process industries. After that, we discuss various challenges and barriers to advanced process control applications in these various types of industries. After acknowledging these challenges and barriers, we explain various research opportunities and what role academia can play on the development of supporting theory in the advanced control of industrial processes. Specifically, how can academia use the existing data and new measurement technique by building advanced process control models for optimization of industrial processes. Finally two success stories from our research group in the dairy and petrochemical industries are presented.

Keynote Speech 5

Xunyuan Yin, Jinfeng Liu*

Distributed Fault Detection and Isolation of Nonlinear Systems Using Output Feedback

Tuesday May 30, 2017
13:10 – 13:40
Room 101

We consider distributed output-feedback fault detection and isolation (FDI) of nonlinear cascade process networks. Decentralized estimators with exponential convergence rates are assumed to exist for the subsystems. A distributed state estimation system is developed based on the existing estimators. Convergence properties of the developed distributed state estimation system are characterized. For each subsystem, a state predictor is designed to provide subsystem state predictions and a residual generator is designed based on the subsystem state estimate given by the distributed state estimation system and the subsystem predictions given by the predictor. The residuals act as references for FDI. A distributed FDI mechanism is proposed with adaptive thresholds for the residual signals. A chemical process example is introduced to demonstrate the effectiveness of the distributed FDI mechanism.

Keynote Speech 6

Toru Yamamoto*, Takuya Kinoshita, Yoshihiro Ohnishi, Sirish L Shah

Design of a Performance-Driven PID Controller

Tuesday May 30, 2017
13:10 – 13:40
ROOM 103

This study proposes a performance-driven control method that performs a “control performance assessment” and a “control system design” from a set of closed-loop data. The method evaluates control performance based on the minimum variance control index from closed-loop data. It also calculates control parameters that improve the control performance from the same closed-loop data by using the fictitious reference iterative tuning method. This method is characterized by not requiring any system model. The effectiveness of this method is verified through a numerical simulation.

Workshop on Process Data Analytics

Date and Time: May 28 (Sun), 9:00 AM – 5:00 PM

Venue: Room 201

Workshop outline

Process data analytic methods rely on the notion of sensor fusion whereby data from many sensors and alarm tags are combined with process information, such as physical connectivity of process units, to give a holistic picture of the health of an integrated plant. The fusion of information from such disparate sources of data is the key step in devising methodologies for a smart strategy for process data analytics.

In the context of the application of analytics in the process industry, the objective in this workshop is to introduce participants to tools, techniques and a framework for seamless integration of information from process and alarm databases complemented with process connectivity information. The discovery of information from such diverse and complex data sources can be subsequently used for process and performance monitoring including alarm rationalization, root cause diagnosis of process faults, hazard and operability (Hazop) analysis, safe and optimal process operation. Such multivariate process data analytics involves information extraction from routine process data, that is typically non-categorical (as in numerical process data from sensors), plus categorical (or non-numerical or qualitative and binary) data from Alarm and Event (A&E) logs combined with process connectivity or topology information that can be inferred from the data through causality analysis or as obtained from piping and instrument diagrams of a process. The latter refers to the capture of material flow streams in process units as well as information flow-paths in the process due to control loops.

Highly interconnected process plants are now common and the analysis of root causes of process abnormality including predictive risk analysis is non- trivial. It is the extraction of information from the fusion of process data, alarm and event data and process connectivity that should form the backbone of a viable process data analytics strategy and this will be the main focus of this workshop.

For efficient and informative analytics, data analysis is ideally carried out in the temporal as well as spectral domains, on a multitude and NOT singular sensor signal time-trends to detect process abnormality, ideally in a predictive mode. With the explosion of applications of analytics in diverse areas (such as aircraft engine prognosis, medicine, sports, finance, social sciences and the advertising industry) statistical learning skills are in high demand. The emphasis in this workshop will be on tools and techniques that help in the process of understanding data and discovering information that will lead to predictive monitoring and diagnosis of process faults.

Typical process data analytic methods require the execution of the following steps:

1. Data quality assessment including outlier detection and noise filtering
2. Data visualization and segmentation
3. Process and performance monitoring including root cause detection of faults
4. Alarm data analysis
5. Data-based process topology discovery and validation

Desired prerequisites for attendees

Basic knowledge of statistics, linear algebra, signal processing, system identification and control.

Target audience

The intended audience for this workshop would be industrial practitioners of control including vendors working in the area of on-line data logging and archiving, graduate students with interests in statistical learning and data science and academics.

Workshop Program

The following topics will be discussed in this workshop. Each topic will be accompanied by one or more industrial case study to convey the utilitarian value of the learning, discovery and diagnosis from process data.

- Overview of the broad analytics area with emphasis on its use in the process industry.
- Basic definitions and introduction to supervised and unsupervised learning: simple regression, classification and clustering.
- Data visualization methods; examination and analysis of data in a multivariate framework (in the temporal as well as the spectral domains).
- Data quality assessment: Outlier detection; filtering and data segmentation.
- Elements of statistical inference and learning including regression analysis using Logistic Regression, Lasso, Regression trees, Random Forests and Boosting.
- Bayesian methods.
- Multivariate methods for data analysis: SVD, PCA, PLS, SVR.
- Case studies on root cause analysis of plant-wide oscillations.
- Alarm data analysis: Detection and removal of nuisance alarms; root-cause analysis of alarms and alarm floods.
- Data-based causality analysis for identification of process topology.
- Future areas to explore in the use of statistical learning, data science and analytics for improved process operation.

Workshop speakers

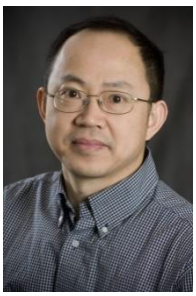
- **Tongwen Chen, Biao Huang and Sirish L. Shah**,

  Faculty of Engineering, University of Alberta , Edmonton, Canada.

- **Jiandong Wang**,

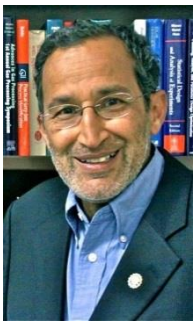
  Department of Electrical Engineering, College of Electrical Engineering and Automation, Shandong University of Science and Technology, China.

Speaker biographies



Tongwen Chen
Tongwen Chen is presently a Professor of Electrical and Computer Engineering at the University of Alberta, Edmonton, Canada. His research interests include computer and network based control systems, event triggered control, process safety and alarm systems, and their applications to the process and power industries. He is a Fellow of IEEE, IFAC, as well as Canadian Academy of Engineering.

Biao Huang
Biao Huang received the B.Sc. and M.Sc. degrees in automatic control from the Beijing University of Aeronautics and Astronautics, Beijing, China, in 1983 and 1986, respectively, and the Ph.D. degree in process control from the University of Alberta, Edmonton, AB, Canada, in 1997. He joined the University of Alberta, in 1997, as an Assistant Professor with the Department of Chemical and Materials Engineering, where he is currently a Professor. He is the Industrial Research Chair in Control of Oil Sands Processes with the Natural Sciences and Engineering Research Council of Canada, and the Industry Chair in Process Control with Alberta Innovates Technology Futures. He has applied his expertise extensively in industrial practice particularly in the oil sands industry. His current research interests include process control, system identification, control performance assessment, Bayesian methods, and state estimation. He is a fellow of the Canadian Academy of Engineering and the Chemical Institute of Canada.



Sirish Shah
Sirish L. Shah is a faculty member at the University of Alberta where he held the NSERC-Matrikon-Suncor-iCORE Senior Industrial Research Chair in Computer Process Control from 2000 to 2012. The main area of his current research is process and performance monitoring, system identification and design, analysis and rationalization of alarm systems. He has coauthored three books, the first titled “Performance Assessment of Control Loops: Theory and Applications”, a second book titled “Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches”, and a more recent brief monograph titled, “Capturing Connectivity and Causality in Complex Industrial Processes”

Jiandong Wang
Jiandong Wang is presently a Professor with the Department of Electrical Engineering, College of Electrical Engineering and Automation, Shandong University of Science and Technology, China. He received the B.E. degree in automatic control from Beijing University of Chemical Technology, Beijing, China, in 1997, and the M.Sc and Ph.D. degrees in Electrical and Computer Engineering from the University of Alberta, Canada, in 2003 and 2007, respectively. From 1997 to 2001, he was a Control Engineer with the Beijing Tsinghua Energy Simulation Company, Beijing, China. From February 2006 to August 2006, he was a Visiting Scholar at the Department of System Design Engineering at the Keio University, Japan. His research interests include system identification, industrial alarm systems, control loop performance monitoring and optimization, and their applications to power, chemical and petrochemical industrial processes. Dr. Wang has been serving as an Associate Editor for Systems and Control Letters.

Technical Programs

ADCONIP 2017 Technical Program Monday May 29, 2017

Track T1	Track T2	Track T3	Track T4
09:00-09:30 MoOC 1F Conference Room Opening Ceremony			
09:30-10:20 MoAMPL 1F Conference Room Advanced Control of Pharmaceutical Crystallization (Richard D. Braatz)			
10:20-10:40 MoTea_Break Ball Room			
10:40-12:40 MoAT1 1F Conf. Room Model-Based Control	10:40-12:40 MoAT2 Room 101 Process Integration and Optimization 1	10:40-12:40 MoAT3 Room 103 Process Analytics and Chemometrics	10:40-12:40 MoAT4 Room 201 Optimization and Scheduling
12:40-13:40 MoLunch_Break Yuehsiang Restaurant			
13:40-14:10 MoKT1 1F Conf. Room Keynote 1 (M. Guay)	13:40-14:10 MoKT2 Room 101 Keynote 2 (Y. Fu, H. Yang)	13:40-14:10 MoKT3 Room 103 Keynote 3 (Y. Zhu)	
14:10-16:10 MoBT1 1F Conf. Room New Directions of Adaptive and Learning Control	14:10-16:10 MoBT2 Room 101 Data Analytics and Machine Learning	14:10-16:10 MoBT3 Room 103 System Identification	14:10-16:10 MoBT4 Room 201 Design and Control of Separation Processes
16:10-16:50 MoPO Ball Room Poster Session			
16:50-17:40 MoPMPL 1F Conference Room Economic Plantwide Control (Sigurd Skogestad)			

18:00-20:00 MoBanquet Ball Room Banquet

Technical Programs

ADCONIP 2017 Technical Program Tuesday May 30, 2017

Track T1	Track T2	Track T3
09:00-09:50 TuAMPL 1F Conference Room Corneal Biomechanical Model and Intraocular Pressure Measurement (Jia-Yushi Yen)		
09:50-10:10 TuAMTea_Break Ball Room		
10:10-12:10 TuAT1 1F Conference Room Model-Based Fault Detection and Diagnosis	10:10-12:10 TuAT2 Room 101 Process Integration and Optimization 2	10:10-12:10 TuAT3 Room 103 Data-Based Controller Tuning
12:10-13:10 TuLunch_Break Yuehsiang Restaurant		
13:10-13:40 TuKT1 1F Conference Room Keynote 4 (B. Young)	13:10-13:40 TuKT2 Room 101 Keynote 5 (J. Liu)	13:10-13:40 TuKT3 Room 103 Keynote 6 (T. Yamamoto)
13:40-15:20 TuBT1 1F Conference Room Identification and Estimation	13:40-15:20 TuBT2 Room 101 Process and Control Monitoring	13:40-15:20 TuBT3 Room 103 Control Applications
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15:40-16:30 TuPMPL 1F Conference Room Mathematical Programming and Dynamic Programming: How They Can Be Combined for Further Use in Planning, Scheduling and Control of Multi-Scale Stochastic Energy Systems (Jay H. Lee)		
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Co-Chair: Kim, Sanghong	Kyoto Univ
Organizer: Yao, Yuan	National Tsing Hua Univ

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Wang, Youqing	Beijing Univ. of Chemical Tech

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Wu, Xiaofei	Zhejiang Univ
Chan, Lik Teck, Lester	Chung Yuan Christian Univ
Chen, Junghui	Chung-Yuan Christian Univ
Xie, Lei	Zhejiang Univ

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Yan, Zhengbing	State Key Lab. Ofindustrialcontroltechnology, Department Of
Chen, Junghui	Chung-Yuan Christian Univ
Zheng-Jiang, Zhang	Department of Electrical and Electronic Engineering, Wenzhou Uni

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Li, Xinhang	Nanjing Univ. of Aeronautics and Astronautics
Lu, Ningyun	Nanjing Univ. of Aeronautics and Astronautics
Jiang, Bin	NUAA
Zhao, huiping	Baoshan Iron and Steel Corp

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Qin, Yan	Zhejiang Univ
Zhao, Chunhui	Zhejiang Univ
Gao, Furong	Hong Kong Univ. of Science & Tech

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Okayama, Naoki	Kyoto Univ
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Chair: Lee, Chang Jun	Pukyong National Univ
Co-Chair: Lee, Jong Min	Seoul National Univ

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Jeong, Dong Hwi	Seoul National Univ
Lee, Chang Jun	Pukyong National Univ
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Zulkafli, Nur Izyan	Cranfield Univ
Kopanos, Georgios M.	Cranfield Univ

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Wang, Linqing	Dalian Univ. of Tech. Dalian, Liaoning
Zhao, Jun	Dalian Univ. of Tech. Dalian, Liaoning
Wang, Wei	Dalian Univ. of Tech
Liu, Ying	Dalian Univ. of Tech
Li, Jian	State Grid Dalian Electric Power Supply Company

11:40-12:00 MoAT4.4

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Liu, Yen-Chun	Industrial Tech. Res. Inst
LIN, SHYANG-MING	Tamkang Univ
HSIU, WEI-SHIANG	Tamkang Univ
Chen, Yih-Hang	Tamkang Univ. Department of Chemical and Materials Enginee
Chang, Hsuan	Tamkang Univ

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Aviso, Kathleen	De La Salle Univ
Cayamanda, Christina	De La Salle Univ
Mayol, Andres Philip	De La Salle Univ
Tan, Raymond	De La Salle Univ

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Wang, Tianyu	Dalian Univ. of Tech
Wang, Linqing	Dalian Univ. of Tech. Dalian, Liaoning
Zhao, Jun	Dalian Univ. of Tech. Dalian, Liaoning
Wang, Wei	Dalian Univ. of Tech
Liu, Ying	Dalian Univ. of Tech

MoKT1 1F Conference Room

Keynote 1 (M. Guay) (Keynote Session)

Chair: Bao, Jie	The Univ. of New South Wales

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Guay, Martin	Queen's Univ

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YANG, Huizhong — Jiangnan Univ
Tao, Hongfeng — Jiangnan Univ

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Zhu, Yucai — Zhejiang Univ

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Co-Chair: Prasad, Vinay — Univ. of Alberta
Organizer: Takahashi, Masanori — Tokai Univ
Organizer: Ohnishi, Yoshihiro — Ehime Univ

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Ishii, Nozomi — Univ. of Hyogo
Araki, Nozomu — Univ. of Hyogo
Konishi, Yasuo — Univ. of Hyogo

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Fujii, Seiya — Kumamoto Univ
Mizumoto, Ikuro — Kumamoto Univ

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Akiyama, Masaki — Advanced Course in National Inst. of Tech. Kagawa Coll
Henmi, Tomohiro — National Inst. of Tech. Kagawa Coll
Yamamoto, Toru — Hiroshima Univ

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Prasad, Vinay — Univ. of Alberta

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Guan, Zhe — Hiroshima Univ
Wakitani, Shin — Hiroshima Univ
Mizumoto, Ikuro — Kumamoto Univ
Yamamoto, Toru — Hiroshima Univ

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Chair: Lee, Chang Jun — Pukyong National Univ
Co-Chair: Chiang, Leo — The Dow Chemical Company
Organizer: Gopaluni, Bhushan — Univ. of British Columbia

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Ren, Lihong — Donghua Univ
Chen, Lei — Donghua Univ
Guo, Fan — Donghua Univ
Ding, Yongsheng — Donghua Univ
Huang, Biao — Univ. of Alberta

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Pon Kumar, Steven Spielberg — Univ. of British Columbia
Gopaluni, Bhushan — Univ. of British Columbia
Loewen, Philip — Univ. of British Columbia

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Lu, Bo — The Dow Chemical Company
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Vargas, Ricardo Emanuel Vaz Vargas — Federal Univ. of Espirito Santo
Munaro, Celso Jose — Federal Univ. of Espirito Santo
Ciarelli, Patrick Marques — Federal Univ. of Espirito Santo
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ZHU, Qunxiong — Beijing Univ. of Chemical Tech
Meng, Qian-Qian — Beijing Univ. of Chemical Tech
XU, Yuan — Beijing Univ. of Chemical Tech
He, Yan-Lin — Beijing Univ. of Chemical Tech

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Matsumoto, Hideyuki — AIST
Yoshikawa, Shiro — Tokyo Institute of Technology

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Chair: Yang, Fan	Tsinghua Univ
Co-Chair: Tangirala, Arun K.	Indian Inst. of Tech. Madras

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Pinnamaraju, Vivek Shankar	IIT Madras
Tangirala, Arun K.	Indian Inst. of Tech. Madras

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Ku, ShaoWu	Zhejiang Univ
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Liu, Yanjun	Jiangnan Univ
Li, Junhong	Nantong Univ
Chen, Jing	Jiangnan Univ

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Shen, Wenyi	Department of Automation, Tsinghua Univ
GAO, Xinqing	Department of Automation, Tsinghua Univ
Yang, Fan	Tsinghua Univ
Jiang, Yongheng	Dept. of Automation, Tsinghua Univ
Ye, Hao	Tsinghua Univ
Huang, Dexian	Tsinghua Univ

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Ren, Jia	Zhejiang Sci-Tech. Univ
McAllister, Jayson	Univ. of Alberta
Zukui, Li	Univ. of Alberta
Liu, Jinfeng	Univ. of Alberta
Simonsmeier, Ulrich	Cybernius Medical Ltd

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Wang, Yalin	Central South Univ
Peng, Kai	Central South Univ
Yuan, Xiaofeng	Central South Univ
Li, Ling	Central South Univ. of Information Science An
Chen, Guanyu	Central South Univ. of Information Science An

MoBT4 Room 201

Design and Control of Separation Processes (Invited Session)

Chair: Chien, I-Lung	National Taiwan Univ
Co-Chair: Lee, Hao-Yeh	National Taiwan Univ. of Science & Tech
Organizer: Lee, Hao-Yeh	National Taiwan Univ. of Science & Tech
Organizer: Chien, I-Lung	National Taiwan Univ

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Chen, Hung-Hsing	National Taiwan Univ
Chen, Meng-Kai	National Taiwan Univ
Chien, I-Lung	National Taiwan Univ

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Zang, Xinxiang	Beijing Univ. of Chemical Tech
Chen, Haisheng	Beijing Univ. of Chemical Tech
Huang, Kejin	Beijing Univ. of Chemical Tech

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Chang, Hsiang-Ning	Natl Taiwan Univ. of Sci & Tech
Lee, Hao-Yeh	Natl Taiwan Univ. of Sci & Tech

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Affandy, Sony Ardian	Chemical Engineering Department, Inst. Teknologi Sepuluh Nope
Handogo, Renanto	Chemical Engineering Department, Inst. Teknologi Sepuluh Nope
Purwo Sutikno, Juwari	Chemical Engineering Department, Inst. Teknologi Sepuluh Nope
Chien, I-Lung	National Taiwan Univ

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Wang, Tengfei	Beijing Univ. of Chemical Tech
Chen, Haisheng	Beijing Univ. of Chemical Tech
Huang, Kejin	Beijing Univ. of Chemical Tech

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Alcántara-Avila, J. Rafael	The Univ. of Tokushima
Terasaki, Masataka	Tokushima Univ
Lee, Hao-Yeh	Natl Taiwan Univ. of Sci & Tech
Chen, Jun-Lin	Natl Taiwan Univ. of Sci & Tech
Cabrera-Ruiz, Julián	Univ. De Guanajuato
Sotowa, Ken-Ichiro	Univ. of Tokushima
Horikawa, Toshihide	The Univ. of Tokushima

