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Technical Program for Tuesday May 24, 2011

proposed. By a system, we refer to a set of variables within a process. An alarm is activated based on the risk associated with the state of the variables in a system. The objectives are to integrate risk estimation with alarm design and to reduce the number of alarms by assigning them to sets of variables instead of single ones. Also based on the relationships among the variables in a system, the future risk associated with the present state of the variables is evaluated. Thus the proposed method has a predictive capability that allows more time to take corrective actions. The applicability of the proposed procedure is demonstrated using the example of a tank process.

11:40-12:00 TuA1.4

Detection of Control Loop Interactions and Prioritization of Control Loop Maintenance (I), pp. 48-53

Rahman, Anisur	Bangladesh Univ. of Engineering & Tech. (BUET)
Choudhury, M. A. A. Shoukat	Bangladesh Univ. of Engineering & Tech. (BUET)

Chemical processes with multiloop control configurations have significant amount of control loop interactions due to tight mass and heat integration. Change in set point and/or controller parameters of one control loop may also affect the variables of other loops. The presence of loop interactions in a process plant can cause significant cost, quality and production losses of the plant. It is challenging to measure the degree of interaction between control loops and rank the loops according to the extent of interactions. This paper provides data driven techniques to determine control loop interactions and rank the loops according to their importance. First, two indices have been developed using integral of absolute or squared error criteria to determine loop interaction and rank of the loops. In another approach, a novel method based on canonical correlation analysis has been developed to calculate interaction among the loops and then normalization is done with respect to the maximum canonical correlation value to determine the rank of the loops. Simulation and experimental results show the validity of the proposed methods.

TuA2 Wanxia Pavilion

Monitoring and Identification (Regular Session)

Chair: Gao, Furong	Hong Kong Univ. of Science & Tech.
Co-Chair: Pan, Shuwen	Zhejiang Univ.

10:40-11:00 TuA2.1

Multivariate Statistical Monitoring of Multiphase Batch Processes with Uneven Operation Durations, pp. 54-59

Yao, Yuan	The Hong Kong Univ. of Science and Tech.
Dong, Weiwei	Hong Kong Univ. of Science and Tech.
ZHAO, Luping	The Hong Kong Univ. of Science and Tech.
Gao, Furong	Hong Kong Univ. of Science & Tech.

In multivariate statistical monitoring, batch process models should well reflect process characteristics in order to achieve satisfactory fault detection results. In manufacturing systems, many batch processes are inherently multiphase. Usually, process features are different from one phase to another, and gradual transitions are often observed between phases. Another important characteristic of batch processes is uneven operation durations. In multiphase batch processes, not only the entire batch durations but also the phase durations may be unequal from batch to batch. In this paper, the Gaussian mixture model (GMM) method is adopted to solve both the multiphase and the uneven-duration problems simultaneously. A benchmark penicillin fermentation process is utilized to verify the phase division, transition identification and process monitoring results based on the proposed method.

11:00-11:20 TuA2.2

An Algorithm for Fault Detection in Stochastic Non-Linear State-Space Models Using Particle Filters, pp. 60-65

Alrowaie, Feras	Univ. of British Columbia
Gopaluni, Bhushan	Univ. of British Columbia
Kwok, Ezra K.	Univ. of British Columbia

We propose a novel model-based algorithm for fault detection in nonlinear and non-Gaussian systems. The algorithm utilizes particle filters to generate a sequence of hidden states, which are then used in a log-likelihood ratio test to detect faults. The state-space models considered in this article are not easily amenable to standard log-likelihood ratio test, hence, a novel test statistic based on the joint likelihood function of hidden states and measurements is proposed. The proposed scheme is illustrated through an implementation on a highly non-linear multi-unit chemical reactor system.

11:20-11:40 TuA2.3

Independent Component Regression Based on Mutual Information Maximization, pp. 66-71

Zeng, Jiusun	Zhejiang Univ.
Xie, Lei	Zhejiang Univ.
Gao, Chuanhou	Zhejiang Univ.
Zhang, Jianming	Zhejiang Univ.

A new independent component regression (ICR) algorithm which maximizes the mutual information (MI) between extracted latent variables (LV) and output variable is proposed. It is found that mutual information between extracted LVs and output variable can be delicately combined with the independent component analysis (ICA) objective and only two-dimensional joint entropy needs to be estimated, which can be approximated by Edgeworth expansion. Balance is achieved between maximizing statistical independency and mutual information by forming a dual objective optimization problem. The performance of the proposed algorithm is tested on both simulation examples and real data sets

11:40-12:00 TuA2.4

Output Error Method for Identification of Multiple-Model Process with Transition, pp. 72-77

Zhao, Yu	Zhejiang Univ.
Huang, Biao	Univ. of Alberta
Su, Hongye	Zhejiang Univ.
Chu, Jian	Zhejiang Univ.

This paper is concerned with the identification of multiple model process with transition using the output error (OE) method. Local multiple linear models with output error model structure are identified at fixed operating points first and then a global nonlinear model is approximated by interpolating the multiple linear models with exponential weighting functions. With all the obtained initial values of the system's parameters, nonlinear optimization strategy is implemented to find the optimal values of the parameters for both the local multiple models and their corresponding weighting functions. Finally a more accurate global model can be obtained. The effectiveness of the proposed approach is demonstrated through simulation examples.

TuA3 QUNYAN ROOM

Process Control Applications I (Regular Session)

Chair: Huang, Hsiao-Ping — National Taiwan Univ.

10:40-11:00 — TuA3.1

Design and Control of Cyclohexanol Reactive-Distillation Process with Alternative Decanter Configurations, pp. 78-83

Lee, Hao-Yeh — National Taiwan Univ.

Lin, Yuan-Lin — Department of Chemical Engineering, National TaiwanUniversity

Huang, Hsiao-Ping — National Taiwan Univ.

Cheng-Liang, Chen — National Taiwan Univ.

Chien, I-Lung — National Taiwan Univ.

Cyclohexanol is widely used in industry as a precursor for the synthesis of intermediates of Nylon. In this paper, design and control of reactive-distillation process for the production of cyclohexanol have been studied. The total annual costs of two alternative decanter configurations are comparable. However, one configuration gives much better operability than the others in the face of feed disturbances. To achieve wider operability, proper selection of the overall control strategy is critically important. Rigorous dynamic simulations will be used to illustrate the findings.

11:00-11:20 — TuA3.2

Modeling and Control System Design of an MCFC System, pp. 84-89

Kim, Huiyong — Sogang Univ.

Cho, JuneHo — Sogang Univ.

Lee, Kwang Soon — Sogang Univ.

A molten carbonate fuel cell (MCFC) system is modeled and a control strategy is proposed. A spatially distributed two-dimensional dynamic model of single cell direct internal reforming MCFC was developed as a numerical process by reducing the PDE model to a set of ODE's using the cubic spline collocation method and the finite difference method. Mean cell temperature, $T_{s,m}$, maximum temperature difference over a cell, $\Delta T_{s,max}$, oxygen conversion, X_{O2}, and hydrogen mole fraction at the anode outlet, $x_{H2,o}$, were considered as controlled variables (CV's) under the assumption that their target values are determined by an optimizer in the upper level. Among the CV's, $T_{s,m}$ and $\Delta T_{s,max}$ have much slower dynamics than the other two and keeping $\Delta T_{s,max}$ below a certain safety limit is critical. Hence $T_{s,m}$ and $\Delta T_{s,max}$ were designed to be separately controlled under model predictive controller (MPC). On the other hand, X_{O2} and $x_{H2,o}$ have faster dynamics and were designed to be regulated by single loop PID controllers with feedforward compensation. The manipulated variables (MV's) for each CV group were determined through a system analysis using the singular value decomposition and relative gain array. The performance of the control scheme was evaluated against load (power demand) changes.

11:20-11:40 — TuA3.3

Evolutionary Algorithm Based on the Evolution of Pareto Archive and Individual Migration, pp. 90-95

Qi, Rongbin — East China Univ. of Science and Tech.

Qian, Feng — East China Univ. of Sci. and Tech.

Sun, Fan — East China Univ. of Science and Tech.

An evolutionary algorithm based on the parallel evolution of multiple single objective populations and Pareto archive population is proposed, which is not only suitable for solving multi-objective optimization, but also effective for multimodal function. For each single objective population, single objective evolutionary algorithm is applied to optimize separately each of multi-objective functions, where individuals generated by tournament selection from the union of single objective and Pareto Archive population form the single objective population of next generation. Especially, individuals in Pareto archive population also join evolutionary operations. Simulations manifest that the proposed method can realize the search from multiple directions to obtain the non-dominated solutions scattered more uniformly over the Pareto frontier with better convergence metric compared to well-known NSGA-II algorithm. Individual migration from Pareto archive population by tournament selection is also proved to have the advantage in improving the converging speed and converging precision. Moreover, for multimodal single objective function, simulations also show that ideal optimizing solution can be obtained by properly separating single objective function into multi-objective function and applying the above method.

11:40-12:00 — TuA3.4

A Two-Degree-Of-Freedom Dead Time Compensator for Stable Processes with Dead Time, pp. 385-390

Kirtania, Kawnish — Bangladesh Univ. of Engineering and Tech. (BUET),

Choudhury, M. A. A. Shoukat — Bangladesh Univ. of Engineering & Tech. (BUET)

This paper presents a new simplified approach for the design of dead time compensators for processes with dead time. The approach is based on a modified structure of the Smith predictor that allows to isolate the disturbance and set-point responses and thereby, providing two-degree-of-freedom control scheme. The proposed structure is easy to analyze and tune. Using an estimation of the dead time and process model of the plant, the proposed compensator has only two tuning parameters that determine the closed-loop performance and robustness. In order to evaluate the proposed compensator, a comparative analysis of robustness with the most recent algorithm proposed in the literature is presented. To demonstrate its applicability to real processes, the method is evaluated on a pilot plant.

TuA4 — JUYAN ROOM

Adaptive and Learning Controller Design (Invited Session)

Chair: Masuda, Shiro — Tokyo Metropolitan Univ.

Co-Chair: Sato, Takao — Univ. of Hyogo

Organizer: Yamamoto, Toru — Hiroshima Univ.

Organizer: Masuda, Shiro — Tokyo Metropolitan Univ.

Organizer: Ishii, Chiharu — Kogakuin Univ.

10:40-11:00 — TuA4.1

Improved Adaptive Steering Controller for Combined Vehicles (I), pp. 102-107

wang, qiang — Kyushu Inst. of Tech.

Oya, Masahiro — Kyushu Inst. of Tech.

Takagi, Natsuki — Miyakonojo National Coll. of Tech.

If the dynamics of combined vehicles such as tractor-semitrailer varies greatly, it may be very difficult for inexperienced drivers to achieve good handling stability. Moreover, once combined vehicles become unstable, it is very difficult for all drivers to stabilize vehicles. However, if the behavior of actual combined vehicles can track a designed desired combined vehicle, the good handling property can be maintained even when the dynamics of actual combined vehicles varies large. To achieve handling performance better than the conventional control schemes, the authors have proposed the adaptive steering controller. However, in this scheme, there is a problem that the method to improve tracking performance was not shown theoretically. Therefore, a trial and error method is required in order to improve robust handling performance. In this paper, to overcome the problem, the authors propose a new adaptive steering controller.

11:00-11:20 TuA4.2

Adaptive Fault-Tolerant Control Based on Hybrid Redundancy (I), pp. 108-113

Takahashi, Masanori Tokai Univ.
Takagi, Taro Tokai Univ.

This paper presents a new adaptive fault-tolerant control system (AFTCS) against actuator failures. The AFTCS utilizes a hybrid of static and dynamic redundancies. In order to maintain the control performance, the redundancy-mode is selected appropriately to remove the effect of the failure. All the switching actions are executed based on only the input and error signals. Hence, any fault detector is not exploited. Furthermore, introducing an adaptive high-gain feedback controller makes it possible to achieve the $lambda$-tracking in the presence of failure. In this paper, several simulation results for the CSTR are shown to confirm the effectiveness of the AFTCS.

11:20-11:40 TuA4.3

Modification of an Adaptive Controller for Systems with Input Saturation and Available Output Derivatives up to the Order of Relative Degree (I), pp. 114-119

Takagi, Natsuki Miyakonojo National Coll. of Tech.
Zhuo, Jinxin Kyushu Inst. of Tech.
Oya, Masahiro Kyushu Inst. of Tech.
wang, qiang Kyushu Inst. of Tech.