MoPO Ball Room

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Co-Chair: Pan, Tianhong — Jiangsu Univ

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Wang, Youqing — Beijing Univ. of Chemical Tech

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Liu, Yi — Zhejiang Univ. of Tech

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Gao, Zengliang — Zhejiang Univ. of Tech

Yao, Yuan — National Tsing Hua Univ

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Wu, Qing-Yang — Chung Yuan Christian Univ

Chan, Lik Teck, Lester — Chung Yuan Christian Univ

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You, Renchun — Xiamen Univ

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Shi, Jia — Xiamen Univ

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Ito, Minoru — National Inst. of Tech. Maizuru Coll

Mizumoto, Ikuro — Kumamoto Univ

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Hsieh, Hsiang-Feng — National Taiwan Univ

Ward, Jeffrey Daniel — National Taiwan Univ

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Wang, Haiyan — Jiangsu Univ

Tan, Fei — Jiangsu Univ

Sheng, Biqi — China Maritime Pol. Acad

Pan, Tianhong — Jiangsu Univ

Fu, Haijun — Jiangsu Univ

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Luo, Jia — Inst. of Electrical Power Res. Guangdong Power Grid, Gu

Zhu, Yucai — Zhejiang Univ

Chen, Shihe — Inst. of Electrical Power Res. Guangdong Power Grid, Gu

Jiang, Pengfei — Zhejiang Univ

Wu, Le — Inst. of Electrical Power Res. Guangdong Power Grid, Gu

Xiao, Yuwen — Hengyi Electrical Power Ltd, Foshan, Guangdong Province

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Chen, William — National Taiwan Univ

Cho, Hung-Chih — National Taiwan Univ

Ward, Jeffrey Daniel — National Taiwan Univ

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Patwardhan, Rohit — Saudi Aramco

Lopez Andreu, Miguel — Saudi Aramco

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HSU, HSIAO-CHING — ChangChun Plastics. Co. Ltd

Wang, San-Jang — National Tsing Hua Univ

Ou, John Di-Yi — National Tsing Hua Univ

Wong, David Shan Hill — National Tsing Hua Univ

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Mitchell, Matthew — The Univ. of Auckland

Abeykoon Udugama, Isuru Sampath Bandara — Univ. of Auckland

Currie, Jonathan — AUT Univ

Yu, Wei — The Univ. of Auckland

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Kinoshita, Takuya — Hiroshima Univ

Yamamoto, Toru — Hiroshima Univ

Samavedham, Lakshminarayanan — National Univ. of Singapore

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Li, Dazi — Beijing Univ. of Chemical Tech

Liu, Zhiyin — Beijing Univ. of Chemical Tech

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Liu, Jialin	Tunghai Univ
Chen, Ding-Sou	China Steel Corp

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Huang, Chien-Chih	Department of Chemical Engineering, National Tsing Hua Univ
Wang, San-Jang	National Tsing Hua Univ
Wong, David Shan Hill	National Tsing Hua Univ

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Pitchaimuthu, Diban	Univ. of Nottingham Malaysia Campus
Foo, Dominic	

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Syu, Wan-Syuan	National Taipei Univ. of Tech
Lee, Jui-Yuan	National Taipei Univ. of Tech

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Eguchi, Hajime	Nagoya Inst. of Tech
Nyambayar, Davaadorj	Nagoya Inst. of Tech
Koshijima, Ichiro	Nagoya Inst. of Tech

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Fu, Qiuhao	Hiroshima Univ
Koiwai, Kazushige	Hiroshima Univ
Yamamoto, Toru	Hiroshima Univ

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Du, Wenli	East China Univ. of Science and Tech
Alkebsi, Khalil Abdulghani Mutahar	East China Univ. of Science and Tech

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Transient Response Analysis of High Pressure Steam Distribution Networks in a Refinery, pp. 418-423.

Chang, Chiao-Ying	National Taiwan Univ
Wang, Shih-Han	National Taiwan Univ
Chen, Cheng-Liang	National Taiwan Univ
Huang, Yu-Cheng	National Taiwan Univ

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Zhao, Zhonggai	Insititute of Automation, Jiangnan Univ
Qi, Pengcheng	Jiangnan Univ
Liu, Fei	Jiangnan Univ

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Tshizubu, Christian	Univ. Federal Fluminense
Santisteban, José Andrés	Univ. Federal Fluminense

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Lin, Ta-Chen	Tunghai Univ
Lee, Ya-Hsun	IV Tech. Co., Ltd

Tuesday May 30, 2017

TuAT1 1F Conference Room

Model-Based Fault Detection and Diagnosis (Invited Session)

Chair: Chang, Chuei-Tin	National Cheng Kung Univ
Co-Chair: Zhao, Jinsong	Tsinghua Univ
Organizer: Chang, Chuei-Tin	National Cheng Kung Univ

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FONG, SHIH-TING	National Cheng Kung Univ
Wang, Chung Jung	National Cheng Kung Univ
Chang, Chuei-Tin	National Cheng Kung Univ

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Kimura, Naoki	Kyushu Univ
Takeda, Yuya	Kyushu Univ
Hasegawa, Taichi	Kyushu Univ
Tsuge, Yoshifumi	Kyushu Univ

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Yamashita, Yoshiyuki	Tokyo Univ. of Agriculture and Tech

11:10-11:30 TuAT1.4

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Ming, Liang	Tsinghua Univ
Zhao, Jinsong	Tsinghua Univ

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Adi, Vincentius Surya Kurnia	National Chung Hsing Univ
Laxmidewi, Rosalia	Independent Scholar
Chang, Chuei-Tin	National Cheng Kung Univ

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Hamaguchi, Takashi	Nagoya Institute of Technology
Yamamoto, Shinya	Nagoya Institute of Technology
Tagawa, Takuya	Nagoya Institute of Technology
Mase, Hiroki	Nagoya Institute of Technology
Koshijima, Ichiro	Nagoya Institute of Technology
Hashimoto, Yoshihiro	Nagoya Institute of Technology

TuAT2 Room 101

Process Integration and Optimization 2 (Invited Session)

Chair: Liu, J. Jay	Pukyong National Univ
Co-Chair: Isafiade, Adeniyi Jide	Univ. of Cape Town
Organizer: Foo, Dominic	Univ. of Nottingham Malaysia Campus

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Li, Bao-Hong	Dalian Nationalities Univ
Chang, Chuei-Tin	National Cheng Kung Univ

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Bazolana, Nsunda Christie	Univ. of the Witwatersrand
Majozi, Thokozani	School of Chemical and Metallurgical Engineering, Univ. Of

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Cheng, Shueh-Hen	Tunghai Univ. Department of Chemical and Materials Enginee
Lo, Chi-Hao	CTCI Corp
Lin, Ta-Chen	Tunghai Univ

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Am, Vathna	Auckland Univ. of Tech
Currie, Jonathan	AUT Univ
Wilson, David I.	Auckland Univ. of Tech

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Brigljevic, Boris	Pukyong National Univ
Liu, J. Jay	Pukyong National Univ

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Isafiade, Adeniyi Jide	Univ. of Cape Town

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Chair: Jeng, Jyh-Cheng	National Taipei Univ. of Tech
Co-Chair: Yamamoto, Toru	Hiroshima Univ
Organizer: Jeng, Jyh-Cheng	National Taipei Univ. of Tech
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Jeng, Jyh-Cheng	National Taipei Univ. of Tech
Jian, Yuan-Siang	National Taipei Univ. of Tech
Lee, Ming-Wei	China Steel Corp
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Yokoyama, Ryoko	Tokyo Metropolitan Univ
Masuda, Shiro	Tokyo Metropolitan Univ
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Nguyen Quang, Huy	Kanazawa Univ
Kaneko, Osamu	The Univ. of Electro-Communications
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Park, Byeong Eon	POSTECH
Sung, Su Whan	Kyungpook National Univ
Lee, In-Beum	POSTECH
11:30-11:50	TuAT3.5
Design of a Performance-Driven PID Controller for a Nonlinear System, pp. 529-534.	
Liao, Yuntao	Hiroshima Univ
Kinoshita, Takuya	Hiroshima Univ
Koiwai, Kazushige	Hiroshima Univ
Yamamoto, Toru	Hiroshima Univ
11:50-12:10	TuAT3.6
PID Control Loop Performance Assessment and Diagnosis Based on DEA-Related MCDA, pp. 535-540.	
Wang, Zun	Beijing Univ. of Chemical Tech
Han, Yongming	Beijing Univ. of Chemical Tech
geng, zhiqiang	Beijing Univ. of Chemical Tech
ZHU, Qunxiong	Beijing Univ. of Chemical Tech
XU, Yuan	Beijing Univ. of Chemical Tech
He, Yan-Lin	Beijing Univ. of Chemical Tech

TuKT1	1F Conference Room
Keynote 4 (B. Young) (Keynote Session)	
Chair: Lee, Jong Min	Seoul National Univ
13:10-13:40	TuKT1.1
Beyond the Theory - How Can Academia Contribute to the Advanced Process Control of Industrial Processes?, pp. 541-546.	
munir, M. Tajammal	The Univ. of Auckland
Abeykoon Udugama, Isuru Sampath Bandara	Univ. of Auckland
Boiarkina, Ira	Univ. of Auckland
Yu, Wei	The Univ. of Auckland
Young, Brent	The Univ. of Auckland

TuKT2	Room 101
Keynote 5 (J. Liu) (Keynote Session)	
Chair: Prasad, Vinay	Univ. of Alberta
13:10-13:40	TuKT2.1
Distributed Fault Detection and Isolation of Nonlinear Systems Using Output Feedback, pp. 547-552.	
Yin, Xunyuan	Univ. of Alberta
Liu, Jinfeng	Univ. of Alberta

TuKT3	Room 103
Keynote 6 (T. Yamamoto) (Keynote Session)	
Chair: Yih, Hwei-Nan	Advanced Control & Systems Inc
13:10-13:40	TuKT3.1
Design of a Performance-Driven PID Controller, pp. 553-558.	
Yamamoto, Toru	Hiroshima Univ
Kinoshita, Takuya	Hiroshima Univ
Ohnishi, Yoshihiro	Ehime Univ
Shah, Sirish L	Univ. of Alberta

TuBT1	1F Conference Room
Identification and Estimation (Regular Session)	
Chair: Liu, Fei	Jiangnan Univ
Co-Chair: Yang, Chunhua	Central South Univ
13:40-14:00	TuBT1.1
A Modified Recursive Locally Weighted NIR Modeling for Fermentation Process, pp. 559-564.	
Chen, Lingyi	Jiangnan Univ
Zhao, Zhonggai	Insititute of Automation, Jiangnan Univ
Liu, Fei	Jiangnan Univ
14:00-14:20	TuBT1.2
On Initialization of the Kalman Filter, pp. 565-570.	
Zhao, Shunyi	Univ. of Alberta
Huang, Biao	Univ. of Alberta
14:20-14:40	TuBT1.3
Improved Compound Controller for Active Power Filter, pp. 571-576.	
Wang, Yifan	Jiangsu Univ
Zheng, Hong	Jiangsu Univ
Wang, Ruoyin	Jiangsu Univ
wen, zhu	Jiangsuuniversity
14:40-15:00	TuBT1.4
Output-Related Feature Representation for Soft Sensing Based on Supervised Locality Preserving Projections, pp. 577-582.	
Yuan, Xiaofeng	Central South Univ
Wang, Yalin	Central South Univ
Yang, Chunhua	Central South Univ
Gui, Weihua	Central South Univ
Jiang, Qingchao	Key Lab. of Advanced Control and Optimization for Chemical
15:00-15:20	TuBT1.5
A Novel Algorithm for Targeted Metabolite Profiling Using NMR Spectrum, pp. 583-588.	
Xu, Frost	Zhejiang Univ
Mantri, Madhav	Indian Inst. of Tech. Kharagpur
Zukui, Li	Univ. of Alberta

TuBT2	Room 101
Process and Control Monitoring (Regular Session)	
Chair: Munaro, Celso Jose	Federal Univ. of Espirito Santo
Co-Chair: Liu, J. Jay	Pukyong National Univ

13:40-14:00 TuBT2.1

Multi-Objective Complexity Reduction for Set-Based Fault Diagnosis, pp. 589-594.

Savchenko, Anton	Univ. of Magdeburg
Andonov, Petar	OvGU Magdeburg
Rumschinski, Philipp	Robert Bosch Automotive Steering GmbH
Findeisen, Rolf	Univ. of Magdeburg

14:00-14:20 TuBT2.2

Statistical Online Model Quality Monitoring for Linear Closed-Loop Control System, pp. 595-600.

Ling, Dan	Huazhong Univ. of Science and Tech
Zheng, Ying	Huazhong Univ. of Science and Tech
Yang, Xiaoyu	Huazhong Univ. of Science and Tech
Wang, Yan	Zhengzhou Univ. of Light Industry

14:20-14:40 TuBT2.3

Application of the Improved Multivariate Empirical Mode Decomposition to Plant-Wide Oscillations Characterization, pp. 601-605.

Lang, Xun	Zhejiang Univ
Zhong, Dan	Zhejiang Univ
Xie, Lei	Zhejiang Univ
Chen, Junghui	Chung-Yuan Christian Univ
Su, Hongye	Zhejiang Univ

14:40-15:00 TuBT2.4

Handling Class Imbalance and Multiple Inspection Objectives in Design of Industrial Inspection System, pp. 606-611.

Yousefian, Ali	Seoul National Univ
Liu, J. Jay	Pukyong National Univ

15:00-15:20 TuBT2.5

Survey on Advanced Alarm Strategies Based on Multivariate Analysis, pp. 612-617.

Yang, Fan	Tsinghua Univ
Guo, Cen	Tsinghua Univ

TuBT3	Room 103
Control Applications (Regular Session)	
Chair: Wu, Wei	National Cheng Kung Univ
Co-Chair: Jang, Shi-Shang	National Tsing-Hua Univ

13:40-14:00 TuBT3.1

A Real-Time Streamline-Based Obstacle Avoidance System for Curvature-Constrained Nonholonomic Mobile Robots, pp. 618-623.

Pei-Li, Kuo	Acad. Sinica
Chung-Hsun, Wang	Acad. Sinica
Chou, Han-Jung	IIS, Acad. Sinica
Liu, Jing-Sin	Acad. Sinica

14:00-14:20 TuBT3.2

Efficient Operating Condition of Side Stream Simulated Moving Bed Chromatography for Ternary Fluid Mixtures, pp. 624-629.

Oh, Tae Hoon	Seoul National Univ
Oh, Se-Kyu	Seoul National Univ
Lee, Jong Min	Seoul National Univ

14:20-14:40 TuBT3.3

Graph-Theoretic Control Structure Synthesis for Optimal Operation of Heat Exchanger Networks, pp. 630-635.

Kang, Lixia	Xi'an Jiaotong Univ
Liu, Yongzhong	Xi'an Jiaotong Univ

14:40-15:00 TuBT3.4

Evaluation of Gas-Liquid Contact Area and Liquid Holdup of Random Packing Using CFD Simulation, pp. 636-641.

Kang, Jia-Lin	National Tsing-Hua Univ
Chen, Wei-Fu	National Tsing Hua Univ
Wong, David Shan Hill	National Tsing Hua Univ
Jang, Shi-Shang	National Tsing-Hua Univ

15:00-15:20 TuBT3.5

Modeling and Optimization of a Fast Fluidized Bed Reactor for Carbonation Reactions, pp. 642-647.

Chen, Jhao-Rong	National Cheng Kung Univ
Wu, Wei	National Cheng Kung Univ

Abstracts

Monday May 29, 2017

MoAT1 1F Conference Room

Model-Based Control (Regular Session)

Chair: Gao, Furong — Hong Kong Univ. of Science & Tech

Co-Chair: Li, Shaoyuan — Shanghai Jiao Tong Univ

10:40-11:00 MoAT1.1

State Feedback Output Regulation for a Boundary Controlled Linear 2X2 Hyperbolic System, pp. 1-6

xu, Xiaodong — Univ. of Alberta

Dubljevic, Stevan — Univ. of Alberta

In this manuscript, the output regulation is addressed for a boundary controlled 2X2 system of first order linear hyperbolic PDEs subject to process and boundary input disturbances. Under the assumption that the structure of the ecosystem is known, the full state feedback boundary control law is developed to achieve disturbances rejection and the reference signal tracking, simultaneously. In addition, the stability of the closed-loop system is ensured with the aid of the backstepping stabilization approach. Furthermore, the existence of the unique solution of the resulting regulator equations is proved, which is essential to the solvability of the output regulation problem. A simulation example is studied to demonstrate the performance of the proposed regulator.

11:00-11:20 MoAT1.2

Robust Distributed Control for Plantwide Processes Based on Dissipativity in Quadratic Differential Forms, pp. 7-12

Zheng, Chaoxu — Univ. of New South Wales

Bao, Jie — The Univ. of New South Wales

Based on dissipativity theory, a robust distributed control approach for plantwide chemical processes are developed in this work. The plantwide process is represented as a network of process units and controllers. The model of each process unit with uncertainty is represented as a polytopic set. The effects of uncertainties of process units on plantwide stability are analyzed based on the concept of dissipativity. The plantwide robust stability condition is formulated in terms of dissipativity, which is conveniently represented as the linear combination of the dissipativity conditions of individual process units and controllers, based on the topologies of the process and controller networks. The dissipativity conditions that individual controllers need to satisfy to ensure plantwide robust stability is developed. A robust distributed control synthesis approach for designing individual controllers is also developed. Dissipativity conditions (storage functions and supply rates) in the Quadratic Differential Forms are adopted to reduce the conservativeness of the proposed robust control approach.

11:20-11:40 MoAT1.3

Double-Layered Model Predictive Control Strategy with Dynamic Trajectory Calculation, pp. 13-18

Wang, Xiao — Shanghai Jiao Tong Univ

Li, Shaoyuan — Shanghai Jiao Tong Univ

Zheng, Yi — Shanghai Jiao Tong Univ

Yang, Yaru — Shanghai Jiao Tong Univ

In industrial process field, the integrations of model predictive control (MPC) and hierarchical control system are widely used. A new double-layered model predictive control strategy with dynamic trajectory calculation (DTC) in its upper layer is presented in this paper, which can be applied in the midst of a hierarchical control system. DTC includes a feasibility stage with prioritized constraints handling and an economic optimization stage in a compatible constraint set. The calculated trajectory for each output is tracked by MPC dynamically in the lower layer. The presented control algorithm with DTC inspired by the steady-state target calculation (SSTC) method from the existing research basis. It could achieve a better economic benefit and tracking effect of external targets (ET) obtained from real-time optimization (RTO). In the simulation example, the introduced and original algorithms are applied to a fluid catalytic cracking (FCC) model which is the core of refining industry. Control results and performance comparison between two methods illustrates effectiveness of the proposed control strategy.

11:40-12:00 MoAT1.4

Optimization of a Pusher Type Reheating Furnace: An Adaptive Model Predictive Control Approach, pp. 19-24

Astolfi, Giacomo — Univ. Pol. Marche

Barboni, Luca — I.process Srl

Cocchioni, Francesco — Univ. Pol. Delle Marche

Pepe, Crescenzo — Univ. Pol. Delle Marche

Zanoli, Silvia Maria — Univ. Pol. Delle Marche

In this paper, an Advanced Process Control system based on a two-layer linear Model Predictive Control strategy is proposed. The control system aims at optimizing a pusher type billets reheating furnace, located in an Italian steel plant. A first principles nonlinear model has been developed, in order to obtain estimations of billets temperature inside the furnace. A Linear Parameter-Varying model for billets temperature has been accordingly derived. To obtain a global modellization of the furnace unit, an additional black-box approach has been adopted for the internal process dynamics. The overall resulting model has been exploited for the design of the Model Predictive Control scheme. Performances on an industrial process have shown the major profitability of the proposed control solution with respect to the previous one, based on a suitable handling of local PID controllers. In particular, significant energy saving has been obtained, together with an improved specifications fulfillment.