In this paper, the main attention is focused on transient property of control input signal, we propose a novel adaptive controller for time-continuous single-input single-output linear systems with an input saturation in which i-th derivatives of the output signal (i=1,..., relative degree) are available. In the proposed adaptive controller, arbitrary deterministic signals can be used as an input of the reference models. It is shown theoretically that the tracking error between the controlled object output and the reference model output can converge to zero when the initial value of the tracking error satisfies a condition. Moreover, it is also shown theoretically that tracking performance can be improved by setting design parameter.

11:40-12:00 TuA4.4

Design of a Hard Disk Drive Control System in a Multirate System for Improvement in Steady-State Intersample Resonse (I), pp. 120-123

Sato, Takao Univ. of Hyogo
Hattori, Yoshiki Univ. of Hyogo
Araki, Nozomu Univ. of Hyogo
Konishi, Yasuo Univ. of Hyogo

This paper proposes a new design method for a hard disk drive (HDD) head positioning control system. In control of a head in an HDD, the control input supplied to a voice coil motor is updated at a fast rate, but the sampling interval of the head position is restricted because of hard ware constraints. Hence, a designed control system is a multirate system. In this study, a multirate control system designed for controlling a head in an HDD is extended such that the intersample response is improved independently of the sample response. The effectiveness of the proposed method is demonstrated by numerical example.

TuPBP NEW CENTURY HALL

Plenary 2: Torsten Soderstrom (Plenary Session)

Chair: Shah, Sirish L. Univ. of Alberta

13:30-14:30 TuPBP.1

Estimation of Material Functions Using System Identification Techniques, pp. 124-138

Soderstrom, Torsten Uppsala Univ.
Rensfelt, Agnes Uppsala Univ.

Material properties of an elastic material are characterized by the elastic modulus, which is real-valued and constant. For viscoelastic materials, such as plastics and polymers, the relationship between stress and strain is instead dynamic, and characterized by the complex-valued and frequency-dependent complex modulus. It is in this paper described how system identification techniques can be used to determine the complex modulus using strain data from wave propagation experiments on a test specimen. Modeling, derivation of estimators, and analysis of their numerical and statistical properties are included. Identifiability and experimental design are examined in some detail. Several practical examples are presented using real-world data, and a number of extensions are outlined.

TuKBK1 NEW CENTURY HALL

Keynote 3 & 5: Tongwen Chen & Hugues Garnier (Regular Session)

Chair: Thornhill, Nina Imperial Coll. London
Co-Chair: Ahmed, Salim Qatar Univ.

14:35-15:05 TuKBK1.1

On Optimal Alarm Filter Design, pp. 139-145

Cheng, Yue Univ. of Alberta
Izadi, Iman Univ. of Alberta
Chen, Tongwen Univ. of Alberta

Accuracy and efficiency of alarm systems are of paramount importance in safe operations of industrial processes. Accuracy is measured by false and missed alarm rates; while efficiency relates to the detection delay and complexity of the technique used. Moving average filters are often employed in industry for improved alarm accuracy at the expense of some detection delay. Can one do better than moving average filters? The following problem is studied in this paper: Given statistic distributions of both normal and abnormal conditions, and relatively fixed filter complexity, design an optimal alarm filter for best alarm accuracy, minimizing a weighted sum of false and missed alarm rates (probabilities). It turns out that the general form of such optimal alarm filters is the so called log-likelihood ratio (LLR) filters, which can be highly nonlinear and difficult to implement in practice. With fixed filter structures (first or second order), design of optimal linear alarm filters and optimal quadratic alarm filters is studied, and numerical optimization based procedures are proposed. Some key elements in the optimal design include use of characteristic functions from probability theory to facilitate computation of the objective function, and a DE algorithm for optimization (the optimization problem is non-convex and with small gradients in some area). The validity of the proposed methods is illustrated by several design examples in which the optimal filters in the general, linear and quadratic forms are computed, and their relative performance in alarm accuracy is fully discussed.

15:05-15:35 TuKBK1.2

Data-Based Continuous-Time Modelling of Dynamic Systems, pp. 146-153

Garnier, Hugues Nancy-Univ.

Data-based continuous-time model identification of continuous-time dynamic systems is a mature subject. In this contribution, we focus first on a refined instrumental variable method that yields parameter estimates with optimal statistical properties for hybrid continuous-time Box-Jenkins transfer function models. The second part of the paper describes further recent developments of this reliable estimation

technique, including its extension to non-uniformly sampled data, closed-loop and nonlinear model identification. It also discusses advantages of the developed methods and how they are implemented in the CONTSID toolbox for Matlab.

TuKBK2 Wanxia Pavilion

Keynote 4 & 6: Bjarne Foss & Jay Lee (Regular Session)

Chair: Hoo, Karlene — Texas Tech. Univ.
Co-Chair: Zhu, Yucai — Eindhoven Univ. Tech.

14:35-15:05 TuKBK2.1

Process Control in the Upstream Petroleum Industries, pp. 154-160

Foss, Bjarne A. — Norwegian Univ. of Science & Tech.

This paper presents some key operational challenges in the petroleum industries in which advanced control and model-based optimization has or may have a significant impact. This includes stabilizing control on an individual well level, model-based optimization for production allocation and long term recovery control.

15:05-15:35 TuKBK2.2

Improved Disturbance and Fault Signal Modeling Via Hidden Markov Models, pp. 161-168

Lee, Jay H — KAIST
Wong, Wee Chin — Self

Understanding and modeling disturbances play a critical part in designing effective advanced model-based control solutions. Existing linear, stationary disturbance models are oftentimes limiting in the face of time-varying character- istics typically witnessed in process industries. These include intermittent drifts, abrupt changes, temporary oscillations, and outliers. This work proposes a Hidden-Markov-Model-based framework to deal with such situations that exhibit discrete, modal behavior. The usefulness of the proposed disturbance framework is demonstrated through two examples: i) tracking abruptly changing feed conditions in the context of a second generation bioethanol fermentor and ii) tracking stiction, a well known problems known to occur in valves.