12:00-12:20 MoAT1.5

Multi-Objective Control of a Fed-Batch Bioreactor Using Shrinking Horizon MPC: A Case Study, pp. 25-30

Markana, Anilkumar — Pandit Deendayal Petroleum Univ. Gandhinagar

Padhiyar, Nitin — Indian Inst. of Tech. Gandhinagar

Moudgalya, Kannan M. — I.I.T. Bombay

This work focuses on offline and online multi-objective control of a fed-batch bioreactor for the induced foreign protein production by recombinant bacteria. Initially, open loop multi-objective control problem is formulated and solved using a single objective optimization after augmenting the individual objectives. The weighting parameters in the augmented objective function represent their priorities. The lexicographic optimization approach has been utilized for the multi-objective control in the MPC framework. Moreover, unlike the continuous processes, the batch processes operate for a definite batch time. Hence, the shrinking horizon approach along with the economic MPC framework is employed in the fed-batch bioreactor control.

12:20-12:40 MoAT1.121

A Multi-Objective Model Predictive Control for Temperature Control in Extrustion Processes, pp. 31-36

Lu, Jingyi — Hong Kong Univ. of Science and Tech

Zhang, Ridong — Hangzhou Dianzi Univ

Yao, Ke — Hong Kong Univ. of Science and Tech

Gao, Furong — Hong Kong Univ. of Science & Tech

In this paper, we consider the temperature control problem of an extrusion process with both heaters and coolers. For the purpose of energy saving and avoiding frequent switch between the

heaters and coolers, the coolers are only used to guarantee the barrel temperature below a given safety bound. When this safety constraint is satisfied, the heaters take actions for reference tracking. This scheme is formulated as a multi-objective optimization problem in the framework of model predictive control. Different objectives have different priority. The safety constraint is of the highest priority, and formulated as a constraint in the optimization. Minimization of the inputs corresponding to the cooler is of the second priority, and incorporated into the objective function with heavy penalty weight. Minimization of the tracking error is of the lowest priority. Thus, this term is also incorporated into the objective function, but with light penalty weight. In this way, energy consumption can be reduced and frequent switch can be avoided. Moreover, a polytopic invariant set is developed to guarantee recursive feasibility of the proposed MPC. Simulations are also conducted to show the effectiveness of the proposed method.

MoAT2 Room 101

Process Integration and Optimization 1 (Invited Session)

Chair: Foo, Dominic	Univ. of Nottingham Malaysia Campus
Co-Chair: Bandyopadhyay, Santanu	Indian Inst. of Tech. Bombay
Organizer: Foo, Dominic	Univ. of Nottingham Malaysia Campus

10:40-11:00 MoAT2.1

Optimal Allocations of Area Margins and Spares to Accommodate HEN Cleaning Schedules (I), pp. 37-42

LIAO, BO-JYUN	National Cheng Kung Univ
Yi, Kuang-Ting	National Cheng Kung Univ
Chang, Chuei-Tin	National Cheng Kung Univ

Due to fouling in one or more heat-transfer unit, the target temperatures of process streams in a heat exchanger network (HEN) may not be achievable after a sufficiently long period of operation. To circumvent this practical problem, a given HEN design should be modified to accommodate online cleaning operations via proper allocation of area margins and spares. Specifically, the candidate units for incorporating margins can be first identified on the basis of sensitivity analysis. The potential locations of additional auxiliary heaters/coolers and bypasses can then be determined according to the heat-load loops and paths embedded in HEN so as to facilitate compensation of the removed duties during defouling. The optimal design refinements and also the spare-supported cleaning schedule can be generated by solving a mathematical programming model formulated on the basis of a superstructure. A simple example is presented in this paper to illustrate the proposed modeling procedure and to demonstrate the feasibility of this scheduling approach.

11:00-11:20 MoAT2.2

Segregated Targeting for Resource Allocation Networks with Dedicated Sources (I), pp. 43-48

Jain, Sheetal	IIT Bombay
Bandyopadhyay, Santanu	Indian Inst. of Tech. Bombay

Segregated targeting problems consist of a set of sources called internal sources and multiple sets of demands called zones. Each zone consists of a set of demands and a unique resource. Internal sources are allocated to different zones such that the total resource requirement for the overall problem is minimized. In this paper, the problem definition is extended to include dedicated sources in each zone. These dedicated internal sources are specific to a zone in which they are present and are not shared with other zones. The primary objective of this paper is to develop an algorithm to determine the minimum resource requirement for the segregated problem with dedicated sources. Using rigorous mathematical arguments, a non-dimensional number is determined that dictates the allocation of an internal source to a zone for overall resource optimality. The applicability of the proposed algorithm is demonstrated through an illustrative example of carbon constrained energy sector planning.

11:20-11:40 MoAT2.3

A Pinch Analysis Approach to Project Selection Problem (I), pp. 49-54

Roychaudhuri, Pritam	IIT Bombay
Bandyopadhyay, Santanu	Indian Inst. of Tech. Bombay
Foo, Dominic	Univ. of Nottingham Malaysia Campus
Tan, Raymond	De La Salle Univ
Kazantzi, Vasiliki	Univ. of Applied Science - TEI of Thessaly

Project selection is a very important decision that every firm has to take; in fact, this decision plays a major role in the prosperity of the firm. Pinch analysis, which was initially developed to conserve energy and improve energy efficiency in industrial process, is now being extended to non-conventional areas. In this paper, pinch analysis is applied to select multiple independent projects from a large pool of viable projects, subject to budget constraints. The underlying mathematical optimization problem is discussed and a graphical approach to obtain optimal insightful solutions is presented. Applicability of the proposed methodology is demonstrated through an illustrative example of energy conservation in the Indian cement industry.

11:40-12:00 MoAT2.4

Active Bypass Design for Optimal Operation of Heat Exchanger Networks (I), pp. 55-60

Gu, Siwen	Dalian Univ. of Tech
Liu, Linlin	Dalian Univ. of Tech
Du, Jian	Dalian Univ. of Tech
Song, Haodong	Dalian Univ. of Tech
Meng, Qingwei	Dalian Univ. of Tech

Optimal operation space of heat exchanger networks (HENs) is largely influenced by either their hard constraints or limitation of operation margin when a bypass or utility unit is selected as a manipulated variable (MV), but previous methods generally focused on solving the identification of inactive bypasses and active pairings in sequence, wherein the inactive bypasses features hard constraints or even saturation during adjustment, and these can result in overly conservative solutions. To improve the operation space of HENs, this paper proposes a feasible solution of bypass design to simultaneously find the inactive bypasses and their active pairings with auxiliary bypasses. In a given network containing disturbance information, they are expressed by mixed integer non-linear programming (MINLP) with the objective function providing minimum control action and utility consumption. A case is subsequently studied to analyse the feasibility of the above framework. The principal orientations and contents of the proposed method lay the groundwork for the integration of HENs synthesis and control.

12:00-12:20 MoAT2.5

Optimal Design of Hydrogen Network with Intermediate Header and Minimum Compressor Work (I), pp. 61-66

Deng, Chun	China Univ. of Petroleum, Beijing
Zhou, Yuhang	Sinochem Xingzhong Oil Staging (Zhoushan) CO, LTD.316000
Zhu, Meiqian	State Key Lab. of Heavy Oil Processing, Coll. of Chemica
Feng, Xiao	School of Chemical Engineering & Tech. Xi'an Jiaotong Univ

Refinery hydrogen consumers (i.e. hydrocracker, hydro-treater) are operated in high pressure. The makeup hydrogen and recycle hydrogen compressors are placed to increase the pressure of hydrogen streams. It leads to a large contribution on compression work and operating cost. Therefore, except for the minimizing the flowrate of hydrogen utility, it is extremely important to reduce the compression work when optimizing hydrogen network. The improved problem table is applied to locate the flowrate targets of hydrogen network with intermediate header in the first step. Next, a novel nearest neighbors algorithm as well as pressure-impurity

diagram are proposed to design the optimal hydrogen network with intermediate header and minimum compression work. The proposed approach is illustrated via a case study. The results show that the optimal targets (11.89 MJ, 8 compressors) are much better than those reported (15.09 MJ, 11 compressors) in the literature. It indicates that intermediate hydrogen header can be installed to reduce the number of compressors as well as the compression work.

12:20-12:40 MoAT2.6

Pinch Analysis Approach to Optimal Planning of Biochar-Based Carbon Management Networks (I), pp. 67-72

Tan, Raymond — De La Salle Univ
Bandyopadhyay, Santanu — IIT Bombay
Foo, Dominic — Univ. of Nottingham Malaysia Campus

Biochar offers a potentially scalable option for achieving negative carbon emissions. The photosynthetic fixation of atmospheric carbon into biomass, followed by carbonization of plant biomass into stable biochar which is then added to soil, results in a reversal of the normal flow of carbon from man-made systems. In addition, these systems can provide economic benefits, such as enhancement of soil quality for agriculture, or co-production of valuable goods (e.g., energy and chemicals) along with biochar. However, the amount of biochar that can be added to agricultural land without causing adverse effects is limited by impurities such as salts, heavy metals and dioxins, which can cause a decline in soil quality. Thus, allocation of biochar from different sources (i.e., pyrolysis plants) to different sinks (i.e., farms or plantations) can be framed as a source-sink optimizations problem. In process integration literature, such problems have been solved via mathematical programming, pinch analysis or allied techniques such as process graphs. In this work, a pinch analysis approach for planning biochar-based carbon management networks is proposed. This methodology provides an alternative or complementary approach that facilitates decision-making and interpretation through visually oriented graphical displays. A case study is solved to illustrate how system-wide carbon sequestration can be maximized, while still satisfying soil impurity limits.

MoAT3 Room 103

Process Analytics and Chemometrics (Invited Session)

Chair: Yao, Yuan — National Tsing Hua Univ
Co-Chair: Kim, Sanghong — Kyoto Univ
Organizer: Yao, Yuan — National Tsing Hua Univ

10:40-11:00 MoAT3.1

Two-Step Principal Component Analysis for Dynamic Processes (I), pp. 73-77

Wang, Youqing — Beijing Univ. of Chemical Tech

A enhanced principal component analysis (PCA), termed as Two-step PCA (TS-PCA), is proposed to handle the dynamic characteristic of industry processes. Differently from the traditional dynamic PCA (DPCA) using the “time lag shift” structure, TS-PCA adopts a new structure to present the dynamic property in the process data. By using this new structure, TS-PCA can extract the time-uncorrelated components from the dynamic data and use it for process monitoring. In addition, it can update the expectation and standard variance of the process data at each step for data normalization.

11:00-11:20 MoAT3.2

Application of Gaussian Processes with Variable Shrinkage Method and Just-In-Time Modeling in the Semiconductor Industry (I), pp. 78-83

Wu, Xiaofei — Zhejiang Univ
Chan, Lik Teck, Lester — Chung Yuan Christian Univ
Chen, Junghui — Chung-Yuan Christian Univ
Xie, Lei — Zhejiang Univ

In semiconductor manufacturing, as some of the variables in processes cannot be easily measured during or after the production, virtual metrology (VM) is employed to predict metrology outputs using ancillary process variables. However, because of changeable processes and high-dimensional inputs, VM can be expensive or difficult to implement. In this work, just-in–time (JIT) modeling is used to cope with changes in process characteristics and to automatically update the statistical model. In addition, owing to the non-uniform data distribution, Gaussian process regression (GPR) as a probabilistic approach is a typical method to enhance the robustness of the system in the probability density space. With high-dimensional input variables in deposition processes, a variable shrinkage and selection method for GPR is proposed. It is superior to the conventional methods. The features of the proposed method are shown by way of illustrative examples and the proposed method is compared to conventional work based on real semiconductor process data.

11:20-11:40 MoAT3.3

Valve Stiction Detection Using the Bootstrap Hammerstein System Identification (I), pp. 84-89

Yan, Zhengbing — State Key Lab. Ofindustrialcontroltechnology, Department Of
Chen, Junghui — Chung-Yuan Christian Univ
Zheng-Jiang, Zhang — Department of Electrical and Electronic Engineering, Wenzhou Uni

Stiction in control valve is one of the long-standing and common problems in the process industries, which accelerates equipment wear and even affects the stability of closed-loop systems. To detect and quantify valve stiction, a bootstrap Hammerstein system identification procedure is proposed. Through the identified set of the model parameters and operation plant data, the parameter confidence intervals can be predefined and the valve stiction can be easily detected. Numerical examples are provided to illustrate the effectiveness of the proposed method.

11:40-12:00 MoAT3.4

A Frequent Pattern Mining Based Shape Defect Diagnosis Method for Cold Rolled Strip Products (I), pp. 90-94

Li, Xinhang — Nanjing Univ. of Aeronautics and Astronautics
Lu, Ningyun — Nanjing Univ. of Aeronautics and Astronautics
Jiang, Bin — NUAA
Zhao, huiping — Baoshan Iron and Steel Corp

Abstract—Flatness is one of the most important specifications for strip products in cold rolling processes. Shape control of cold rolled product is often characterized as a complex process with multiple operation conditions, multi-variables, time-varying parameters, strong coupling and nonlinearity. Accurate online shape defect diagnosis is still a difficult task. This paper proposed a frequent pattern mining algorithm based shape defect diagnosis method, aiming to solve a bottleneck problem associated with the Apriori algorithm when applied for defect diagnosis in complex industrial processes. An improved Apriori algorithm is presented, which maps the defect data into a 0-1 matrix and then calculate the unique frequent itemsets for different defect data via pruning and processing of matrix and mining of correlation between different shape defects and operation conditions. The obtained shape defect diagnosis results can be supportive to improve product quality management in the rolling processes. Case study based on the data collected from Baosteel 2030 cold rolling product line can show the validity of the proposed method.

12:00-12:20 MoAT3.5

Subspace Decomposition Based Cumulative Quality Analysis for Multiphase Batch Processes (I), pp. 95-100

Qin, Yan — Zhejiang Univ
Zhao, Chunhui — Zhejiang Univ
Gao, Furong — Hong Kong Univ. of Science & Tech

Quality analysis and prediction has been of great significance to ensure consistent and high product quality for chemical engineering processes. However, cumulative quality effect which is of typical nature for batch processes has rarely been analyzed by previous methods. With time development, the process variation will determine the final product quality in a cumulative manner. In this paper, considering the multiphase nature, a phase-wise cumulative quality analysis method is proposed based on subspace decomposition which can explore the non-repetitive quality-relevant information (NRQRI) from the process variation at each time within each phase. NRQRI refers to the quality-relevant process variations at each time that are orthogonal to those of previous time and thus represents complementary quality information which is the key index to cumulatively explain quality variations time-wise. By the two-level cumulative quality analysis (i.e., phase-wise and process-wise), it is feasible to judge whether the quality has the cumulative effect in advance and thus proper quality prediction model can be developed. The feasibility and performance of the proposed algorithm are illustrated by a typical chemical engineering process, injection molding.

12:20-12:40 MoAT3.6

Modified Joint-Y PLS Model for Integrated Use of Data from Similar Plants, pp. 101-106

Okayama, Naoki — Kyoto Univ
Kim, Sanghong — Kyoto Univ
Kano, Manabu — Kyoto Univ
Hasebe, Shinji — Kyoto Univ

Statistical modeling methods have been used for estimating quality variables by using easy-to-measure variables. The estimation performance of a statistical model depends on the quality and quantity of data. To solve this problem, joint-Y partial least squares (JY-PLS) was proposed. JY-PLS can concurrently use the data from the similar plants, and improve the quantity of the data as well as the estimation performance. However, JY-PLS has room to improve. In JY-PLS, common regression coefficients for the latent variables are used in all models of similar plants. However, the estimation performance can be improved when different regression coefficients are used. In this research, a new method which can derive appropriate regression coefficients for each model of a plant is proposed. Its usefulness is demonstrated in numerical examples.

MoAT4 Room 201

Optimization and Scheduling (Regular Session)

Chair: Lee, Chang Jun — Pukyong National Univ
Co-Chair: Lee, Jong Min — Seoul National Univ

10:40-11:00 MoAT4.1

A Novel Run-To-Run Optimization Algorithm for Batch Processes Using Localized Partial Least Squares Regression Models, pp. 107-112

Jeong, Dong Hwi — Seoul National Univ
Lee, Chang Jun — Pukyong National Univ
Lee, Jong Min — Seoul National Univ

Driving a process to optimal conditions under various uncertainties is a key issue for meeting objectives of productivity and quality of batch or fed-batch product. To overcome a limitation of two-step approaches unable to cope with nonparametric or large uncertainty, several gradient based iterative optimization methods have been proposed. Among these, latent variable model based approaches have an advantage point that it can estimate plant gradient with less number of excitations than common model-free ones when the variables are correlated. In this paper, a novel run-to-run optimization approach using partial least squares regression is proposed. Being different from the existing latent variable model based ones, the proposed method excites and utilizes only interpolating data set for gradient estimation by introducing trust region. In addition, input constraints are considered in the iterative updates for optimization. Finally, a case study in which a fed-batch bio-reactor's feeding rates are optimized validates the utility of proposed method.

11:00-11:20 MoAT4.2

Simultaneous Planning of Production and Utility Systems under Performance Degradation, pp. 113-118

Zulkafli, Nur Izyan — Cranfield Univ
Kopanos, Georgios M. — Cranfield Univ

A general optimization framework for the simultaneous planning of production and utility systems under performance degradation is presented. The comparison of the solutions of this integrated approach against the traditional sequential approach has been made. The proposed integrated approach can achieve significant reduction in startup/shutdown cost, cleaning costs and total utility purchases

11:20-11:40 MoAT4.3

A Dynamic Causal Diagram and Constraint-Based Method for Scheduling in Blast Furnace Gas System of the Steel Industry, pp. 119-124

Jin, Feng — Dalian Univ. of Tech. Dalian, Liaoning
Wang, Linqing — Dalian Univ. of Tech. Dalian, Liaoning
Zhao, Jun — Dalian Univ. of Tech. Dalian, Liaoning
Wang, Wei — Dalian Univ. of Tech
Liu, Ying — Dalian Univ. of Tech
Li, Jian — State Grid Dalian Electric Power Supply Company

Blast furnace gas (BFG) is one of the important secondary energy in the iron and steel enterprises. The reasonable use of BFG can raise economic profit and alleviate the environment pollution. The existing scheduling mode may cause not only a waste of gas, but also additional operations for compensating the inadequate initial scheduling. In this study, a dynamic causal diagram and constraint-based scheduling method is proposed to calculate the scheduling amount in order to overcome the drawbacks. Probability which is used to calculate the sufficiency of the continuous data is defined along with the computing method so as to select the most related variables to the gas tank level. Furthermore, a dynamic causal diagram for BFG system is established according to the selected variables, and an objective function based on the difference between BFG generation and consumption is constructed as well as the inequality constraints of the related variables for calculating the scheduling amount. The experiments using real practical data coming from a steel plant in China indicate that the proposed method can effectively improve the scheduling accuracy and reduce the gas diffusion.

11:40-12:00 MoAT4.4

Energy and Economic Performance of Carbon Dioxide Chemical Absorption System with Gas Pressurized Stripping, pp. 125-130

Liu, Yen-Chun — Industrial Tech. Res. Inst
LIN, SHYANG-MING — Tamkang Univ
HSIU, WEI-SHIANG — Tamkang Univ
Chen, Yih-Hang — Tamkang Univ. Department of Chemical and Materials Enginee
Chang, Hsuan — Tamkang Univ

Post-combustion capture of carbon dioxide from fossil fuel fired power plants is essential for the control of greenhouse gas emissions. The major challenge of the amine-based solvent systems, which is the state-of-art technology, is the high capital and operating costs. The gas pressurized stripping process utilizes a high-pressure stripping gas to reduce the water vaporization energy consumption and produce high-pressure carbon dioxide gas. This paper presents the design and the comparison of energy and economic performance of three processes, including the conventional simple stripping (SS), the basic gas pressurized stripping (BGPS) operated at different temperatures, and a modified GPS (MGPS).

12:00-12:20 MoAT4.5

*P-Graph Approach to Human Resource Reallocation in Industrial Plants under Crisis Conditions**, pp. 131-136

Aviso, Kathleen De La Salle Univ
Cayamanda, Christina De La Salle Univ
Mayol, Andres Philip De La Salle Univ
Tan, Raymond De La Salle Univ

P-graph methodology was originally proposed as a systematic approach to process network synthesis (PNS). However, this graph theoretic approach has also been applied to a broad range of problems with similar structure as PNS. In particular, recent work has demonstrated the similarity of PNS problems to input-output (IO) optimization problems; the latter class of problems has been applied for physical flows at scales ranging from process plant level to supply chain level. IO models have also been proposed to plan the allocation of human resource in organizations. In this work, a P-graph based approach to reallocation of human resources in an industrial plant during a transient crisis is presented. The model determines how personnel can be reassigned to allow a plant to operate at an alternative temporary steady state when the plant becomes short-handed due to a disruptive external event. This methodology is demonstrated using a representative case study involving an instant coffee plant. Results show that in the occasion that a reduction in available workforce is experienced, workforce is allocated in more critical areas and productivity is maximized by minimizing interaction with less critical departments.

12:20-12:40 MoAT4.6

Evolutionary Adaptive Dynamic Programming Algorithm for Converter Gas Scheduling of Steel Industry, pp. 137-142

Wang, Tianyu Dalian Univ. of Tech
Wang, Linqing Dalian Univ. of Tech. Dalian, Liaoning
Zhao, Jun Dalian Univ. of Tech. Dalian, Liaoning
Wang, Wei Dalian Univ. of Tech
Liu, Ying Dalian Univ. of Tech

It is significant to perform an effective scheduling of byproduct gas system in steel industry for reducing cost and protecting environment. The existing studies largely focused on extracting specific knowledge from human experience or directly optimizing the scheduling performance, which failed to provide a dynamic optimization process for making the scheduling scheme updated online. In this study, an action-dependent heuristic dynamic programming (ADHDP) framework is proposed for the Linz–Donawitz converter gas (LDG) scheduling, in which the scheduling amount is calculated based on the gas system states by utilizing a Tagaki-Sugeno-Kang (TSK) fuzzy model, while a utility function is introduced in the critic network considering the time delay of the gas system to evaluate the scheduling performance over time. For achieving online learning process, the concept of a modified evolutionary algorithm is combined with the ADHDP to obtain the near-optimal scheduling policy at each time instance. To demonstrate the performance of the proposed method, the practical data coming from the energy center of a steel plant are employed. The results show that the proposed method can supply the human operators with effective solution for secure and economically justified optimization of the LDG system.

MoKT1 1F Conference Room

Keynote 1 (M. Guay) (Keynote Session)

Chair: Bao, Jie The Univ. of New South Wales

13:40-14:10 MoKT1.1

Adaptive Gain Nonlinear Observer Design Techniques, pp. 143-148

Guay, Martin Queen's Univ

In this study, two novel observer design techniques are proposed in which the observer gain is computed in real-time using online gain updates. First, an adaptive Luenberger observers is proposed. The approach borrows from the application of Chandrasekhar-type algorithms that are amenable to the design of an adaptive gain approach to the design of Luenberger observers. Second, an extremum-seeking control based observer is proposed. This approach provides an effective unstructured approach to compute observer gains for a general class of detectable nonlinear systems. Both approaches avoid the need for the computation of a solution of a Riccati equation or its nonlinear counterpart.

MoKT2 Room 101

Keynote 2 (Y. Fu, H. Yang) (Keynote Session)

Chair: Wang, Youqing Beijing Univ. of Chemical Tech

13:40-14:10 MoKT2.1

Simultaneous Estimation of the Number of Principal Components and Kernel Parameter in KPCA, pp. 149-154

Fu, Yujia Jiangnan Univ
YANG, Huizhong Jiangnan Univ
Tao, Hongfeng Jiangnan Univ

This article proposed a novel method to determine the number of principal components and the optimal values of tuning factors for kernel principal component models. Existing work predominantly relies on ad-hoc rules or cross-validatory approaches to estimate. To guarantee statistical independence, the proposed technique incorporates a two-fold cross-validatory approach by omitting one variable in turn, which is predicted by the remaining ones. For these regressions, the number of principal components varies. This finally yields an optimum selection for the parameters, which application and the analysis of recorded industrial data from a glass melter process confirm.

MoKT3 Room 103

Keynote 3 (Y. Zhu) (Keynote Session)

Chair: Zhao, Chunhui Zhejiang Univ

13:40-14:10 MoKT3.1

System Identification: New Developments of the Asymptotic Theory and Method, pp. 155-160

Zhu, Yucai Zhejiang Univ

The so-called asymptotic theory of Ljung (1985) gives an error description of identified black-box model in the frequency domain. Based on the theory the asymptotic method of identification has been developed and applied successively in industrial MPC control and PID tuning. In this work, new results that extend the asymptotic theory and method will be presented: (1) an asymptotically globally convergent Box-Jenkins model estimation algorithm; (2) errors-in-variables model identification; and (3) accurate model identification using over-sampling scheme.

MoBT1 1F Conference Room

New Directions of Adaptive and Learning Control (Invited Session)

Chair: Takahashi, Masanori Tokai Univ
Co-Chair: Prasad, Vinay Univ. of Alberta
Organizer: Takahashi, Masanori Tokai Univ
Organizer: Ohnishi, Yoshihiro Ehime Univ

14:10-14:30 MoBT1.1

Extension of a Multi-Rate Control Law Independently of Both Reference and Disturbance Responses (I), pp. 161-165

Sato, Takao Univ. of Hyogo
Ishii, Nozomi Univ. of Hyogo
Araki, Nozomu Univ. of Hyogo
Konishi, Yasuo Univ. of Hyogo

This study discusses a design method for sampled-data multi-rate control systems, in which the sampling interval of the plant output is an integer multiple of the hold interval of the control input. In this study, a desired response in discrete time is assumed to be obtained using a multi-rate control law, and then the multi-rate control law is extended such that an existing discrete-time disturbance and reference responses are simultaneously maintained. In the proposed multi-rate control system, the intersample response can be improved independently of the discrete-time response. Finally, the effectiveness of the proposed method is shown through numerical examples.

14:30-14:50 MoBT1.2

Adaptive Output Feedback Control with Predictive Feedforward Input Based on Extended Output Estimator (I), pp. 166-171

Fujii, Seiya Kumamoto Univ
Mizumoto, Ikuro Kumamoto Univ

In this paper, a two-degree-of-freedom adaptive output feedback control system design scheme with a predictive control input as feedforward control input and with an ASPR based adaptive output feedback control as feedback control is proposed. An extended output estimator for systems with uncertain disturbances will be proposed, and based on the obtained output estimator, a robust output predictor with respect to uncertain disturbances is designed for predictive feedforward control. The stability of the obtained control system is guaranteed via ASPR based adaptive output feedback. The effectiveness of the proposed adaptive predictive control will be confirmed through numerical simulations.

14:50-15:10 MoBT1.3

Verification of the Relationship between Desired Angle Ratio and Control Performance in the Links of a Gymnastic Based Controller for an Underactuated Robot (I), pp. 172-177

Akiyama, Masaki Advanced Course in National Inst. of Tech. Kagawa Coll
Henmi, Tomohiro National Inst. of Tech. Kagawa Coll
Yamamoto, Toru Hiroshima Univ

In this paper,the influence on control performance with a changing desired angle ratio are discussed,for a gymnastic based controller of an underactuated robot. An original evaluation function, which uses input torques and an amount of energy change, is applied for a verification of the control performance.

15:10-15:30 MoBT1.4

A Bayesian Learning and Data Mining Approach to Reaction System Identification: Application to Biomass Conversion, pp. 178-183

Tefea, Dereje Univ. of Alberta
de Klerk, Arno Univ. of Alberta
Prasad, Vinay Univ. of Alberta

The growing environmental concern over the use of fossil fuels calls for alternative sources of energy with smaller environmental footprint, and biomass-derived fuels have been extensively investigated as a substitute. In biofuels production, the development of reaction networks and kinetic models is unquestionably a major challenge due to the difficulty in characterizing the reaction products. Therefore, there is a need for a better way to retrieve the information about the reaction from the available experimental data. This study uses a data mining and Bayesian learning approach to estimate the reaction network of the acid and base catalyzed hydrous pyrolysis of hemicellulose from Fourier Transform Infrared (FTIR) spectroscopy. Cluster analysis is used to model the system in terms of lumps and a Bayesian network structure-learning algorithm is then used to device a reaction network. Three Bayesian network structure-learning algorithms were implemented to estimate the reaction network. The results from each were identical, indicating that the model representing the reaction network is most probably in the optimal equivalence space. The model was compared against expert-based reaction models and the agreement is encouraging. A useful aspect of this model is its self-updating capability, i.e., the reaction model can provide a quantitative description of the effect of the change in the operation condition from spectroscopic data. Hence, the model may be used for the real time analysis of the investigated process.

15:30-15:50 MoBT1.5

Self-Repairing Control for Plants with High Relative Degrees (I), pp. 184-189

Takahashi, Masanori Tokai Univ

In the previous works, a self-repairing control (SRC) has been developed for plants with unknown sensor failures. The SRC is recognized as one of the active fault-tolerant control based on dynamic redundancy, and has the advantage that the failed sensor can be found with no a priori information about the plant within a prescribed detection time. However, the SRC has been applicable for only a class of plants with relative degree one. As a remedy, using the well--known backstepping, this paper alleviates the condition on the relative degree in the designing the SRC system. Furthermore, to confirm the effectiveness, an application to a CSTR is shown.

15:50-16:10 MoBT1.6

Design of a Discrete-Time ASPR Based Adaptive Output Feedback Control System with a Feedforward Input (I), pp. 190-194

Guan, Zhe Hiroshima Univ
Wakitani, Shin Hiroshima Univ
Mizumoto, Ikuro Kumamoto Univ
Yamamoto, Toru Hiroshima Univ

This paper presents a discrete-time adaptive output feedback control system design scheme based on the almost strictly positive real (ASPR) of controlled systems with a feedforward input. The reference signal is used to calculate the feedforward input. It is well-known that a stable adaptive output feedback control system can be designed based on ASPR conditions. However, most realistic systems do not satisfy ASPR conditions. One of alleviation ways is to use various forms of parallel feedforward compensators (PFC) which can configure the ASPR conditions. The problem is output of ASPR augmented system remains output of the original plant. In this paper, an output feedback control system design scheme with feedforward input is proposed in discrete-time. The proposed scheme eliminates the output error and controller structure is much simpler.

MoBT2 Room 101

Data Analytics and Machine Learning (Invited Session)

Chair: Lee, Chang Jun Pukyong National Univ
Co-Chair: Chiang, Leo The Dow Chemical Company
Organizer: Gopaluni, Bhushan Univ. of British Columbia

14:10-14:30 MoBT2.1

A Weighted Gaussian Process Regression for Multivariate Modelling (I), pp. 195-200

Hong, Xiaodan Donghua Univ
Ren, Lihong Donghua Univ
Chen, Lei Donghua Univ
Guo, Fan Donghua Univ
Ding, Yongsheng Donghua Univ
Huang, Biao Univ. of Alberta

This paper develops three weighted Gaussian process regression (GPR) approaches for multivariate modelling. Taking into account weighted strategy in the traditional univariate GPR, the heteroscedastic noise problem has been solved. The present paper extends the univariate weighted GPR algorithm to the multivariate case. Considering the correlation and weight between data, as well as the correlation between outputs, the covariance functions of the proposed approaches are formulated. By

formulating different process noise mechanisms, the proposed methods can solve different multivariate modelling problems. The effectiveness of the proposed algorithm is demonstrated by a numerical example as well as a six-level drawing of a Carbon fiber example.

14:30-14:50 MoBT2.2

Deep Reinforcement Learning Approaches for Process Control (I), pp. 201-206

Pon Kumar, Steven Spielberg — Univ. of British Columbia
Gopaluni, Bhushan — Univ. of British Columbia
Loewen, Philip — Univ. of British Columbia

In this work, we have extended the current success of deep learning and reinforcement learning to process control problems. We have shown that if reward hypothesis functions are formulated properly, they can be used for industrial process control. The controller setup follows the typical reinforcement learning setup, whereby an agent (controller) interacts with an environment (process) through control actions and receives a reward in discrete time steps. Deep neural networks serve as function approximators and are used to learn the control policies. Once trained, the learned network acquires a policy that maps system output to control actions. Though the policies are not explicitly specified, the deep neural networks were able to learn policies that are different from the traditional controllers. We evaluated our approach on Single Input Single Output Systems (SISO), Multi-Input Multi-Output Systems (MIMO) and tested it under various scenarios.

14:50-15:10 MoBT2.3

Advances in Big Data Analytics at the Dow Chemical Company (I), pp. 207-208

Chiang, Leo — The Dow Chemical Company
Lu, Bo — The Dow Chemical Company
Castillo, Ivan — The Dow Chemical Company

Big data analytics is the journey to turn data into insights for more informed business and operational decisions. As the Chemical Engineering community is collecting more data (volume) from different sources (variety), this journey becomes more challenging in terms of using the right data and the right tools (analytics) to make the right decisions in real-time (velocity). This paper highlights recent advancements in the big data analytics journey at The Dow Chemical Company in the areas of Enterprise Manufacturing Intelligence, multivariate analysis, on-line fault detection, inferential sensors, and batch data analytics.

15:10-15:30 MoBT2.4

Proposal of Two Classifiers of Offshore Naturally Flowing Wells Events Using K-Nearest Neighbors, Sliding Windows and Time Multiscale, pp. 209-214

Vargas, Ricardo Emanuel Vaz Vargas — Federal Univ. of Espirito Santo
Munaro, Celso Jose — Federal Univ. of Espirito Santo
Ciarelli, Patrick Marques — Federal Univ. of Espirito Santo
Araújo, Jean Carlos dias de — Petróleo Brasileiro S.A

This paper considers two approaches for detecting and classifying undesirable events in offshore naturally flowing wells. The operation of an oil well requires many decisions that can avoid production losses and additional costs. Two data-based methods are proposed using k-nearest neighbors, sliding windows and time multiscale. The parameters required by these classifiers are tuned using data from simulations of an oil well. Validations are performed using data from both simulation and a real plant as well. Statistical indices are used to compare different methods and parameters. The outcome provides encouraging results that can be readily implemented in a real plant.

15:30-15:50 MoBT2.5

Research and Application of KICA AROMF Based Fault Diagnosis, pp. 215-220

ZHU, Qunxiong — Beijing Univ. of Chemical Tech
Meng, Qian-Qian — Beijing Univ. of Chemical Tech
XU, Yuan — Beijing Univ. of Chemical Tech
He, Yan-Lin — Beijing Univ. of Chemical Tech

With the development of the modern industrial system, data-driven fault diagnosis has attracted more attention. Fault diagnosis of complex industrial processes based on one-dimensional adaptive rank-order morphological filter (AROMF) may miss key information because of excessive dimension reduction of process data. To solve this problem, a method combines the kernel independent component analysis (KICA) with one-dimensional AROMF is proposed. Firstly, KICA is used for nonlinear feature extraction, getting the template signal and the test signal of each pattern. Then, achieve diagnosis via multi-dimensional signal classification method bases on AROMF proposed in this paper. The advantage of the proposed method was confirmed by the simulation of the Tennessee Eastman process.

15:50-16:10 MoBT2.6

Pattern Analysis of Time-Series Pressure Data by Combining Analysis of CFD Simulation Data for Monitoring of Liquid-Liquid Parallel Flows in Micro Slit (I), Invited Talk

Matsumoto, Hideyuki — AIST
Yoshikawa, Shiro — Tokyo Institute of Technology

Previously the applicability of dynamic analysis of static pressure data has been reported as a method for in situ monitoring of the contact line between two immiscible flows in a micro slit. In order to control dynamic behavior of the two parallel flow efficiently, classification of the operational conditions by associating with flow pattern is significant. In the present paper, we propose an application method of the batch self-organizing map as a method of cluster analysis of pressure fluctuation data by combining system analysis of CFD simulation data. The proposed method has demonstrated that monitoring of pressure fluctuation data by using the cluster analysis could give us useful information about dynamic behavior of confluence of two immiscible flows in micro slit.

MoBT3 — Room 103

System Identification (Regular Session)

Chair: Yang, Fan — Tsinghua Univ
Co-Chair: Tangirala, Arun K. — Indian Inst. of Tech. Madras

14:10-14:30 MoBT3.1

Challenges in the Discrete-Time Identification of LTI Multiscale Systems: A Critical Overview, pp. 221-226

Pinnamaraju, Vivek Shankar — IIT Madras
Tangirala, Arun K. — Indian Inst. of Tech. Madras

Multiscale systems are characterized by dynamics that evolve over different times scales and are encountered frequently in process industries. Conventional identification techniques yield poor results when applied directly to MS systems because of their inherent assumption that the system evolves at a single scale. In this paper, we discuss the key challenges in the discrete-time (DT) identification of linear time invariant (LTI) multiscale systems with a critical review of the existing literature. These challenges are seen to exist right from the experimental design to the model development stage. We take this opportunity to provide a few perspectives and highlight certain burning open-ended problems (e.g., input design and determining the number of scales from data) in multiscale identification. Simulation examples are presented to bolster our arguments, wherever necessary.

14:30-14:50 MoBT3.2

Identification of LTV Systems with Cascade Control Loops Using Basis Function Approach, pp. 227-232

Ku, ShaoWu — Zhejiang Univ
Chen, Junghui — Chung-Yuan Christian Univ
Chan, Lik Teck, Lester — Chung Yuan Christian Univ

In this work, the subspace identification method (SID) based on the linear time varying (LTV) state space model is developed to

identify a nonlinear process under cascade control loops. By using the basis functions, the LTV subspace identification can describe a nonlinear process mathematically the same as the LTI one. Then, like the conventional LTI-SID approach, the same two-step procedure is developed. The subspace spanned by the columns of the extended observability matrix is estimated first from the input-output data of the system. Second, the system matrices are determined directly by the extended observability matrix. Also, to deal with closed-loop data, an innovation estimation method is adopted. Finally, level cascade control for reflux drum is presented to illustrate the features of the proposed LTV-SID method in comparison with the past LTI-SID method.

14:50-15:10 MoBT3.3

Parameter Identification Method for Process Control Systems Based on the Newton Iteration, pp. 233-238

Xu, Ling — Jiangnan Univ
Ding, Feng — Jiangnan Univ
Liu, Yanjun — Jiangnan Univ
Li, Junhong — Nantong Univ
Chen, Jing — Jiangnan Univ

The typical second-order system is a widely used model in control system analysis. The typical second-order system responses contain abundant dynamical information and can be modeled and identified. The modeling for the typical second-order system is significant. This paper studies the identification method for the typical second-order system by means of the impulse response experiment and presents a Newton iterative parameter estimation algorithm for the second-order system with under-damping ratio. An example is provided to test the algorithm performance. Moreover, the proposed method is applied to a mechanical system. The simulation results show that the proposed identification method can work effectively.

15:10-15:30 MoBT3.4

Identification of FIR Models Using Basis Models of First-Order Plus Time Delays, pp. 239-244

Shen, Wenyi — Department of Automation, Tsinghua Univ
GAO, Xinqing — Department of Automation, Tsinghua Univ
Yang, Fan — Tsinghua Univ
Jiang, Yongheng — Dept. of Automation, Tsinghua Univ
Ye, Hao — Tsinghua Univ
Huang, Dexian — Tsinghua Univ

In this article, a new methodology is presented for identification of finite-impulse-response (FIR) models. The central idea is to use a series of stable models of first-order plus time delays (FOPTD) to approximate the dynamics of the process. A quantitative analysis of the modelling error is provided. Compared to the existing basis model approaches, the advantages of the proposed method lie in the following aspects: (i) a simple model structure with a small number of basis models is sufficient to obtain satisfactory approximations, thereby reducing the model structural risks; and (ii) basis models could be determined with limited prior process information, which is beneficial for practical implementations. Representative simulation examples are provided to illustrate the superiority of our method over the existing identification approaches based on basis models.