TuB1 NEW CENTURY HALL

Applications in Modeling, Control and Optimization (invited Session in Honor of Prof. Sirish L. Shah) (Invited Session)

Chair: Ben-Zvi, Amos — Univ. of Alberta
Co-Chair: Prasad, Vinay — Univ. of Alberta
Organizer: Gopaluni, Bhushan — Univ. of British Columbia

15:50-16:10 TuB1.1

Data-Based Modeling and Prediction of Cytotoxicity on Microelectronic Sensors (I), pp. 169-174

Khatibisepehr, Shima — Univ. of Alberta
Ibrahim, Fadi — Univ. of Alberta
Xing, James Z. — Univ. of Alberta
Roa, Wilson — Cross Cancer Inst.
Huang, Biao — Univ. of Alberta

This paper is concerned with dynamic modeling, prediction and analysis of cell cytotoxicity. A real-time cell electronic sensing (RT-CES) system has been used for continuously monitoring dynamic cytotoxicity responses of living cells. Cells are grown onto the surfaces of the microelectronic sensors. Changes in cell number expressed as cell index (CI) have been recorded on-line as time series. The CI data are used to develop dynamic prediction models for cell cytotoxicity process.

We consider Support Vector Regression (SVR) algorithm to implement data-based system identification. Through several validation studies, multi-step ahead predictions are calculated and compared with the actual CI. It is shown that SVR-based dynamic modeling has great potential in predicting the cytotoxicity response of the cells in the presence of toxicant.

16:10-16:30 TuB1.2

Towards Forecasting Flu Dynamics Using a Regionalized State Space Model (I), pp. 175-180

Ponnambalam, Loganathan — National Univ. of Singapore
Ho, Chee Siang — National Univ. of Singapore
Lee, Hao Ran — National Univ. of Singapore
Samavedham, Lakshminarayanan — National Univ. of Singapore

The emergence of H1N1 in 2009 and a subsequent pandemic onset illustrated the importance of developing effective models with useful predictive capabilities for infectious diseases. The early identification of epidemic peaks can help the authorities to strategize effective anti-epidemic plans. In this regard, we propose a particle filter approach using the Susceptible-Exposed-Infected and Recovered (SEIR) epidemic model. The epidemic model was integrated with an observation model characterizing real-time influenza-like illnesses (ILI) data originating from general practice / family doctors (GPFDs) located in Singapore. The systematic resampling algorithm used in our approach resulted in better parameter estimates and the approach was able to predict the ILI peak registered around Day 40. However, the current approach suffers a serious limitation in its sensitivity towards the initial prior distribution assumed. The shortcomings of the current approach can be overcome by using a regionalized approach. Future efforts will be dedicated towards initializing the prior based on region-specific socio-demographic variables. Such regionalized models can provide good insight concerning the execution of efficient region-specific anti-epidemic plans for preventing future pandemics.

16:30-16:50 TuB1.3

Design and Implementation of Nonlinear Internal Model Controller on the Simulated Model of Ph Process (I), pp. 181-186

Prakash, J — Madras Inst. of Tech.
K., Srinivasan — NIT Trichy

In this paper, the authors have designed local internal model controllers on the basis of multiple-linear discrete transfer function models and the weighted sum of the output from the local internal model controllers (Non-linear Internal Model Controller) has been used to control the nonlinear process. The effectiveness of the proposed control schemes has been demonstrated on a pH process. From the extensive simulation studies, we have shown that the proposed non-linear internal model controller provides satisfactory servo as well as regulatory performances.

16:50-17:10 TuB1.4

A Kinetic Model for Hydroconversion Processing of Vacuum Residue (I), pp. 187-191

Shams, Shiva — Univ. of Alberta
McCaffrey, William — Univ. of Alberta
Gray, Murray — Univ. of Alberta
Ben-Zvi, Amos — Univ. of Alberta

Hydroconversion is a complex process involving many chemical reactions. Mathematical models of hydroconversion processes often have more kinetic parameters than can be estimated from data. In this

work the identifiability and estimability of parameters in a model describing the hydroconversion processing of vacuum residue are analyzed. The model under consideration contains five states, two outputs, and seven parameters. This lumped model was developed by grouping molecules based on their solubility characteristics. The model parameters were found to be identifiable. However, using previously published experimental data, the model parameters were found to be inestimable. It is shown that the model can be reparameterized using a linear transformation in the parameter space. This transformation allows the model outputs to be predicted based on only three pseudo-parameters. Confidence intervals for the three pseudo-parameters and the mean responses were calculated.

17:10-17:30 TuB1.5

Adaptive Predictive Control of a High Purity Distillation Column Using Irregularly Sampled Multi-Rate Data (I), pp. 192-197

Muddu, M — Inst. of Tech. Bombay

Patwardhan, Sachin — Indian Inst. of Tech. Bombay

This work aims at the development of multi-rate adaptive model predictive control (MR-AMPC) based on the fast rate model, which is identified from irregularly sampled multi-rate data. The model is assumed to have output error structure and is parameterized using generalized orthonormal basis filters. The identified model is used to generate inter-sample estimates of the irregularly sampled outputs and for performing future trajectory predictions in the proposed MRMPC formulation. The effectiveness of the proposed adaptive multi-rate control scheme is demonstrated by conducting simulation studies on a benchmark binary distillation column system [1]. The results from the simulation reveal that the proposed adaptive multi-rate model predictive control successfully manages transition of the distillation column from moderate purity region to the high purity region where the system exhibits highly nonlinear dynamics.

17:30-17:50 TuB1.6

Robust Design of Catalysts Using Stochastic Nonlinear Optimization (I), pp. 198-203

Lee, Chang Jun — Seoul National Univ.

Prasad, Vinay — Univ. of Alberta

Lee, Jong Min — Seoul National Univ.

Computational methods for designing an optimal catalyst have recently been gaining more popularity in the fields of catalysis and reaction engineering of energy systems. However, in general, the problem in these approaches is that uncertainties present in process models should be handled correctly to achieve a robust design. To find the optimal design under these uncertainties, a stochastic optimization method can be employed. In this work, the optimal properties of a catalyst for ammonia decomposition to produce hydrogen are investigated, and uncertainties associated with the reactions and their parameters are modeled as exogenous uncertain variables which follow known probability distributions. The goal of this work is to find the optimal binding energies of the catalyst that maximize conversion of ammonia in a microreactor. Our stochastic optimization problem is nonlinear, and involves the expectation operator as well as integration in the objective function. To tackle this complex system, the expectation of conversion based on a sample average approximation (SAA) method is evaluated. However, the exponential increase in the number of samples to be considered with the number of uncertain parameters lead to severe computational problems when using all possible combinations of the uncertain parameters. To solve this, linearity analysis, together with partial least squares, is implemented to reduce the number of uncertain parameters. In the optimization step, a particle swarm optimization (PSO) is employed. The results indicate that the stochastic optimum shows higher conversion and different optimal binding energies than the deterministic optimum, and is a more robust solution.

TuB2 Wanxia Pavilion

Optimization (Regular Session)

Chair: Lee, Jong Min — Seoul National Univ.

Co-Chair: LIU, Xinggao — Zhejiang Univ.

15:50-16:10 TuB2.1

An Improved Quantum-Behaved PSO Algorithm for a New Process Optimization Problem Based on Mechanism Model of LBE Converter, pp. 204-209

Zhang, Jun — the Liaoning Key Lab. ofManufacturingSystemandLogisti cs, T

Jia, Fengyong — Northeastern Univ.

Tang, Lixin — Northeastern Univ.

A process optimization method based on LBE converter mechanism model is studied in this paper. According to the characteristic of converter steelmaking, the composition of molten steel plays an important role on quality of steelmaking production. The optimal setting of input raw materials is extremely complex, and the classical low efficiency heuristic model is usually adopted in actual applications. A process optimization model based on mechanism method of LBE converter is proposed in this paper by making the raw material cost and hitting rate of endpoint as objective at the same time, using the energy, mass conservation equations and physical-chemical balances of the steel-making process as constraints, which is also very crucial in the actual production. Those are different from other common research literatures. Evenly, the objective is highly non-linear, lots of constraints are satisfied at the same time, and there is also some complicated physicochemical reaction in the hot bath. It is significant and challenging to solve this sort of complex, multivariate and highly non-linear problem. An evolution quantum-inspired particle swarm optimization algorithm (EQPSO) is proposed to solve the process model in this paper. Instead of position and velocity in the original PSO algorithm, every individual particle is depicted by a wave function and DE evolutionary strategy in EQPSO, which make the particles have quantum behavior. Meanwhile, the global and local convergence ability are improved simultaneously by the operation of differential evolution by introducing , raising the convergence accuracy of EQPSO. The experimental results show the effectiveness of the model with the EQPSO.

16:10-16:30 TuB2.2

Optimization of Energy Consumption for Evaporation Process Using Vortex Motion Based Particle Swarm Optimization, pp. 210-215

Chai, Qinqin — Central South Univ.

Yang, Chunhua — Central South Univ.

Gui, Weihua — Central South Univ.

Wang, Xiaoli — Central south Univ.

Considering the mount of high temperature steam consumed in the evaporation process is large, which is much higher than designed value, an optimization model is established to minimize steam consumption per ton of evaporated water. It focuses on operation optimization of evaporation process and takes into account a wide range of operating conditions and system configurations. And a new vortex motion based particle swarm optimization (VMPSO) algorithm is proposed to solve this complex optimization model where a penalty function is introduced to handle the inequality constraints. The effectiveness of the proposed optimization method is demonstrated in an industry evaporation process used to concentrate sodium aluminate liquor. Simulation results reveal that VMPSO is faster than other optimization algorithms, and achieves better results. Moreover, the steam consumption per ton of evaporated water is decreased by optimal operation.

16:30-16:50 TuB2.3

Optimal Boundary Control of Parabolic PDE with Time-Varying Spatial Domain, pp. 216-221

Ng, James — Univ. of Alberta
Dubljevic, Stevan — Univ. of Alberta

This paper considers the optimal boundary control of reaction-diffusion process with time-varying spatial domain in the context of the Czochralski crystal growth process. A parabolic partial differential equation (PDE) model of the reaction-diffusion process which preserves the dynamical features attributed to the time-varying spatial domain is developed. The parabolic PDE is coupled to a second order ordinary differential equation (ODE) which describes the time-evolution of the spatial domain. The infinite-dimensional linear state space representation of the PDE system with control input at the boundary is reformulated into an abstract form and provides the framework on which the optimal boundary control problem is considered. The optimal control law is determined and numerical results of the closed-loop system are provided.

16:50-17:10 TuB2.4

Acceleration of Benders Decomposition for Mixed Integer Linear Programming, pp. 222-227

Yang, Yu — Univ. of Alberta
Lee, Jong Min — Seoul National Univ.

This paper presents a novel strategy for speeding-up the classical Benders decomposition for large-scale mixed integer linear programming problems. This method is particularly useful for the cases where the optimality cut is difficult to obtain. The distances between the selected feasible points and feasibility cutting planes, as a metric, determine the tighter constraint, thus improving the convergence rate. The application of this approach in a scheduling problem for multi-product, multi-purpose batch plants show substantial improvement both in the computational time and the number of Benders iterative steps.

17:10-17:30 TuB2.5

An Optimization Method for the Refinery Hydrogen Network and Its Application, pp. 228-233

Jiao, Yunqiang — Inst. of Cyber-Systems and Control, Zhejiang Univ.
Su, Hongye — Inst. of Cyber-Systems and Control, ZhejiangUniversity.
Hou, Weifeng — ZHEJIANG SUPCON SOFTWARE CO.,LTD.

The requirement of hydrogen in oil refineries is increasing as market forces and environmental legislation, so the management and optimization of hydrogen system in refineries is becoming increasingly more important. In this paper, an improved approach for the optimization of hydrogen network is proposed. The method decomposes the optimization problem into two sub-problems, the optimization of feed routes of purification system and hydrogen network. By establishing a superstructure model, all possible placements of existing compressors and purifiers are incorporated in the proposed NLP model. The approach in this paper makes best use of resources and can provide significant environmental and economic benefits. A real case study is introduced to illustrate the applicability of the presented approach.