15:30-15:50 MoBT3.5

Modeling of Hemoglobin Response to Erythropoietin Therapy through Constrained Optimization, pp. 245-250

Ren, Jia — Zhejiang Sci-Tech. Univ
McAllister, Jayson — Univ. of Alberta
Zukui, Li — Univ. of Alberta
Liu, Jinfeng — Univ. of Alberta
Simonsmeier, Ulrich — Cybernius Medical Ltd

Hemoglobin response modeling is critical for accurately predicting the hemoglobin level of anemic patients and it is the foundation of optimal control based Erythropoietin (EPO) therapy. In this paper, a novel Hemoglobin response modeling method is proposed. This method was inspired from a study on the physiological model of hemoglobin response to Erythropoietin. Insights on the effect of EPO is first gained from the physiological model and then transformed into an auto-regressive with exogenous input (ARX) model parameter pattern. The ARX model parameter estimation problem is formulated as a constrained optimization problem. Tests on simulated data using the physiological model and the real clinical data both show that the proposed modeling method has superior performance while also being less complex than the physiological model.

15:50-16:10 MoBT3.6

Parameter Identification for Breakage Distribution Function of Bauxite Based on State Transition Algorithm, pp. 251-256

Wang, Yalin — Central South Univ
Peng, Kai — Central South Univ
Yuan, Xiaofeng — Central South Univ
Li, Ling — Central South Univ. of Information Science An
Chen, Guanyu — Central South Univ. of Information Science An

The breakage distribution function of bauxite plays an important effect in the ball milling process, which can be used to predict particle size distribution of the product at the outlet of the ball mill. The structure of the breakage distribution function can be determined by the experience knowledge. Parameters of the distribution function are usually identified by using the grinding test data. The parameter identification problem is a complex constrained nonlinear problem in the grinding process. In this paper, a two-stage modeling method is proposed, which divides multiple single models into two parts that are symmetric about the line. It can quickly search the global optimal solution, which can avoid the trap of local optimum. At the same time, the state transition algorithm is applied to optimize the parameters of the breakage distribution function in the two-stage model because of its simplicity and good numerical results. Experimental results show that the optimization of the two-stage model with state transition algorithm can reduce the error than the single model, and it can find the optimal solution more quickly and accurately than the Powell algorithm.

MoBT4 Room 201

Design and Control of Separation Processes (Invited Session)

Chair: Chien, I-Lung — National Taiwan Univ
Co-Chair: Lee, Hao-Yeh — National Taiwan Univ. of Science & Tech
Organizer: Lee, Hao-Yeh — National Taiwan Univ. of Science & Tech
Organizer: Chien, I-Lung — National Taiwan Univ

14:10-14:30 MoBT4.1

Using [EMIM][OAC] As Entrainer for Isopropyl Alcohol Dehydration Via Extractive Distillation (I), pp. 257-262

Chen, Hung-Hsing — National Taiwan Univ
Chen, Meng-Kai — National Taiwan Univ
Chien, I-Lung — National Taiwan Univ

Recently, many researchers focus on the applications of ionic liquids (ILs) because they are almost non-volatile, thus appear to be easily separated. One of the applications is that ionic liquids can be used as entrainer in extractive distillation. This work designs an extractive distillation system using ionic liquids as entrainer for isopropyl alcohol (IPA) dehydration. First, a way to build thermodynamic models of ionic liquids is proposed. Second, the entrainer recovery with two-flashers and flasher-stripper configurations using IL as entrainer are discussed. Finally, the process using 1-ethyl-3-methylimidazolium acetate ([EMIM][OAC]) as entrainer is compared with the one using dimethyl sulfoxide (DMSO) as entrainer under two IPA purity specifications. The total

annual cost (TAC) of the two recovery configurations using [EMIM][OAC] under higher IPA purity specification are both higher in comparison with the conventional designs. On the other hand, the TAC of the IL process with lower IPA purity specification with two-flashers and flasher-stripper configurations are 7.19% and 8.34% lower in comparison with the conventional designs. This case study indicates that the favorable properties of ionic liquid as entrainer are to greatly enhance relative volatility of the mixture going to be separated and to have better thermal stability.

14:30-14:50 MoBT4.2

Performance of Reactive Distillation Columns with Multiple Reactive Sections for the Disproportionation of Trichlorosilane to Silane (I), pp. 263-268

Zang, Xinxiang — Beijing Univ. of Chemical Tech
Chen, Haisheng — Beijing Univ. of Chemical Tech
Huang, Kejin — Beijing Univ. of Chemical Tech

With reference to the disproportionation of trichlorosilane to silane, a three-stage consecutive reversible reaction with a rather unfavorable reaction kinetics, in-depth comparison in steady-state performance is performed between the column with a single reactive section and those with multiple reactive sections, adopting the equal number of trays and the equal amount of catalyst. The reactive distillation column with multiple reactive sections appears to be considerably superior in the aspect of economic advantages to the reactive distillation columns with single reactive section and these strengths originate essentially from the additional degrees of freedom resulted from the arrangement of multiple reactive sections in process synthesis and design. Arrangement of side-condensers is also examined towards the columns with multiple reactive sections and the outcomes reveal the thermodynamic rational to adopt multiple reactive sections in process development. Although these findings are derived from the specific case study chosen, it should be regarded as the significant potential for analyzing the reactive distillation columns with intricate multiple reversible reactions and separating intricate multiple components.

14:50-15:10 MoBT4.3

Design and Control of Diphenyl Carbonate Reactive Distillation Using a Thermally Coupled Configuration (I), pp. 269-274

Chang, Hsiang-Ning — National Taiwan Univ. of Science and Tech
Lee, Hao-Yeh — National Taiwan Univ. of Science & Tech

This study investigated the energy-saving design and control of diphenyl carbonate (DPC) reactive distillation (RD) process by using phenyl acetate (PA) and diethyl carbonate (DEC) through a thermally coupled arrangement. A thermally coupled arrangement eliminates the remixing effect and reduces the total energy. Two cases of DPC synthesis through RD configuration have been discussed in a previous study. However, a remixing effect can be observed between the RD and separation columns through composition profile analysis. To decrease the total heat duty, the remixing effect must be eliminated. This paper presents two cases of the proposed thermally coupled arrangement. After reducing the total heat duty through thermal coupling, the minimum TAC was determined in order to implement dynamic control. The product DPC as well as the byproduct EtAc was met the industrial specifications by temperature controller under the ±10% throughput and −5%, −10% composition disturbances.

15:10-15:30 MoBT4.4

Simulation and Optimization of Structured Packing Replacement in Absorption Column of Natural Gas Dehydration Unit Using Triethylene Glycol (TEG) (I), pp. 275-281

Affandy, Sony Ardian — Chemical Engineering Department, Inst. Teknologi Sepuluh Nope
Handogo, Renanto — Chemical Engineering Department, Inst. Teknologi Sepuluh Nope
Purwo Sutikno, Juwari — Chemical Engineering Department, Inst. Teknologi Sepuluh Nope
Chien, I-Lung — National Taiwan Univ

Natural gas dehydration is an important process in the gas processing. In this process, water vapor is removed from natural gas streams since it can cause some problems in the next process. Application of structured packing in separation processes like natural gas dehydration has been increased since last few years. In this work, a domestic natural gas dehydration unit using triethylene glycol (TEG) was simulated. Predictive Redlich-Kwong-Soave (PSRK) equation of state was applied in the simulation. The existing tray column was replaced by structured packing and then was optimized. The results show that by replacing tray column with packed bed column can reduce the size of the column and also reduce the total annual cost (TAC) of the natural gas dehydration unit.

15:30-15:50 MoBT4.5

Dynamics and Control of Totally Reboiled Reactive Distillation Columns (I), pp. 282-287

Wang, Tengfei — Beijing Univ. of Chemical Tech
Chen, Haisheng — Beijing Univ. of Chemical Tech
Huang, Kejin — Beijing Univ. of Chemical Tech

The object of the study is the totally reboiled reactive distillation columns. In the current work, transfer function based process models exhibits the dynamics and operation of TRRDCs. In the reaction operation and the separation operation, there are the special topological configuration and the intricate interplay, resulting in under-damped step responses. The under-dampness can be substantially alleviated through the tight inventory control of bottom reboiler and this presents beneficial effects to process dynamics and operation. Two illustrative examples, a hypothetical synthesis reaction from A and B to C, and a real decomposition reaction from 1, 4-butanediol to tetrahydrofuran and water are used to demonstrate the dynamics and the performance of the above control strategy.

15:50-16:10 MoBT4.6

Design and Control of Diphenyl Carbonate Reactive Distillation Processes Using Arrangements with Heat-Integrated Stages (I), pp. 288-293

Alcántara-Avila, J. Rafael — The Univ. of Tokushima
Terasaki, Masataka — Tokushima Univ
Lee, Hao-Yeh — National Taiwan Univ. of Science & Tech
Chen, Jun-Lin — National Taiwan Univ. of Science & Tech
Cabrera-Ruiz, Julián — Univ. De Guanajuato
Sotowa, Ken-Ichiro — Univ. of Tokushima
Horikawa, Toshihide — The Univ. of Tokushima

Diphenyl carbonate is a very important precursor of polycarbonate. Therefore environmental friendly chemical routes and low-cost processes are necessary to cope with its demand. In this study, a new green route to produce diphenyl carbonate and methyl acetate from the reaction between phenyl acetate and dimethyl carbonate was adopted. Also, reactive distillation (RD) is the adopted process to do the reaction and separation simultaneously because this process can overcome chemical equilibrium limitations, obtain high selectivity, and can use the heat of reaction in distillation. The advantages of RD can increase the process efficiency and reduction of investments and operational costs. This study aims to design an RD process with heat-integrated stages that can further reduce the energy consumption in comparison with conventional RD technology. At the steady state, simulation and optimization techniques were combined to find the best design while at the dynamic state, the theoretical control properties at open loop and the close loop performance were done to find the best control scheme and controller parameters.

MoPO Ball Room

Poster Session (Interactive Session)

Chair: Ward, Jeffrey Daniel — National Taiwan Univ

Co-Chair: Pan, Tianhong — Jiangsu Univ

16:10-16:50 MoPO.1

Robust Preliminary-Summation-Based Principal Component Analysis for Non-Gaussian Processes with Outliers (I), pp. 294-299

Wang, Youqing — Beijing Univ. of Chemical Tech

Preliminary-summation-based PCA (PS-PCA), was recently proposed to handle the non-Gaussian features of industrial processes. However, when PS-PCA is applied to the monitoring of data with outliers, the “summation infection” phenomenon occurs, which makes PS-PCA ineffective. To eliminate the influence of outliers, this paper proposes a novel robust PS-PCA (RPS-PCA) which distinguishes outliers from the faulty data using the consecutive detection results and then removes them. Because RPS-PCA only eliminates the influence of outliers in the normal process data while retaining the outliers in the faulty data, it can use the outliers to improve its fault-detecting ability.

16:10-16:50 MoPO.2

Online Flooding Prognosis in Packed Columns by Monitoring Parameter Change in EGARCH Model (I), pp. 300-305

Liu, Yi — Zhejiang Univ. of Tech

Hseuh, Bo-Fan — National Tsing Hua Univ

Gao, Zengliang — Zhejiang Univ. of Tech

Yao, Yuan — National Tsing Hua Univ

In the chemical industry, packed columns are commonly used operating units for separation. However, the flooding phenomenon often reduces the efficiency of packed columns and interferes with the performance of the system. Due to this reason, research on the real-time prognosis of flooding becomes a necessity in practice. Pressure drop is a key factor that indicates flooding phenomenon in packed columns. In this paper, the trajectory of pressure drop in each time window is modeled with an exponential generalized autoregressive conditional heteroskedastic (EGARCH) process. The onset of flooding is then implied by the parameter change of the model. To capture the change in an efficient manner, a nonparametric charting technique is adopted for statistical process control (SPC). The feasibility and efficiency of the proposed method are illustrated by the experimental results.

16:10-16:50 MoPO.3

Active Learning Dynamic Soft Sensor with Forward-Update Scheme (I), pp. 306-311

Wu, Qing-Yang — Chung Yuan Christian Univ

Chan, Lik Teck, Lester — Chung Yuan Christian Univ

Chen, Junghui — Chung-Yuan Christian Univ

Soft sensors are used to infer the quality variable from easy-to-measure process variables. The conventional static soft sensor is incapable of handling the dynamic of processes. For data-based soft sensor development, with abundance of the raw sensor data, the problem of variable correlations and large number of sample are encountered. This work presents a latent variable model (LVM) based active learning strategy to select representative data for efficient development of the dynamic soft sensor model. In order to carry out data selection the uncertainty information is provided by Gaussian process (GP) model. The LVM with auxiliary GP model is developed under a dynamic framework which is suitable for dynamic processes. A forward-update scheme for updating the soft sensor model in advance is proposed so that the soft sensor is able to reflect the current status of the process and to improve the soft sensor model without waiting for the quality measurements. The proposed method is applied to an industrial fluid catalytic cracking process data.

16:10-16:50 MoPO.4

Tensor-Based Ultrasonic Signal Processing for Defect Detection in Fiber Reinforced Polymer (FRP) Structures (I), pp. 312-317

You, Renchun — Xiamen Univ

Yao, Yuan — National Tsing Hua Univ

Shi, Jia — Xiamen Univ

Ultrasonic testing (UT) technique has been widely used in defect detection of composite materials. To better identify the defective regions, a number of one- or two-dimensional signal processing methods have been adopted for defect signal enhancement. However, the application of these methods is limited by their complex operation. Most of the existing methods cannot deal with the entire three-dimensional tensor of UT data in an efficient manner. In order to solve this problem, a third-order tensor decomposition method, Tucker3, is adopted in this paper for UT-based defect detection in fiber reinforced polymer (FRP) structures. After Tucher-3 decomposition, the defect information is extracted by a small number of factors, which is further summarized by the leverages. The candidate defective regions are then identified from the leverages, based on which the locations and the shapes of the defects can be calculated by clustering.

16:10-16:50 MoPO.5

Parameter Optimization of Simple Adaptive Control Via Differential Evolution (I), pp. 318-323

Takagi, Taro — National Inst. of Tech. Maizuru Coll

Ito, Minoru — National Inst. of Tech. Maizuru Coll

Mizumoto, Ikuro — Kumamoto Univ

This paper deals with a parameter optimization problem of adjusting laws of simple adaptive control (SAC). SAC adjust their gains automatically, and thus the control system can be stable and can obtain a good control performance after a sufficient time. Although the control performance in a transient state depends on the parameter of adjusting laws, its decision method has not been proposed. For this problem, in the case of that a nominal model of plant is known, Differential Evolution (DE) is applied. Finally, we show a numerical experiment to confirm the effectiveness of the method.

16:10-16:50 MoPO.6

Empirical Trajectories for Batch Crystallization Control with Constraints, pp. 324-329

Hsieh, Hsiang-Feng — National Taiwan Univ

Ward, Jeffrey Daniel — National Taiwan Univ

Optimization of batch crystallization is studied with tight constraints on the maximum rate of change of batch temperature or maximum rate of evaporation. It is observed that under tight constraints, the constraint has the greatest effect on the shape of the batch trajectory. Three crystallization systems are simulated for different values of the batch time and crystal yield. The resulting temperature or evaporation rate trajectories are plotted in dimensionless coordinates and fit to an empirical equation. The empirical equation performs similar to other convex trajectories recommended in the literature and much better than the linear trajectory.

16:10-16:50 MoPO.7

R2R Controller Design Using T-S Fuzzy Model and Extended State Observer, pp. 330-335

Wang, Haiyan — Jiangsu Univ

Tan, Fei — Jiangsu Univ

Sheng, Biqi — China Maritime Pol. Acad

Pan, Tianhong — Jiangsu Univ

Fu, Haijun — Jiangsu Univ

The wafer quality measurement delay is the common phenomenon in the semiconductor manufacturing processes. The reason is that the measurement is expensive or cannot always be

performed online. Furthermore, the measured delay is stochastic, which will affect the stability of controller. In this paper, a new kind of R2R controller integrated T-S fuzzy model and Extended State Observer (ESO) is developed to keep the expected performance of system. Firstly, a R2R controller based on ESO is presented. Then T-S fuzzy model is used to modify the proposed R2R controller. Stochastic delay is analyzed using the Markov chain theory to get the membership function of T-S fuzzy model. A numerical example of the mixed-product manufacturing process demonstrates the performance of the proposed R2R controller.

16:10-16:50 MoPO.8

A Power Plant Coordinated Control System Using MPC, pp. 336-341

Luo, Jia	Inst. of Electrical Power Res. Guangdong Power Grid, Gu
Zhu, Yucai	Zhejiang Univ
Chen, Shihe	Inst. of Electrical Power Res. Guangdong Power Grid, Gu
Jiang, Pengfei	Zhejiang Univ
Wu, Le	Inst. of Electrical Power Res. Guangdong Power Grid, Gu
Xiao, Yuwen	Hengyi Electrical Power Ltd, Foshan, Guangdong Province

This work report an industrial application of model predictive control (MPC) to a 600 MW coal fired electrical power plant is presented. The coordinated control system (CCS) is the most important part of the project. Dynamic models are obtained using multivariable closed-loop identification. In MPC control, plant nonlinearity caused by load changes is treated using simple LPV model. Initial tests to the power plant show that MPC technology can achieve much more stable operation of the power plant, reduction of coal consumption by more than 1%.

16:10-16:50 MoPO.9

Control of Two Batch Crystallization Processes with Apparent Growth-Rate Dispersion, pp. 342-347

Chen, William	National Taiwan Univ
Cho, Hung-Chih	National Taiwan Univ
Ward, Jeffrey Daniel	National Taiwan Univ

Control of batch crystallization processes is studied for two experimental systems: potassium aluminum sulfate and adipic acid. Both systems showed significant broadening of the crystal size distribution during the batch operation, which was attributed to growth-rate dispersion. Models for crystal nucleation and growth, including growth-rate dispersion, were developed to describe both processes.

16:10-16:50 MoPO.10

A Novel Single-Input Two-Output Strategy for Split Range Control, pp. 348-353

Fatani, Sultan	Saudi Aramco
Patwardhan, Rohit	Saudi Aramco
Lopez Andreu, Miguel	Saudi Aramco

This paper presents a novel method* for implementing a split range control using Proportional-Integral (PI) controller where two valves, small and big, are available to simultaneously control the underlying process. The proposed method is demonstrated on a dehydrator drum level at a gas oil separation process (GOSP).

*The proposed control scheme strategy discussed in this document has been filed for patent in the US (Ref:38136-0156001)

16:10-16:50 MoPO.11

Plant-Wide Design and Control of C5 Separation Processes, pp. 354-359

HSU, HSIAO-CHING	ChangChun Plastics. Co. Ltd
Wang, San-Jang	National Tsing Hua Univ
Ou, John Di-Yi	National Tsing Hua Univ
Wong, David Shan Hill	National Tsing Hua Univ

In this study, the dynamic responses of three C5 fraction separation processes: conventional, simplified, and intensified processes with control systems are investigated. The simplified process provides higher concentration of DCPD in the product and can be stable in the dynamic state. While an intensified process can substantially reduce energy consumption, it is necessary to fix the liquid split ratio in the divided wall column that separate IP from extractive solvent NMP and DCPD to maintain the steady state. Otherwise loss of NMP to DPCD will upset the process.

16:10-16:50 MoPO.12

Software Integration for Online Dynamic Simulation Applications, pp. 360-364

Mitchell, Matthew	The Univ. of Auckland
Abeykoon Udugama, Isuru Sampath Bandara	Univ. of Auckland
Currie, Jonathan	AUT Univ
Yu, Wei	The Univ. of Auckland

Current process industries such as refineries and pharmaceutical industries have been facing increasing challenges with respect to productivity, reducing waste and energy consumption, as well as environmental and safety issues becomingly increasingly comprehensive. One way to address these issues is to utilize online dynamic simulation via process modelling and control software. While there are multiple process simulation packages available, such as VMGsim, HYSYS, Aspen etc., comprehensive control algorithms such as Model Predictive Control (MPC) or many Advanced Process Control (APC) algorithms which are available in the literature and third party packages cannot be easily and/or directly implemented in these packages. In this paper, we develop a software integration framework which allows Matlab to drive dynamic simulations built within a software simulator. The framework will open these high-fidelity process simulation packages for engineers and researchers to test, implement and tune advanced process control strategies, in both offline and online scenarios.