17:30-17:50 TuB2.6

Power Consumption in Refrigeration Systems - Modeling for Optimization, pp. 234-239

Hovgaard, Tobias Gybel — Danfoss A/S
Larsen, Lars Finn Sloth — Danfoss A/S
Skovrup, Morten Juel — IPU Tech. Development
Jørgensen, John Bagterp — Tech. Univ. of Denmark

Refrigeration systems consume a substantial amount of energy. Taking for instance supermarket refrigeration systems as an example they can account for up to $50-80%$ of the total energy consumption in the supermarket. Due to the thermal capacity made up by the refrigerated goods in the system there is a possibility for optimizing the power consumption by utilizing load shifting strategies. This paper describes the dynamics and the modeling of a vapor compression refrigeration system needed for sufficiently realistic estimation of the power consumption and its minimization. This leads to a non-convex function with possibly multiple extrema. Such a function can not directly be optimized by standard methods and a qualitative analysis of the system's constraints is presented. The description of power consumption contains nonlinear terms which are approximated by linear functions in the control variables and the error by doing so is investigated. Finally a minimization procedure for the presented problem is suggested.

TuB3 QUNYAN ROOM

Asset Management and Maintenance (Regular Session)

Chair: Xie, Lei — National Key Lab. of Industrial Control Tech.
Co-Chair: Young, Brent — The Univ. of Auckland

15:50-16:10 TuB3.1

Structure Restricted (PID) Controller Performance Assessment for Multi-Stage Batch Processes with Tracking and Regulatory Requirements, pp. 240-245

Fu, Ruowei — Zhejiang Univ.
Xie, Lei — National Key Lab. of Industrial Control Tech.
Song, Zhihuan — Zhejiang Univ.

A new control performance assessment method based on a structured residual for multi-stage batch processes is presented. After separating the process into different stages according to reference signal dynamics, based on specific tracking and regulatory requirements of different stage, a structured residual focusing on deterministic part of output error with different weights on each stage is minimized to form the performance benchmark. In this way, it explores the equilibrium control effect in tracking and regulatory stages of batch processes in the whole batch sense. The best control performance with respect to stage balance and the overall optimal controller settings are searched using Newton's method. The application to an exothermic chemical batch reactor shows its effectiveness and feasibility.

16:10-16:30 TuB3.2

A Comparison of Nonlinear Control Performance Assessment Techniques for Hammerstein-Wiener Processes, pp. 246-251

Yu, Wei — The Univ. of Auckland
Wilson, David I. — Auckland Univ. of Tech.
Young, Brent — The Univ. of Auckland

Assessing the quality of industrial control loops is an important routine auditing task for the control engineer. However there are complications when considering nonlinear control loops, where one must consider both the type of nonlinearity, and the precise structure of the loop. This paper shows that certain nonlinear CPA strategies fail when faced with disturbance signals that are immediately passed through a nonlinearity, whereas others, admittedly more computationally demanding, are immune to this noise structure.

16:30-16:50 TuB3.3

Data Reconciliation with Simultaneous Bias and Leak Estimation Based on Generalized T Distribution and Akaike Information Criterion, pp. 252-257

Xiao, Liyong	Inst. of Cyber-Systems and Control, Zhejiang Univ.
Miao, Yu	Dalian Univ. of Tech.
Su, Hongye	Inst. of Cyber-Systems and Control, ZhejiangUniversity.

A data reconciliation with simultaneous bias and leak estimation approach is proposed in this paper, which is based on combining merits of the generalized T distribution method and the extended Akaike information criterion (AIC) method proposed in this paper. This approach makes use of GT distribution function to eliminate the effects of measurement biases and applies extended AIC approach to address process leaks to achieve accurate data reconciliation and estimate measurement biases and process leaks on even nonlinear steady systems. This combination will retain the advantage of robust estimator to adaptively fit to measurement errors distribution and will also consider process model uncertainty such as process leaks. The Simulation results from a heat-exchange network, a nonlinear steady system, demonstrate the accuracy and effectiveness of the proposed approach.

16:50-17:10 TuB3.4

Leak Detection of Gas Transport Pipelines Based on Wigner Distribution, pp. 258-261

Yang, Hongying	Tsinghua Univ.
Ye, Hao	Tsinghua Univ.
Zhai, Shouchao	Tsinghua Univ.
Wang, Guizeng	Tsinghua Univ.

This paper reports on the application of Wigner-Ville Distribution (WVD) method in leak detection of gas transport pipelines. WVD of the acoustic signal inside a pipeline is used to detect the change of the signal caused by leak. In order to reduce the influence of cross term disturbances, the time average of WVD results is calculated and used as the residual to detect leak faults. Experimental results based on real data show that the method can detect the leak faults of long gas transport pipelines effectively.

17:10-17:30 TuB3.5

Primary Separation Vessel Interface Control, pp. 262-264

LI, Bo	Syncrude Canada Ltd
Xu, Fangwei	Syncrude Canada Ltd.
Ren, Zhengyun	Donghua Univ.
Espejo, Aris	Syncrude Canada Ltd

The Primary Separation Vessel (PSV) plays a key role in oil sands extraction process. Controlling the interface between the froth and middlings at an optimal level provides significant economical and environmental benefits. Traditional level transmitters are not sufficient enough to provide consistent interface level information due to slurry quality changes from time to time. Two novel measuring approaches are discussed in this paper, which have been applied at PSV interface level control in Syncrude Canada Limited. One is based on image signals captured from a camera installed on the PSV sight glass; the other one is based on density readings along the PSV depth provided by a density profiler installed inside the vessel. Application results show both approaches perform outstandingly in detecting the interface, and are promising to improve the performance of PSV interface level control.

17:30-17:50 TuB3.6

Complex Distillation Arrangements to Improve Energy Efficiency in NGL Recovery Process, pp. 265-265

Nguyen, Van Duc Long	Yeungnam Univ.
Lee, Moonyong	Yeungnam Univ.

In this work, our aim is how to utilize complex distillation arrangements, such as the double prefractionator arrangement (DPA), double dividing wall column arrangement (DDWC) and Agrawal arrangement, to improve the performance in depropanizing, debutanizing and deisobutanizing fractionation steps in NGL processing. Starting from an initial conventional column sequence, the designs for the DPA and DDWC were obtained. The results show that the DDWC offers many benefits by decreasing the reboiler and condenser duty. In addition, the reducing of number of columns and their diameter may give a chance to reduce the investment costs. Furthermore, interreboiling of the bottom section of the 2nd DWC was also applied to improve the performance of the DDWC.