16:10-16:50 MoPO.13

Design of a Data-Oriented Cascade Control System, pp. 365-370

Kinoshita, Takuya	Hiroshima Univ
Yamamoto, Toru	Hiroshima Univ
Samavedham, Lakshminarayanan	National Univ. of Singapore

In process industries, PID control has been applied to controlled objects such as chemical plants. A cascade control system is applied in order to improve control performance by using several feedback loops. However, it is complicated to design a cascade control system because this control system includes plural controllers. In this paper, a design scheme of data-oriented cascade control system without system identification is proposed. According to the proposed scheme, PID gains included in plural controllers can be determined by using only closed-loop data. The effectiveness of the proposed scheme is verified by using a simulation example and an experiment of the water level control system.

16:10-16:50 MoPO.14

OS-L1-ELM: Online Sequential L1-Regularized-ELM Based on ADMM, pp. 371-376

Li, Dazi	Beijing Univ. of Chemical Tech
Liu, Zhiyin	Beijing Univ. of Chemical Tech

As business data and scientific data become larger and larger, the study of incremental learning algorithms becomes more and more important. Online sequential extreme learning machine (OS-ELM) algorithm is an incremental learning algorithm that can learn data one by one. On the basis of OS-ELM, an online sequential extreme learning machine incremental learning algorithm is proposed based on the L1-regularization (OS-L1-ELM). The proposed method can make use of the original learning results and does not need to re-learn all the data, thus can save time and space resources. By adding L1-regularization, the sparse model

can effectively avoid the over-fitting problem. At the same time, alternating direction method of multipliers (ADMM) and the proximity algorithm are used to solve the OS-L1-ELM. The algorithm is deduced into a recursive form, which greatly reduces the computational complexity. Experimental results show that the proposed method has good generalization and robustness.

16:10-16:50 MoPO.15

Process Design of Aqueous Ammonia-Based Post-Combustion CO2 Capture, pp. 377-382

Liu, Jialin — Tunghai Univ

Chen, Ding-Sou — China Steel Corp

In the present work, the aqueous ammonia-based post-combustion CO2 capture (PCC) process is simulated using the rate-based model in Aspen Plus, by which the method of sizing column heights is revealed. The column heights of the staged CO2 absorbers and the NH3 absorber are determined as 5 m, 6 m, and 6 m; in addition, the heights of the CO2 and NH3 strippers are 12 m and 6 m, respectively. It is well known that the CO2 stripper is operated at high pressure that can effectively relieve the energy burden of the solvent regeneration. However, since the CO2 absorber is operated at atmosphere, the pressurized lean solvent needs to be relieved either in the absorber or before entering the absorber. In the present work, the electric power that is used to compress the released vapor back into the CO2 stripper, and the energy saving that is due to the higher operating pressure of the CO2 stripper are evaluated in order to find the optimal operating conditions, which poses the minimal regeneration energy. The minimum of the energy requirement can be found at 3.0 GJ/ton-CO2 under the operating conditions of the CO2 lean loading at 0.13 and the stripper pressure at 2 atm.

16:10-16:50 MoPO.16

Design and Control of a Plant-Wide Process for the Production of Epichlorohydrin, pp. 383-388

Huang, Chien-Chih — Department of Chemical Engineering, National Tsing Hua Univ

Wang, San-Jang — National Tsing Hua Univ

Wong, David Shan Hill — National Tsing Hua Univ

Epichlorohydrin (ECH) is a primary raw material in the production of some polymers. However, traditional ECH production methods suffer from several disadvantages. Hydrogen peroxide is relatively non-toxic and widely accepted as an environmentally friendly and green oxidant. In the study, we propose the plant-wide process design and control for ECH synthesis by the epoxidation of allyl chloride with hydrogen peroxides over the catalyst of TS-1 in the presence of methanol. In the plant-wide process, the product from a plug flow reactor is separated by a distillation column. Nitrogen gas is fed into the column top for safety concerns. The column bottom product containing mostly ECH and water is decanted into two liquid phases. High purity ECH and water are obtained from the bottoms of two strippers which the liquids of organic and aqueous phases in the decanter are respectively fed into. The control strategy is constructed by steady-state analysis for the plant-wide process and its performance is evaluated by dynamic simulation. Simulation results reveal that the process can be safely operated and product purities can be maintained around the desired values by temperature control in spite of disturbances.

16:10-16:50 MoPO.17

An Automated Approach for Supertargeting of Heating Medium System, pp. 389-394

Pitchaimuthu, Diban — Univ. of Nottingham Malaysia Campus

Foo, Dominic — Univ. of Nottingham Malaysia Campus

Heating utility system is commonly used in offshore platform to provide heating requirement for heavy crude oil of high viscosity from the reservoir. Heating the oil reduces its viscosity and hence improves oil/water separation which eventually leads to reduced size and cost of the separator. In conventional design, heating medium is distributed to the heat exchangers in parallel configuration to provide the required heating duties. This design however contributes to the overdesign of heating utility system. In this paper, a recently established process integration technique is extended to determine the optimum heating medium flowrate and minimum total annualised cost for a heating utility system. The newly extended technique makes use of the capital cost targeting approach based on pinch analysis technique, but implemented on an optimisation framework. The approach caters for capital and operating cost trade-off for the heat exchanger network (HEN) and waste heat recovery unit (WHRU) in the heating utility system. An industrial case study is used to elucidate the newly extended technique.

16:10-16:50 MoPO.18

Regional Energy Planning Using Mathematical Optimisation, pp. 395-399

Syu, Wan-Syuan — National Taipei Univ. of Tech

Lee, Jui-Yuan — National Taipei Univ. of Tech

This paper presents a two-stage optimisation approach to regional energy planning with biomass utilisation. The aim of the first stage is to determine the optimal energy mix and the bioenergy target, which is to be fulfilled in the second stage when synthesising the optimal biomass supply chain network. The mathematical formulation of the two stages yields two linear models, for which global optimality is guaranteed if a solution exists. A literature case study is used to illustrate the proposed approach.

16:10-16:50 MoPO.19

Contribution of Production Support System to Reinforce Process Resilience in the Chemical Industry, pp. 400-405

Eguchi, Hajime — Nagoya Inst. of Tech

Nyambayar, Davaadorj — Nagoya Inst. of Tech

Koshijima, Ichiro — Nagoya Inst. of Tech

The chemical industry can be defined as a typical type of plant industry. As it is impossible to see inside of a plant directly, a system; PSS (Production Support System) that enables to monitor a process status with sensors is applied. Since it costs to implement PSS, a company checks the reasonability of the amount of investment from the viewpoints of resource saving, energy saving and man-power saving by estimation of effects provided by PSS. The company tends to rely on the manpower saving out of these three kinds of saving though such man-power saving causes a decline of total skills in a production process plant. This situation brings a risk of occurrence of many issues in the process plant. Actually, in the industry, the resilience of production process is worthy of notice as a capacity to restrain a lot of disruptive signals. The process resilience is generated by 1) Production plant personnel, 2) PSS, and 3) Production unit. It is necessary to prevent accidents and some troubles to execute the production activity. Especially the level of skills and knowledge of the production plant personnel are mostly concerned with the process resilience. If margin time can be produced due to PSS, it will be devoted to educating and training the production plant personnel. As a result, the process resilience will be reinforced.

16:10-16:50 MoPO.20

Design of a Data-Oriented Evolutionary Controller for a Nonlinear System, pp. 406-411

Fu, Qiuhao — Hiroshima Univ

Koiwai, Kazushige — Hiroshima Univ

Yamamoto, Toru — Hiroshima Univ

In order to design a controller for the nonlinear system, the model-based design method that makes a mathematical model for the system has been proposed. However, the requirement for the accuracy of the model to get a desired control performance is high. Therefore, a data-oriented control method was proposed to prevent making mathematic model for the system. Still, in some cases, a desired control performance is not able to be obtained because the structure of the controller has been fixed when determining the controller. In this paper, a new controller design method that determines the controller using a set of closed-loop data is proposed. With this method, both the control structure and the control parameters can be determined simultaneously. The

control structure is decided by the genetic algorithm, and the control parameters are computed by using the least squares method. In this way, a controller that can provide a desired control performance is determined. Furthermore, some simulation examples are verified.

16:10-16:50 MoPO.21

Model Predictive Control and Optimization of Vacuum Pressure Swing Adsorption for Carbon Dioxide Capture, pp. 412-417

Du, Wenli — East China Univ. of Science and Tech

Alkebsi, Khalil Abdulghani Mutahar — East China Univ. of Science and Tech

This study presents a control strategy of carbon dioxide capture from flue gas by Vacuum Pressure Swing Adsorption (VPSA). The key objective of this work is to control and optimize the purity and recovery of the adsorption product (carbon dioxide) by manipulating the time duration of the VPSA cycle steps. Based on a single fixed-bed 6-step VPSA process simulation using 5A zeolite as adsorbent for CO2 capture from gas mixture with 15% CO2 and 85% N2 (resembling post-combustion flue gases of power stations), a two-input/two-output control model was obtained, in which Feed step time and Purge step time are taken as manipulative variables and CO2 Purity and Recovery are the controlled variables. For control purpose, a multi-input/multi-output model predictive control (MIMO-MPC) system is proposed to handle the inherent non-linear nature and discontinuous operation of the VPSA process. The MIMO-MPC control scheme is tested and showed good results in terms of system stability and fast tracking of the set-points. Finally, PSO algorithm is applied to maximize the purity and recovery by finding the optimal duration time of feed step and purge step, the results shows that with such VPSA process, over 98% of CO2 is recovered with purity of 59%, at tfeed = 202s and tpurge= 114s.

16:10-16:50 MoPO.22

Transient Response Analysis of High Pressure Steam Distribution Networks in a Refinery, pp. 418-423

Chang, Chiao-Ying — National Taiwan Univ

Wang, Shih-Han — National Taiwan Univ

Chen, Cheng-Liang — National Taiwan Univ

Huang, Yu-Cheng — National Taiwan Univ

This article aims to develop a rigorous mathematical model for analyzing the transient response of the high pressure steam pipeline network in a refinery. A sequentially iterative fully implicit method has been propounded to deal with the unsteady nonlinear equations in a pipeline. The proposed method is then combined with the modified Hardy-Cross method to study the transient response in a looped pipeline network. A complex high pressure steam network problem is used for demonstrating the applicability of the proposed solution method in analyzing the transient response in a pipeline network. This analysis is critical for optimizing operation and control of the steam distribution systems.

16:10-16:50 MoPO.23

Iterative Learning State Estimation for Batch Process, pp. 424-429

Zhao, Zhonggai — Insititute of Automation, Jiangnan Univ

Qi, Pengcheng — Jiangnan Univ

Liu, Fei — Jiangnan Univ

Unlike continuous processes, a batch process contains many batch runs. Considering the repetitive nature of batch processes, an iterative learning strategy is proposed to estimate the state in batch processes, where the state prediction is updated twice rather than once in conventional state estimation methods: within a batch run, the measurements are employed to update the state prediction to obtain the state estimate; along the batch dimension, the estimation performance of pervious batch runs is used as a learning reference for the state estimate according to the repetitive nature. As a result, the current batch run is related with previous batch runs during the state estimation, and the information of the whole batch process is incorporated. Considering that the batch process is characterized by nonlinearity and non-Gaussianity, the particle filtering method is employed as the key algorithm for the state estimation. The effectiveness and practicability of the proposed method is indicated by its application in a beer fermentation process.

16:10-16:50 MoPO.24

A Simple PID Controller for a Magnetic Bearing with Four Poles and Interconnected Magnetic Flux, pp. 430-435

Tshizubu, Christian — Univ. Federal Fluminense

Santisteban, José Andrés — Univ. Federal Fluminense

The conventional structures of active magnetic bearings to support rotors dispose of eight poles operating in such a way that two adjacent poles share the same magnetic flux. In this work, a different electromagnetic structure is presented which is based on the so named bearingless motor with split windings. While this device is originally supplied by alternate electrical currents, in this case, as the purpose is to generate only radial forces, the windings are supplied by continuous currents forming a magnetic flux with four equivalent poles. To test this approach, a conventional induction motor was used and its rotor was appropriately modified. It will be shown that although the magnetic fluxes are coupled, for low speed rotation, all the controlled plant can be modeled as an unstable second order system, so PID controllers can be appropriately designed. In order to test this approach, a workbench consisting of displacement sensors, signal conditioners and two microcontrollers development boards was implemented. For different radial loads and changes of displacement references, the experimental results were well succeeded.

16:10-16:50 MoPO.25

Dynamic Optimization of Semi-Batch Acetone–Butanol–Ethanol Fermentation with In-Situ Pervaporation Membrane Separations, pp. 436-441

Lin, Ta-Chen — Tunghai Univ

Lee, Ya-Hsun — IV Tech. Co., Ltd

To alleviate the severe impact of the substrate and product inhibitions leads to the design of the semi-batch bio-reactors, which aims at finding the optimal control of substrate feed rate through time. The consequence of this problem is challenging, which highlights the numerical difficulties arising from the non-linear, constrained and often discontinuous nature of these dynamic systems. In this work, following the control vector parameterization (CVP), a profile generator algorithm is utilized to produce functions in an exponential form that can represent path of the control space comprising elements of both linearity and curvature. A novel method of stochastic dynamic optimization using Simulated Annealing incorporating direct search through a specialized model predictive controller is used to tackle final volume point state constraints. A case study of glucose to acetone–butanol–ethanol (ABE) production, in terms of structured kinetics model, with in-situ pervaporation will be illustrated. Prior to optimization, we proposed revised models based on model identification for the published experimental data in the literature of batch bio-reactor system. Modeling of the pervaporation membrane separations for the system have also been presented.

TuAT1 1F Conference Room

Model-Based Fault Detection and Diagnosis (Invited Session)

Chair: Chang, Chuei-Tin — National Cheng Kung Univ
Co-Chair: Zhao, Jinsong — Tsinghua Univ
Organizer: Chang, Chuei-Tin — National Cheng Kung Univ

10:10-10:30 TuAT1.1

A Hybrid Modeling Strategy for Synthesizing Diagnostic Tests in Sequential Material and Energy-Transfer Operations (I), pp. 442-447

FONG, SHIH-TING — National Cheng Kung Univ
Wang, Chung Jung — National Cheng Kung Univ
Chang, Chuei-Tin — National Cheng Kung Univ

Although diagnostic tests have already been developed in the past for differentiating the originally inseparable fault origins in several simple batch processes, their applicability in realistic systems is still questionable. To address this practical issue, the dynamic behavior of every processing unit involved in a given sequential operation is modeled here by integrating both the generic engineering knowledge and also the ASPEN-generated simulation data into a single automaton. The improved test plans can then be synthesized according to the system model obtained by assembling all such automata. The feasibility of this model building strategy is demonstrated with an example concerning the start-up operation of a flash process.

10:30-10:50 TuAT1.2

Agent Based Fault Detection Using Negative Selection Algorithm for Chemical Processes (I), pp. 448-452

Kimura, Naoki — Kyushu Univ
Takeda, Yuya — Kyushu Univ
Hasegawa, Taichi — Kyushu Univ
Tsuge, Yoshifumi — Kyushu Univ

In this study, a fault detection system for a chemical processes using agent and negative selection algorithm was proposed. The operational data using dynamic plant simulator were obtained to verify the effectiveness of our method. The simulations of fault detection were carried out. And also the results of simulation are presented in this paper.

10:50-11:10 TuAT1.3

Model-Based Monitoring of Fouling in a Heat Exchanger (I), pp. 453-456

Yamashita, Yoshiyuki — Tokyo Univ. of Agriculture and Tech

Fouling is the deposition of undesired material on heat transfer surface. It significantly decreases the thermal performance of heat exchangers. In this work, a novel method to detect fouling in a thermosiphon reboiler is proposed. The method combines physical model and data-driven model for the estimation of the heat transfer mechanism. Overall heat transfer coefficient and the heat flux are modeled by physical models. Partial least square regression is used for the modeling of the inside film heat transfer coefficient. A methodology to estimate the fouling resistance is presented. The proposed method was demonstrated on a reboiler in a simulated debutanizer column.

11:10-11:30 TuAT1.4

Review on Chemical Process Fault Detection and Diagnosis (I), pp. 457-462

Ming, Liang — Tsinghua Univ
Zhao, Jinsong — Tsinghua Univ

According to industry 4.0, modern factories are transforming into smart factories, which set higher requirements for fault detection and diagnosis (FDD) to enhance operating safety and manufacturing sustainability. This paper gives a brief review on the state-of-the-art and challenges of chemical process FDD. Since the applications of FDD to real chemical processes are few, recent researches mainly focus on solving practical problems. Furthermore, with the big data era coming, the automation of FDD in chemical processes would be realized.

11:30-11:50 TuAT1.5

Fault-Tolerant Design of Membrane Modules for Organic Mixture Separation (I), pp. 463-468

Adi, Vincentius Surya Kurnia — National Chung Hsing Univ
Laxmidewi, Rosalia — Independent Scholar
Chang, Chuei-Tin — National Cheng Kung Univ

Given the recent advances in membrane technology for energy efficient separation, most studies mainly focused on the development of materials while the operability issues of structured modules have been ignored. It has been well established that uncertain disturbances are inevitable and should be considered as an inherent feature in the realistic operations. It is assumed in the present work that the immediate effects of randomly-occurred faults of the system can be characterized mathematically by the uncertain parameters. An ill-designed membrane system, when operated under uncertainties, may perform poorly and result in unnecessary energy waste. Therefore, this work investigates the operational flexibility of membrane modules under the influence of random fault-induced disturbances. The recently developed volumetric flexibility index is adopted as a performance measure. The case studies presented in this paper clearly demonstrate that such an index can indeed provide insights for configuring various fault-tolerant membrane modules.

11:50-12:10 TuAT1.6

Unsafe Situations Avoidance Systems using ICS Sandbox and backup systems for Plant Operations (I), Invited Talk

Hamaguchi, Takashi — Nagoya Institute of Technology
Yamamoto, Shinya — Nagoya Institute of Technology
Tagawa, Takuya — Nagoya Institute of Technology
Mase, Hiroki — Nagoya Institute of Technology
Koshijima, Ichiro — Nagoya Institute of Technology
Hashimoto, Yoshihiro — Nagoya Institute of Technology

It is desirable to support plant operations to prevent unsafe situations at chemical plants. Unsafe situations might be caused as the result of unsuitable automatic controls or manual interventions. Such operation might be caused by not only operators but also cyber-attackers. To realize suitable real time controls and prevent such unsuitable operations, intelligent support systems are needed to check commands to controllers from SCADA system. In this paper, a mechanism for unsafe situation avoidance systems for plant safety is proposed. The systems consist of ICS Sandbox and backup systems.

TuAT2 Room 101

Process Integration and Optimization 2 (Invited Session)

Chair: Liu, J. Jay — Pukyong National Univ
Co-Chair: Isafiade, Adeniyi Jide — Univ. of Cape Town
Organizer: Foo, Dominic — Univ. of Nottingham Malaysia Campus

10:10-10:30 TuAT2.1

Retrofitting Industrial Heat Exchanger Network Based on Pinch Analysis (I), pp. 469-474

Li, Bao-Hong — Dalian Nationalities Univ
Chang, Chuei-Tin — National Cheng Kung Univ

A systematic but simple pinch–based retrofit procedure is developed to lower the utility consumption levels of any given industrial Heat Exchanger Network (HEN) under new minimum temperature approach at the cost of minor capital investment. This

work is an extended and improved version of our previous work (Li and Chang, 2010). New visualized identification method for cross-pinch heat load is proposed to cover the case that phases change in the cross-pinch heat exchanger. Main characters of industrial HENs which are large scale, varied heat capacity flow rate and multiple pinches are fully addressed. Specifically, each cross-pinch exchanger is identified and those exchanges with large loads are removed first, and then, their heat loads on the hot and cold streams are both divided according to pinch temperatures. Next, at either side of or between the pinches, the divided heat loads on each stream are combined to remove small heat loads and matched according to a systematic procedure derived from simple pinch analysis. Note that modifications are focused on those cross-pinch matches and utility exchangers, which greatly simplifies the retrofitting procedure of an industrial HEN. An industrial case of Crude Oil Preheat Train (COPT) is retrofitted to illustrate the effectiveness of the proposed procedure.

10:30-10:50 TuAT2.2

Optimum Water Network Design for Multipurpose Batch Plants with an Electrodialysis Central Regeneration Unit (I), pp. 475-480

Bazolana, Nsunda Christie — Univ. of the Witwatersrand

Majozi, Thokozani — School of Chemical and Metallurgical Engineering, Univ. Of

This paper presents a mathematical formulation for the simultaneous optimization of the production schedule and utility consumption of a multipurpose batch plant. The amount of wastewater generated is minimized through the exploration of direct, indirect, and regeneration reuse opportunities within the plant. Water regeneration is achieved through partial purification of highly contaminated wastewater using electrodialysis (ED). A design model for the ED process is included in the formulation in order to minimize the amount energy consumed by the regenerator simultaneously with the amount of water used by batch operations. The resultant model was applied to a case study and proved to significantly decrease the freshwater usage by up to 41 %, hence increasing the overall plant profit.

10:50-11:10 TuAT2.3

Use of Confidence Region in the Optimal Design of a Separation Process in the Presence of Uncertainties, pp. 481-486

Cheng, Shueh-Hen — Tunghai Univ. Department of Chemical and Materials Enginee

Lo, Chi-Hao — CTCI Corp

Lin, Ta-Chen — Tunghai Univ

A large number of real-world problems nowadays require that decisions be made in the presence of uncertainties. Traditionally, the task of separation systems design neglects the influence of uncertainties. This work, however, explores the optimization strategy of a frequently encountered equilibrium-based distillation system design problem in the face of uncertainties. In particular, uncertainties arising from thermodynamic model parameters, which represent the vapor-liquid equilibrium (VLE) behavior of non-ideal mixtures involved in the system and are germane to the rational design of the separation system, are considered in the work. Joint confidence regions for the key thermodynamic model parameters estimated by the nonlinear least squares method have been incorporated in the analysis of the uncertain regions. We propose a novel two-stage stochastic programming solution scheme utilizing the optimum searching capacity of the simulated annealing algorithm in the first (design) stage and ASPEN Plus flowsheet simulator in the second (operating) stage in which Hammersley sequence sampling scheme has been implemented. A case study that investigates the optimal design of a two-column distillation system in an isopropanol (IPA) process will be demonstrated. Overall, this study provides us with a useful means to scrutinize the uncertainties and to optimize our design by quantifying the impact associated with them.

11:10-11:30 TuAT2.4

A Systematic Approach to Modeling Organic Rankine Cycle Systems for Global Optimization, pp. 487-492

Am, Vathna — Auckland Univ. of Tech

Currie, Jonathan — AUT Univ

Wilson, David I. — Auckland Univ. of Tech

The demand for organic Rankine cycle (ORC) systems to be efficient and economically competitive drives the need for a reliable and robust modeling approach that is suitable for optimization. However existing commercial simulation software is not typically tailored for optimization and they generally cannot guarantee a global optimum. This paper proposes a modeling approach to approximate a rigorous simulation model that is suitable for global optimization. This involves a combination of regression and thermodynamic analysis, in addition to integer programming techniques. Three different solvers, namely COBYLA, SCIP, and BARON, are used to optimize the ORC model and are compared against each other to demonstrate the prospect of achieving the global optimum using this approach. In addition, this paper also presents a technique to improve the model accuracy by using a piecewise fit to approximate the output characteristic of the ORC unit operations.

11:30-11:50 TuAT2.5

Process Design and Simulation of Industrial Scale Biofuel Production Via Pyrolysis of Saccharina Japonica, pp. 493-498

Brigljevic, Boris — Pukyong National Univ

Liu, J. Jay — Pukyong National Univ

Pyrolysis of 3rd generation biomass i.e., microalgae and macroalgae for biofuel production has only been recently studied compared to 1st and 2nd generation biomass. Since macroalgae composition differs greatly from terrestrial biomass, especially in the large water and ash contents, thus the pyrolysis process has to be redesigned and reevaluated for this particular feedstock. In this study, the extent of modifications in process design is presented. Primary differences, compared to similar processes using terrestrial biomass include: (i) pretreatment (acid wash and drying), (ii) pyrolysis and combustion optimization, as well as (iii) the number and severity of stabilization and upgrading steps. Moreover, the simulation results indicate the overall energy requirements, and provide indications about the economic viability of the process.

11:50-12:10 TuAT2.6

Synthesis of Flexible Multi-Period Heat Exchanger Networks for a Changing Utility Cost Scenario, pp. 499-504

Isafiade, Adeniyi Jide — Univ. of Cape Town

Key process parameters in the synthesis of heat exchanger networks, such as process stream supply and target temperatures and process stream flowrates, may vary from time to time due to issues such as changing environmental conditions, plant start-ups/shut-downs, changes in product quality demand, etc. Also some other key design parameters which may also change from time to time include the availability of utilities as well as their costs. These changes may be due to factors such as seasonality issues, e.g. for utilities sourced from renewable energies, or government policies in form of tax, availability of utilities due to shortage of supply, etc. This implies that heat exchanger networks should not only be designed to be flexible in order to satisfy heat demand under changing process parameter scenarios, but should also be flexible in situations where utility costs as well as their availability change from time to time. Hence this paper aims to extend existing stage-wise superstructure (SWS) based multi-period heat exchanger network synthesis methods to be capable of satisfying the heat demand under scenarios where both process stream parameters and utility parameters such costs change from time to time in a pre-defined manner. The approach used entails extending the current multi-period SWS model through the inclusion of additional time index to represent future costs of utilities. The model is applied to one example so as to demonstrate its benefits.

TuAT3 Room 103

Data-Based Controller Tuning (Invited Session)

Chair: Jeng, Jyh-Cheng — National Taipei Univ. of Tech
Co-Chair: Yamamoto, Toru — Hiroshima Univ
Organizer: Jeng, Jyh-Cheng — National Taipei Univ. of Tech

10:10-10:30 TuAT3.1

Data-Based Design of Centralized PID Controllers for Decoupling Control of Multivariable Processes (I), pp. 505-510

Jeng, Jyh-Cheng — National Taipei Univ. of Tech
Jian, Yuan-Siang — National Taipei Univ. of Tech
Lee, Ming-Wei — China Steel Corp

This paper presents a data-based design method of decoupling PID controllers for multivariable processes. The controller design directly exploits experimental process data without identifying process models. By employing the virtual reference approach, a centralized controller that achieves ideal decoupling control is first synthesized. Then, each controller element is approximated to PID structure. The control design depends on the reference model that is optimally specified according to the attainment of the reference model and the effectiveness of decoupling. Because the controller design is applicable to closed-loop data, it is preferable in industrial applications and the method can be used to improve existing underperforming controllers. Simulation studies demonstrate the effectiveness of the proposed design methodology.

10:30-10:50 TuAT3.2

Convergence Property for Iterative Data-Driven PID Gain Tuning Based on Generalized Minimum Variance Regulatory Control (I), pp. 511-516

Yokoyama, Ryoko — Tokyo Metropolitan Univ
Masuda, Shiro — Tokyo Metropolitan Univ

The paper gives analytical results on convergence property for the iterative data-driven PID gain tuning based on generalized minimum variance (GMV) regulatory control. The method can achieve improved PID gains based on generalized minimum variance evaluation without using a process model. Originally, the method has been developed for non-iterative control parameter tuning method, such as Virtual Reference Feedback Tuning (VRFT), Fictitious Reference Iterative Tuning (FRIT) and Non-iterative Correlation Based Tuning (NCbT). In contrast, our previous work numerically confirmed that the data-driven PID gain tuning successively improves the control performance by applying the method iteratively, and finally converges to the fixed PID gain parameters. The present work theoretically examines the convergence property. To this end, the iterative data-driven PID gain tuning is reformulated from the cost criterion expressed by H_2 norm where the number of the collected data grows to infinity. The theoretical analysis shows that the iterative PID gain tuning makes the PID gains converge to certain fixed values under some condition. Finally, a numerical simulation result is shown to support the theoretical analysis.

10:50-11:10 TuAT3.3

Fictitious Reference Iterative Tuning of Cascade Control Systems for Non-Minimum Phase Systems (I), pp. 517-522

Nguyen Quang, Huy — Kanazawa Univ
Kaneko, Osamu — The Univ. of Electro-Communications

In this paper, we address a controller parameter tuning of cascade controllers systems for linear time-invariant non-minimum phase systems. We consider the case where a mathematical model of a plant is unknown and only measured data are available. By utilizing the measured data directly, the purpose of this paper is to provide the tuning method for obtaining the parameter that achieves the desired tracking property of the cascade control systems. Here, we apply fictitious reference iterative tuning (FRIT), which is a controller tuning that enables us to obtain the desired controller parameter with only one-shot experiment data, as a method of a parameter tuning.

11:10-11:30 TuAT3.4

Design of Centralized PID Controllers for TITO Processes, pp. 523-528

Park, Byeong Eon — POSTECH
Sung, Su Whan — Kyungpook National Univ
Lee, In-Beum — POSTECH

A new method for designing the centralized proportional-integral-derivative (PID) controllers in two-input two-output (TITO) processes is proposed. The proposed method has two diagonal part PID controllers and two off-diagonal part PID controllers. The diagonal part PID controllers are to attenuate the interactions of the TITO processes and the off-diagonal part PID controllers are to track the setpoint. The diagonal part PID controllers are directly tuned by the conventional single-input single-output (SISO) PID tuning methods on the basis of the diagonal part of a process model matrix. And the tuning parameters of the off-diagonal part PID controllers are calculated by minimizing the effects of the off-diagonal components of the open-loop transfer function matrix in frequency domain. The proposed control method shows better decoupling and setpoint tracking performance than previous appro

11:30-11:50 TuAT3.5

Design of a Performance-Driven PID Controller for a Nonlinear System, pp. 529-534

Liao, Yuntao — Hiroshima Univ
Kinoshita, Takuya — Hiroshima Univ
Koiwai, Kazushige — Hiroshima Univ
Yamamoto, Toru — Hiroshima Univ

In industrial control process, it requires fast response for transient state and for steady state it is necessary to maintain user-specified control performance to achieve desired productivity. Moreover, in industrial control process, the Proportional-Integral-Derivative(PID) control algorithm is the most widely used control algorithm. Hence, in this paper an algorithm to tune PID control parameters that can improve control performances of transient state and steady state is proposed. In proposed method, the PID control parameters are tuned by using cerebellar model articulation controller(CMAC) for both in transient and steady state. At the same time, in order to avoid the error that may caused by modeling of system, the CMAC is combine with the algorithm of fictitious reference iterative tuning (FRIT). Therefore, the PID control parameters can be off-line tuned without using system parameters. At last, the effectiveness of the proposed method is numerically verified by using a simulation example.

11:50-12:10 TuAT3.6

PID Control Loop Performance Assessment and Diagnosis Based on DEA-Related MCDA, pp. 535-540

Wang, Zun — Beijing Univ. of Chemical Tech
Han, Yongming — Beijing Univ. of Chemical Tech
geng, zhiqiang — Beijing Univ. of Chemical Tech
ZHU, Qunxiong — Beijing Univ. of Chemical Tech
XU, Yuan — Beijing Univ. of Chemical Tech
He, Yan-Lin — Beijing Univ. of Chemical Tech

Control loop performance assessment and diagnosis have been attracting more and more attention in the academia and industry. Both traditional performance assessment method and minimum variance method often require the process model and provide limited information, which is not particularly convenient for practical applications. Therefore, the method based on data envelopment analysis (DEA)-related multiple criteria decision analysis (MCDA) is developed for assessing and diagnosing PID control loop performance, which relies solely upon the collected process data during routine plant operation. The control loop performance is assessed and sorted by utilizing the self-evaluation DEA-related MCDA model. The operation priority of the control loop is ranked and determined by utilizing the cross-evaluation DEA-related MCDA model. The improving direction and quantitative space of control loop performance can be diagnosed by DEA-related MCDA model with slack variables and non-Archimedean infinitesimal ε. The correctness and effectiveness of

the proposed method are confirmed and validated by simulation examples.

TuKT1	1F Conference Room
Keynote 4 (B. Young) (Keynote Session)	
Chair: Lee, Jong Min	Seoul National Univ

13:10-13:40 TuKT1.1

Beyond the Theory - How Can Academia Contribute to the Advanced Process Control of Industrial Processes?, pp. 541-546

munir, M. Tajammal — The Univ. of Auckland
Abeykoon Udugama, Isuru Sampath Bandara — Univ. of Auckland
Boiarkina, Ira — Univ. of Auckland
Yu, Wei — The Univ. of Auckland
Young, Brent — The Univ. of Auckland

This paper discusses the role of academia in contributing to the advanced process control of industrial processes. We first review the current maturity of process control in different process industries. After that, we discuss various challenges and barriers to advanced process control applications in these various types of industries. After acknowledging these challenges and barriers, we explain various research opportunities and what the role of academia can play on the development of supporting theory in the advanced control of industrial processes. Specifically, how can academia use the existing data and new measurement technique by building advanced process control models for optimisation of industrial processes. Finally two success stories from our research group in the dairy and petrochemical industries were presented.

TuKT2	Room 101
Keynote 5 (J. Liu) (Keynote Session)	
Chair: Prasad, Vinay	Univ. of Alberta

13:10-13:40 TuKT2.1

Distributed Fault Detection and Isolation of Nonlinear Systems Using Output Feedback, pp. 547-552

Yin, Xunyuan — Univ. of Alberta
Liu, Jinfeng — Univ. of Alberta

We consider distributed fault detection and isolation (FDI) of nonlinear cascade processes based on output feedback. Based on the assumption that an exponentially convergent estimator exists for each subsystem, a distributed state estimation system is first developed. For each subsystem, a state predictor is also designed to provide subsystem state predictions. A residual generator is designed for each subsystem based on subsystem state estimates given by the distributed state estimation system and subsystem predictions given by the predictor. The residuals act as references for FDI. A distributed FDI mechanism is proposed based on the residuals. A chemical process example is introduced to demonstrate the effectiveness of the distributed FDI mechanism.

TuKT3	Room 103
Keynote 6 (T. Yamamoto) (Keynote Session)	
Chair: Yih, Hwei-Nan	Advanced Control & Systems Inc

13:10-13:40 TuKT3.1

Design of a Performance-Driven PID Controller, pp. 553-558

Yamamoto, Toru — Hiroshima Univ
Kinoshita, Takuya — Hiroshima Univ
Ohnishi, Yoshihiro — Ehime Univ
Shah, Sirish L — Univ. of Alberta

This study proposes a performance-driven control method that performs a ”control performance assessment” and a ”control system design” from a set of closed-loop data. The method evaluates control performance based on the minimum variance control index from closed-loop data. It also calculates control parameters that improve the control performance from the same closed-loop data by using the fictitious reference iterative tuning method. This method is characterized by not requiring any system model. The effectiveness of this method is verified through a numerical simulation.

TuBT1	1F Conference Room
Identification and Estimation (Regular Session)	
Chair: Liu, Fei	Jiangnan Univ
Co-Chair: Yang, Chunhua	Central South Univ

13:40-14:00 TuBT1.1

A Modified Recursive Locally Weighted NIR Modeling for Fermentation Process, pp. 559-564

Chen, Lingyi — Jiangnan Univ
Zhao, Zhonggai — Insititute of Automation, Jiangnan Univ
Liu, Fei — Jiangnan Univ

To deal with the time-varying and non-linear problems in near infrared (NIR) spectroscopy modeling, the recursive modeling algorithm has been introduced within a just-in-time framework by a moving window. Recursive strategy is quite effective by adding of new samples and discarding oldest samples. For fermentation process, while moving window is adopted to facing the changing of target property, the initial database is expected to be a wide coverage to ensure the robustness of NIR model. To make a balance between robustness (more initial samples included) and adaptability (more impact of new samples), a modified recursive locally weighted modeling approach is proposed and applied in a Chinese yellow wine (CYW) fermentation process. Meanwhile,the distance measurement of the original recursive locally weighted algorithm is improves by taking target property into consideration. The proposed approach improves window moving strategy and distance measurement for NIR modeling, which can fully preserve the initial database and achieve high detection accuracy.

14:00-14:20 TuBT1.2

On Initialization of the Kalman Filter, pp. 565-570

Zhao, Shunyi — Univ. of Alberta
Huang, Biao — Univ. of Alberta

As a recursive algorithm, the Kalman filter (KF) assumes the initial state distribution is known a priori, while the initial distributions used in practice are commonly treated as design parameters. In this paper, the influences of initial states are analyzed under the KF framework. That is, we address the questions about how the initial mean and variance affect the subsequent estimates and how much performance is sacrificed if incorrect values are used. Based upon this, two initialization methods are developed for the cases with large initial uncertainties. A drafting stochastic resonator model is employed to verify the theoretical analysis result as well as the proposed initialization approach.

14:20-14:40 TuBT1.3

Improved Compound Controller for Active Power Filter, pp. 571-576

Wang, Yifan — Jiangsu Univ
Zheng, Hong — Jiangsu Univ
Wang, Ruoyin — Jiangsu Univ
wen, zhu — Jiangsuuniversity

In order to eliminate a certain type of harmonics in power grid, this paper presents a novel compound controller to improve the performance of active power filter (APF) based on synchronous frame. The proposed controller can work effectively with the help of a proportional-integral (PI) control and an advanced repetitive controller. By optimizing the internal model of the repetitive controller, the controller can deal with the current from grid directly, which simplifies the APF system dramatically. Because there is no need to add extra sensors and the APF system does

not require a harmonic detector. Moreover, the proposed controller which has a shorter convergence time for its smaller repetitive period can eliminate the harmonics faster than the traditional one. And its repetitive cycle is only one-sixth as that of the traditional. In addition, thanks to an advanced voltage phase collector, the voltage phase collected from the grid becomes more accurate, which improves the compensation performance of APF. The controller design algorithm is also given in detail. Theoretical analysis and results obtained by simulations validate the superiority of the proposed controller.

14:40-15:00 TuBT1.4

Output-Related Feature Representation for Soft Sensing Based on Supervised Locality Preserving Projections, pp. 577-582

Yuan, Xiaofeng — Central South Univ
Wang, Yalin — Central South Univ
Yang, Chunhua — Central South Univ
Gui, Weihua — Central South Univ
Jiang, Qingchao — Key Lab. of Advanced Control and Optimization for Chemical

Locality preserving projection (LPP) is a useful tool for learning the manifold of high dimensional data, which is a linear approximation of nonlinear Laplacian Eigenmap (LE). However, the original LPP algorithm is an unsupervised method that extracts features without any reference to the output information. In this paper, a supervised LPP (SLPP) framework is proposed for output-related feature extraction in soft sensor applications. In the SLPP framework, the output information is utilized to guide the procedures for constructing the adjacent graph and calculating the weight matrix, with which the intrinsic structure of the data can be better described. Two specific SLPP algorithms are described. For performance evaluation of the proposed methods, experiments on a numerical example and an industrial iromaking process are carried out. The results show the effectiveness of the proposed framework.

15:00-15:20 TuBT1.5

A Novel Algorithm for Targeted Metabolite Profiling Using NMR Spectrum, pp. 583-588

Xu, Frost — Zhejiang Univ
Mantri, Madhav — Indian Inst. of Tech. Kharagpur
Zukui, Li — Univ. of Alberta

Increasing interests in metabolomics have motivated the need for efficient and accurate metabolite profiling method. In this paper, we proposed a new method for targeted metabolite profiling. The approach relies on nonlinear least squares technique and a novel peak assignment algorithm. Peaks from experimental spectra are assigned to a reference compound library with the aid of mixed integer nonlinear optimization technique. Nonlinear least squares method is further applied to improve the concentration and chemical shift estimation. Results on several synthetic data sets demonstrate the good performance of the new method.