TuB4 JUYAN ROOM

Soft Sensing (Regular Session)

Chair: Espejo, Aris	Syncrude Canada Ltd
Co-Chair: Li, Shaoyuan	Shanghai Jiao Tong Univ.

15:50-16:10 TuB4.1

Feature Extraction and Selection Based on Vibration Spectrum with Application to Mill Load Modeling, pp. 266-271

Tang, Jian	Northeastern Univ.
Chai, Tianyou	Northeastern Univ.
zhao, Lijie	Northeastern Univ.
Yu, Wen	CINVESTAV-IPN

Feature extraction and selection were important issues in soft sensing. Using the spectrum of vibration or acoustical signal may simplify the modeling process. In this study, shell vibration signals of ball mill were first transformed into vibration spectrum by fast Fourier transform (FFT). Then, the candidate features set were extracted from the spectrum, which included three types of features: characteristic frequency sub-bands, spectral kernel principal components (KPCs), masses and central frequencies of spectral peaks. We used several techniques, such as genetic algorithm (GA), partial least square (PLS) and kernel principal component analysis (KPCA), to obtain these features. The optimal selection of input sub-features and model parameters were calculated by GA based optimization method. The test results showed that the proposed approaches were effective for modeling parameters of mill load.

16:10-16:30 TuB4.2

Knn-RVM Lazy Learning Approach for Soft-Sensing Modeling of Fed-Batch Processes, pp. 272-276

Ji, Jun	Zhejiang Univ.
Wang, Hai-qing	Zhejiang Univ.
Chen, Kun	Zhejiang Univ.
Liu, Yi	Zhejiang Univ. of Tech.

Fed-batch processes are inherently difficult to model owing to non-steady-state operation, small-sample condition, instinct time-variation and batch-to-batch variation caused by drifting. Furthermore, when the process switches to different operation phrases, global learning modeling methods would suffer poor performance due to the negative impact of overdue training samples. In this paper, a k nearest neighbor relevance vector machine (kNN-RVM) based lazy learning method is proposed to model the fed-batch processes to soft-sense the corresponding production indices. A recursive algorithm is developed to effectively obtain the kernel matrices used by previous kNN step and following modeling process. Simulative soft-sensors of penicillin production process and rubber mixing process are implemented to valid the proposed method.

Comparative results indict that proposed method has better precision and much lower computational complexity than relevance vector machine (RVM) on soft-sensing modeling of fed-batch processes.

16:30-16:50 TuB4.3

Estimation of Froth Quality Using Bayesian Information Synthesis, pp. 277-280

Xu, Fangwei — Syncrude Canada Ltd.
Shao, Xinguang — Univ. of Alberta
Espejo, Aris — Syncrude Canada Ltd

This paper presents the design of soft sensors for estimation of froth quality in oil sands extraction processes. One of the most important quality indexes for bitumen froth is the water content. Due to the variations of oil sands compositions and the complexity of the extraction process, existing hardware sensors are not reliable enough to provide accurate water content information. Laboratory analysis result is obtained off-line with large sampling interval and irregular time delay. Therefore, it is not sufficient for real-time monitoring and control. Bayesian information synthesis is proposed to fuse all the existing information to produce more reliable and more accurate real-time froth quality information. The technique has been applied in oil sands extraction units in Syncrude Canada Limited. Application results illustrate its promising perspectives for soft sensor development.

16:50-17:10 TuB4.4

Soft Sensing and Optimization of Pesticide Waste Incinerator, pp. 281-286

Zhengbing, YAN — State Key Lab. of IndustrialControlTechnology,Depa rtment o
LIU, Xinggao — Zhejiang Univ.

Three soft sensor models (RBF, SVM, ICA-SVM) are proposed to infer the Chemical Oxygen Demand (COD) of quench water produced from pesticide waste incinerator respectively. An optimization model of COD is further proposed based on the above soft sensor models. Furthermore, chaos genetic algorithm is introduced to solve the optimization model. The procedure is demonstrated and discussed for practical industrial cases, where the mean relative error of the proposed ICA-SVM model is 0.16% for COD prediction, and mean of COD can decrease from 1140 to 393, by 65.53%, with the proposed optimal soft sensing approach.

17:10-17:30 TuB4.5

Plant-Wide Temperature Drop Monitoring in Run-Out Table Strip Cooling Process, pp. 287-292

zheng, yi — Shanghai Jiao Tong Univ.
Li, Shaoyuan — Shanghai Jiao Tong Univ.

For the progression of strip temperature can only be measured at a few positions on the inside of cooling section, a new approach of monitoring transient temperature of strip during cooling process is proposed in this paper. Here a simple and accurate state space representation is designed to describe the temperature drop of strip. The Extended Kalman Filter is used to reconstruct the strip temperature distribution because of its simple designation. For coordinating convergence rate and stability, a trade-off feed-back coefficient of EKF is chosen. The reliability of the proposed method was demonstrated by the experimentation in one steel Ltd.

17:30-17:50 TuB4.6

Multiple Model Based Soft Sensor Development with Irregular/missing Process Output Measurement, pp. 293-298

Jin, Xing — Univ. of Alberta
Wang, Siyun — Univ. of Alberta
Huang, Biao — Univ. of Alberta
Forbes, J Fraser — Univ. of Alberta

Data-driven soft sensors have been applied extensively in process industry for process monitoring and control. Linear soft sensors, which are only valid within relatively small operating envelope, are considered to be insufficient in practice when the processes transit among several pre-designed operating conditions. Moreover, owing to a variety of causes such as malfunction of sensors, multiple rate sampling scheme for different process variables, etc., missing data problem is commonly experienced in process industry. In this paper, nonlinear soft sensor development with irregular/missing output data is considered and a multiple model based modeling scheme is proposed for nonlinear processes. The efficiency of the proposed algorithm is demonstrated through several numerical simulation examples as well as the experimental data collected from a pilot-scale setup. It is shown through the comparison with the traditional missing data treatment methods in terms of the parameter estimation accuracy that, the developed soft sensors enjoy improved performance by employing the expectation maximization (EM) algorithm in handling the missing process data and model switching problem.

WePP NEW CENTURY HALL

Plenary 3: Tianyou Chai (Plenary Session)

Chair: Chu, Jian — Zhejiang Univ.