TuBT2 Room 101

Process and Control Monitoring (Regular Session)

Chair: Munaro, Celso Jose — Federal Univ. of Espirito Santo
Co-Chair: Liu, J. Jay — Pukyong National Univ

13:40-14:00 TuBT2.1

Multi-Objective Complexity Reduction for Set-Based Fault Diagnosis, pp. 589-594

Savchenko, Anton — Univ. of Magdeburg
Andonov, Petar — OvGU Magdeburg
Rumschinski, Philipp — Robert Bosch Automotive Steering GmbH
Findeisen, Rolf — Univ. of Magdeburg

Fault diagnosis methods ensure safe operation of industrial plants. Steadily increasing appearance of larger and interconnected systems and the necessity to take process uncertainties into account drives the need for reliable diagnosis procedures. Set-based frameworks for model-based fault diagnosis allow to handle these challenges, albeit at a high cost of computations. We propose a method to reduce the complexity of polynomial discrete-time models that retain the guarantee of fault detection. The relaxation-based method substitutes uncertain parts of model dynamics which are not relevant to diagnosing the fault. The method is illustrated with a fault detection example for an automatic air conditioning system of a building.

14:00-14:20 TuBT2.2

Statistical Online Model Quality Monitoring for Linear Closed-Loop Control System, pp. 595-600

Ling, Dan — Huazhong Univ. of Science and Tech
Zheng, Ying — Huazhong Univ. of Science and Tech
Yang, Xiaoyu — Huazhong Univ. of Science and Tech
Wang, Yan — Zhengzhou Univ. of Light Industry

The performance of model-based control system depends a lot on the model fidelity. The mismatch between the modelandthetrueplantplaysanimportantroleinpoorcontrol quality of the closed-loop control system. In this paper, a new statistical online model quality monitoring method for closedloop systems is presented, which monitors model quality only requiring the real-time routine operation data. The proposed method adopts the moving window method to online update model evaluation index which is obtained from the closedloop input/output data. Then the statistical process control (SPC) technique is used to monitor model quality by Shewhart control chart. The approximate statistical distribution of the model evaluation index can be obtained by adaptive Least absolute shrinkage and selection operator (Lasso) method. The simulated examples are presented to verify the effectiveness of the proposed monitoring method.

14:20-14:40 TuBT2.3

Application of the Improved Multivariate Empirical Mode Decomposition to Plant-Wide Oscillations Characterization, pp. 601-605

Lang, Xun — Zhejiang Univ
Zhong, Dan — Zhejiang Univ
Xie, Lei — Zhejiang Univ
Chen, Junghui — Chung-Yuan Christian Univ
Su, Hongye — Zhejiang Univ

A novel time domain method based on improved multivariate empirical mode decomposition (MEMD) for plant-wide oscillations characterization is proposed. The original MEMD is ameliorated in the following aspects, (i) decorrelation of the two-dimensional Halton sequences, (ii) boundary processing to restrain end effect and (iii) improved criterion for sifting process stoppage. Due to its capability to analyze multiple channels data, MEMD is especially suitable for characterizing plant-wide control loop oscillations. Simulation examples and industrial case study are provided to demonstrate the effectiveness of the proposed MEMD based approach.

14:40-15:00 TuBT2.4

Handling Class Imbalance and Multiple Inspection Objectives in Design of Industrial Inspection System, pp. 606-611

Yousefian, Ali — Seoul National Univ
Liu, J. Jay — Pukyong National Univ

A large number of real-world machine learning and data mining problems have several crucial issues that need to be solved, such as class imbalance and multiple objectives; these issues cannot be easily overcome with many learning methods. This study proposes an efficient approach to address the issues and applies the approach in the design of a machine vision system for a real-world problem: inline inspection of surface defects on glass

substrates of thin-film transistor liquid crystal displays (TFT-LCDs). The three major steps in the machine vision system are: (1) selective extraction of defect features from images using 2-dimemnsional wavelet decomposition, (2) training cost-sensitive classifiers to handle class imbalance, and (3) use of ensemble techniques to achieve multiple manufacturing objectives. When applied to an industrial case study, the achieved performance shows that using the proposed approach in defect inspection of TFT-LCD glass substrates is a viable alternative to manual inspection.

15:00-15:20 TuBT2.5

Survey on Advanced Alarm Strategies Based on Multivariate Analysis, pp. 612-617

Yang, Fan Tsinghua Univ
Guo, Cen Tsinghua Univ

Alarm management, as a topic of significant interest in both academia and industry, has a lot of unsolved open problems. In particular, univariate monitoring techniques can only handle fundamental problems, such as alarm chattering and bad actors, and yet they cannot meet all the requirements in practice to provide accurate information and guide to operators. For this purpose, we need to incorporate techniques developed in related areas to build a multivariate framework, which is the novel and advanced alarm strategy. Existing and developing methods are summarized in this paper, especially data-based methods, including the strategies based on multivariate statistics, performance deterioration, pattern matching in alarm floods, fault propagation, and risk assessment. Each method utilizes different type of information and has its own scope of application. Such methods shed some light on the future development of advanced alarm management.

TuBT3 Room 103
Control Applications (Regular Session)

Chair: Wu, Wei National Cheng Kung Univ
Co-Chair: Jang, Shi-Shang National Tsing-Hua Univ

13:40-14:00 TuBT3.1

A Real-Time Streamline-Based Obstacle Avoidance System for Curvature-Constrained Nonholonomic Mobile Robots, pp. 618-623

Pei-Li, Kuo Acad. Sinica
Chung-Hsun, Wang Acad. Sinica
Chou, Han-Jung IIS, Acad. Sinica
Liu, Jing-Sin Acad. Sinica

This work presents a streamline-based strategy for curvature-constrained nonholonomic robots to safely navigate in real-world partially unknown environments with static cylinder-shaped obstacles whose locations are detected on-line. We propose the use of three primitive curvature-constrained collision-free paths derived from the manipulation and search of streamlines generated from harmonic potential function of a stationary circle. The primitive paths allow emergent turning and reduce the clearance with an obstacle. Assuming enough clearances between adjacent obstacles, the algorithm is extended to avoid multiple cylinder obstacles by pursuing a primitive path based on lateral distance of the robot and the closest obstacle, which can be calculated and updated in real time using pure pursuit tracker. Experiments validate that the obstacle avoidance system allows a two-wheel driving mobile robot to on-line navigate safely along a path without violating curvature constraint in partially unknown cluttered environments.

14:00-14:20 TuBT3.2

Efficient Operating Condition of Side Stream Simulated Moving Bed Chromatography for Ternary Fluid Mixtures, pp. 624-629

Oh, Tae Hoon Seoul National Univ
Oh, Se-Kyu Seoul National Univ
Lee, Jong Min Seoul National Univ

Simulated moving bed chromatography has been researched as an efficient separation technology. The limitation of chromatography, which is only usable for binary mixture, can be overcome with side stream simulated moving bed chromatography. In this paper, the basic modeling and design of side stream simulated moving bed are presented. In addition, the optimum operating condition which maximized the recovery of each stream is discussed with the condition of assuming equilibrium theory and linear adsorption isotherm. In addition, using the extended Langmuir isotherm, the simulation was done with the ternary fluid mixture. Even though the analysis was well done on the linear isotherm, the results of the simulation represent the limits of this analysis. For a future work, more elaborate analysis and simulation should be done side stream simulated moving bed with the nonlinear adsorption isotherm.

14:20-14:40 TuBT3.3

Graph-Theoretic Control Structure Synthesis for Optimal Operation of Heat Exchanger Networks, pp. 630-635

Kang, Lixia Xi'an Jiaotong Univ
Liu, Yongzhong Xi'an Jiaotong Univ

In this paper, a recently developed procedure for the selection of control structure of heat exchanger networks for optimal operation is improved and reformulated in a graph-theoretic setting. A graph representing take-over relationship between the manipulations is constructed to generate the feasible split-range pairs based on active constraint regions. These feasible split-range pairs are then used to calculate a structural coupling matrix on the basis of the relative degree. The optimal control pairings are thus obtained through the solution of a bipartite matching problem, taking the structural coupling matrix as the weight matrix. A case study is used to verify the application of the proposed method.

14:40-15:00 TuBT3.4

Evaluation of Gas-Liquid Contact Area and Liquid Holdup of Random Packing Using CFD Simulation, pp. 636-641

Kang, Jia-Lin National Tsing-Hua Univ
Chen, Wei-Fu National Tsing Hua Univ
Wong, David Shan Hill National Tsing Hua Univ
Jang, Shi-Shang National Tsing-Hua Univ

This study provided a method to simulate flow field of an irregular arrangement of random packing in an absorber using commercial software, Fluent®. Volume of fluid model was employed in this study to deal with gas and liquid phases contacting issue. Volume of fluid model has validated that it is able to simulate gas and liquid interface. 10 flow fields of small-scale absorbers in which several raschig rings were stacked randomly, were established to evaluate average values of gas-liquid contact area and liquid holdup. The results showed that both of values are increased as liquid velocity increases. The simulated gas-liquid contact area has the same trend with the correlations provided from literature. The simulated liquid holdup completely matches the liquid holdup correlation for traditional absorbers.

15:00-15:20 TuBT3.5

Modeling and Optimization of a Fast Fluidized Bed Reactor for Carbonation Reactions, pp. 642-647

Chen, Jhao-Rong National Cheng Kung Univ
Wu, Wei National Cheng Kung Univ

A carbonator is described as a fast fluidized bed reactor to capture CO2. The proposed mathematical model is validated by literatures and experimental data. In our approach, the bed temperature and inventory weight are used to optimize the reactor design and the water gas shift (WGS) reaction with calcium oxide improves the hydrogen production under the modified WGS kinetics. It is validated that the carbonation can break the chemical equilibrium of WGS and make the reaction go forward to reduce CO and generate a quantity of hydrogen gas.

Taipei Metro

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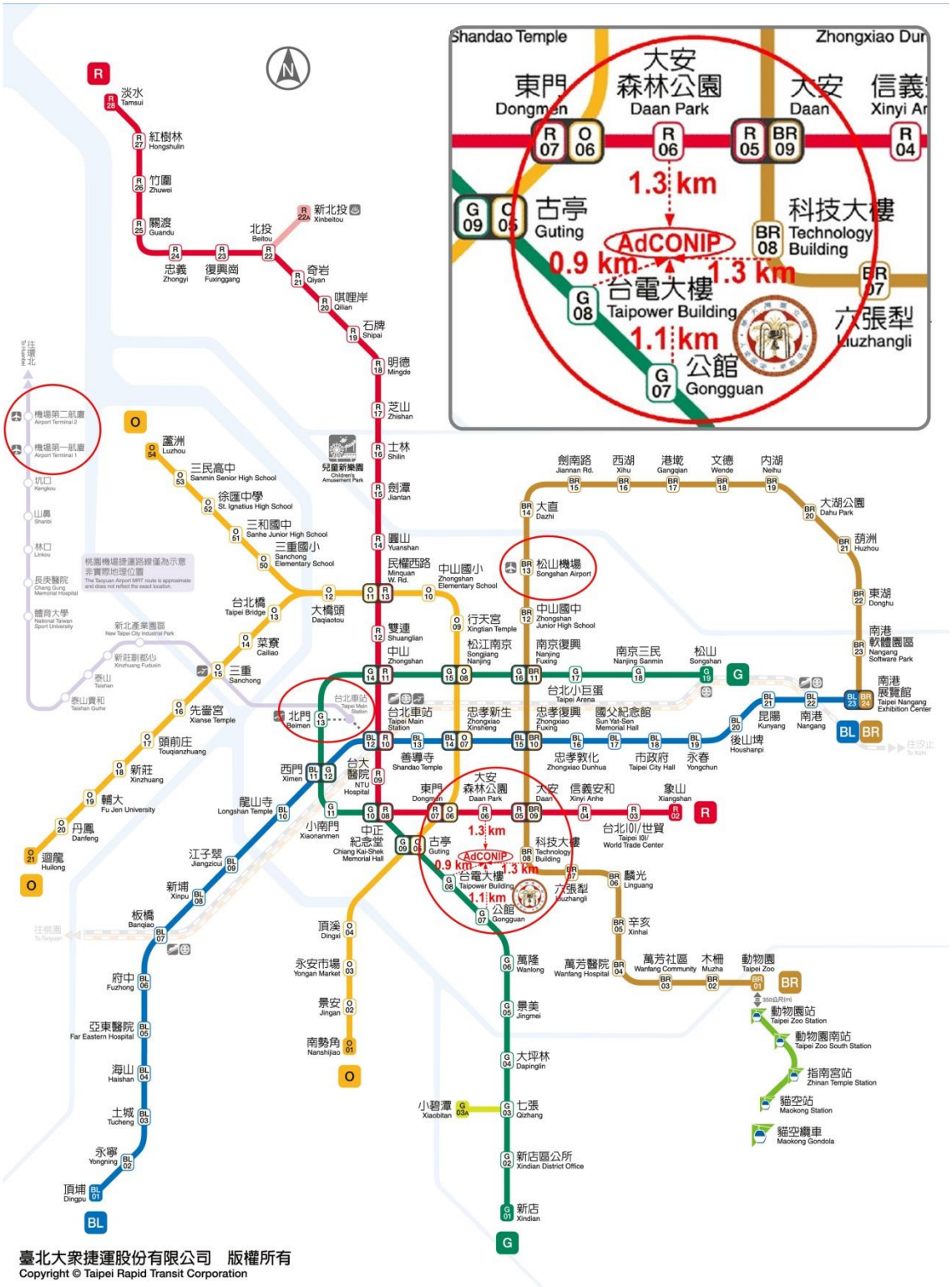

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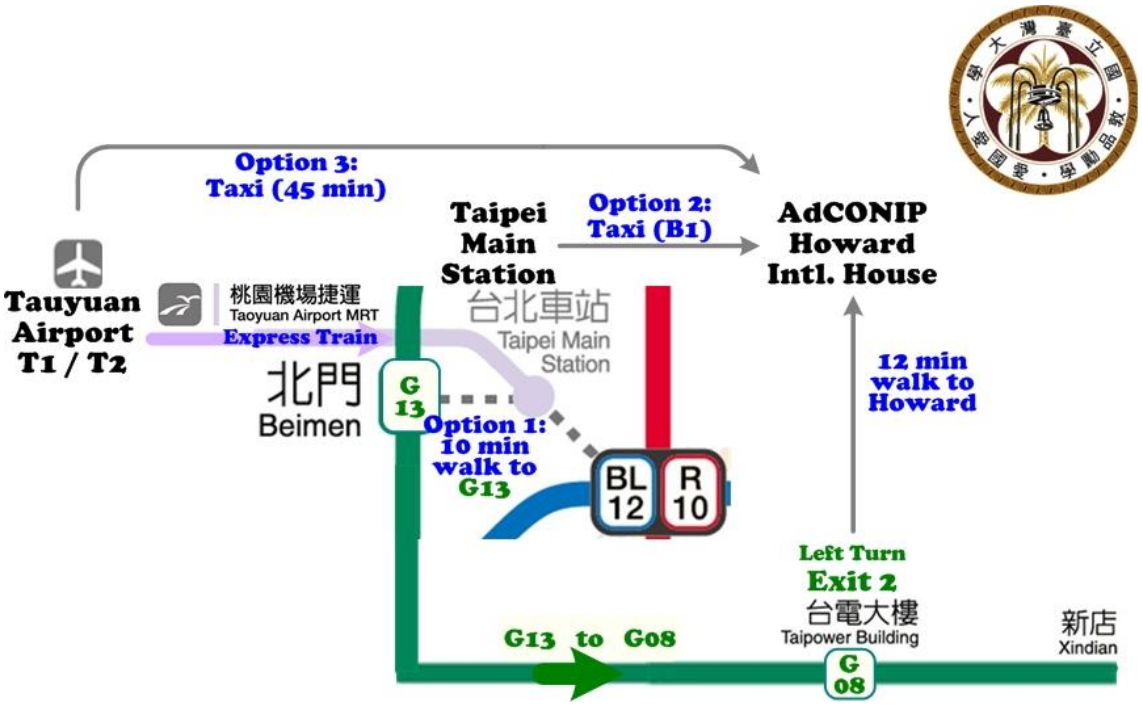

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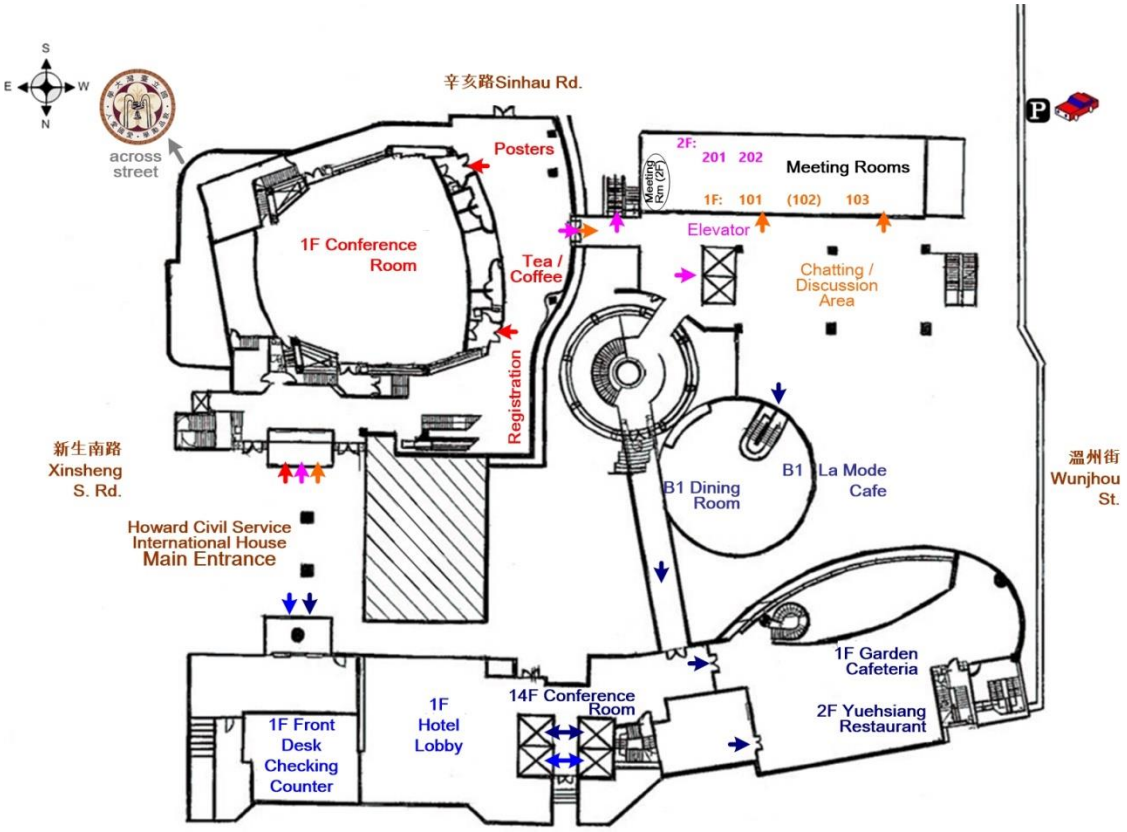
Floor Plan



Workshop	09:00-17:00	28 May	**2F**	201 (Lunch: **2F** Yuehsiang)
Registration	14:00-18:00		**1F**	Conference Room
Welcome Reception	18:00-20:00		**14F**	Conference Room
AdCONIP Sessions	09:00-17:40	29 May	**1F**	Conference Room; 101; 103; 201
Lunch	12:40-13:40		**2F**	Yuehsiang Restaurant
Banquet	18:00-20:00		**2F**	Yuehsiang Restaurant
AdCONIP Sessions	09:00-16:50	30 May	**1F**	Conference Room; 101; 103
Lunch	12:10-13:10		**2F**	Yuehsiang Restaurant
Dinner (Optional)	18:00-20:00		**1F**	Garden Cafeteria (show *ticket*)
Optional Tour	10:00-15:30	31 May	**1F**	Lobby (10:00) – Palace Musuem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