08:00-09:00 WePP.1

Hybrid Intelligence Optimal Control for Operation of Complex Industrial Processes, pp. 299-299

chai, tianyou — Northeastern Univ.

With ever increased needs for an improved product quality, production efficiency, and cost in today's globalized world market, advanced process control should not only realize the accuracy of each control loops, but also has the ability to achieve an optimization control of production indices that are closely related to the improved product quality, enhanced production efficiency and reduced consumption. As a result, the optimal control of complex industrial process has attracted an increased attention of various process industries. This talk firstly introduces the research stare-of-art and existing problems for optimal operation of industrial processes, and then presents the meanings for optimal operation control. In view of the characteristics of complex industrial processes, a hybrid intelligent control method for optimal operation is proposed, which is composed of a control loop pre-setting model, a feed-forward and feedback compensators, a production index prediction model, and a fault working-condition diagnosis unit plus a fault-tolerant control model. When production condition and working condition changes, this method can adjust the set points of control loops adaptively so that production index can be controlled in its target range. An application case study of this method in the roasting process of a shaft furnace for the ore concentration industry is also presented. Shaft furnace is a facility which is used widely in the ore concentration industry to turn the weak-magnetic low-grade hematite ore into strong-magnetic one. The target of optimal operation control for the roasting process of shaft furnace is to control the production indices, namely the magnetic tube recovery ratio (MTRR) that represents the quality, the efficiency, and the consumption of the product processing, close to its target value within limited ranges, and to make it as high as possible. The proposed optimal operation control method in this paper has been applied to the roasting process undertaken by 22 shaft furnace in Jiugang Ore Concentration plant of China. It has been shown that the MTRR is controlled to the rational range around the target value, with a result of 2% increase; the equipment's operation ratio is enhanced by 2.98%, resulting in a raise of 0.57% in concentrated grade and 2% in metal recovery rate. Such an industrial application has successfully demonstrated the performance of the proposed optimal control method which will therefore has a high potential for further and much wider applications.

WeKK1 NEW CENTURY HALL

Keynote 7 & 9: Yongzai Lu & J. Richalet (Regular Session)

Chair: Su, Hongye — Inst. of Cyber-Systems and Control, ZhejiangUniversity.

09:05-09:35 WeKK1.1

The Perspective of Industrial Control Driven by Global Economy and Information Technologies, pp. 300-305

lu, yongzai — Zhejiang Univ.

This paper starts with the investigation of challenging problems driven by global economy and the cutting-edge information technology for the integrated modeling and optimization control and decisions in a large scale manufacturing enterprise.

09:35-10:05 WeKK1.2

Elementary Predictive Functional Control: A Tutorial, pp. 306-313

Richalet, J. — Cork Inst. of Tech.

WeKK2 Wanxia Pavilion

Keynote 8 & 10: Akira Ohata & Hwei-Nan Yih (Regular Session)

Chair: Samavedham, Lakshminarayanan — National Univ. of Singapore

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

09:05-09:35 WeKK2.1

Importance of Close Linkages among Modeling, Control Design, Calibration and Verification for Automotive Controls, pp. 314-319

Ohata, Akira — Toyota Motor Corp.

The automotive industry has encountered the complexity issue of control system development due to the pressures from the social demands of fuel economy, clean exhaust gas and safety. MBD (Model-Based Development) has been regarded as the direction to mitigate the issue. The close linkages among modeling, control design, calibration and verification are highly important to make MBD process efficient because a missing linkage interrupts control system developments and drastically decreases the productivity of development.

09:35-10:05 WeKK2.2

The Evolution of Plant Process Control in Taiwan, pp. 320-324

Yih, Hwei-Nan — Advanced Control & Systems Inc.

This paper delineates the major milestones for process control development in Taiwan which includes the first DCS project, the first APC project; the first PC based training simulator, etc. To bridge the gap between academia and practitioner on process control, many efforts had been exerted through the forums, conferences during that period of time. In 1990, the environment and safety issues became the focal points of plant operation, APC and optimization were regarded as “nice to have” instead of “must have”. Things were changed when FPCC entered into the refinery market. The APC was proposed again to increase the competitiveness. Recently, the energy saving, performance improvement, safety upgrade become the new focal points for owner operator in Taiwan. The simulation, control and IT technologies will be the key components to achieve the new request. Reviewing the evolution of process control in Taiwan will provide the lesson learnt and the future prospect on plant process control.

WeA1 NEW CENTURY HALL

Novel Developments in Modeling and Control (invited Session in Honor of Prof. Sirish L. Shah) (Invited Session)

Chair: Samavedham, Lakshminarayanan — National Univ. of Singapore

Co-Chair: Kwok, Ezra — Univ. of British Columbia

Organizer: Gopaluni, Bhushan — Univ. of British Columbia

10:20-10:40 WeA1.1

State and Parameter Estimation Via Minimum Distortion Filtering with Application to Chemical Process Control (I), pp. 325-330

Goodwin, Graham C. — Univ. of Newcastle

Cea Garrido, Mauricio Esteban — Univ. of Newcastle

State and parameter estimation are cornerstone problems in Chemical Process Control. When the prolem is linear and gaussian, the celebrated Kalman Filter provides a simple and elegant solution to the recursive filtering problem. However, many practical systems (including most Chemical Processes) are nonlinear. In this case, the Kalman Filter cannot be directly applied and other methods are necessary. In this paper, we describe a new approach to Nonlinear Filtering known as Minimum Distortion Filtering (MDF). We show that this method is computationally tractable for typical Chemical Process Control problems including estimation of unmeasured states and unknown parameters such as activation energy or frequency factor constants. We illustrate by a simulation study of a Continuous Stirred-Tank Reactor (CSTR).

10:40-11:00 WeA1.2

Design of Performance-Adaptive PID Controllers (I), pp. 331-336

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

In the challenge to manufacture high quality products for less, it is necessary to regularly monitor performance of control loops that regulate the quality variables of interest. This paper describes performance-adaptive PID control schemes which is based on a unified approach to the design of a control performance and PID controller. According to the proposed approach, the control performance is first monitored regularly. Then, if the performance exceeds a user-defined threshold, the system identification is initiated and PID parameters are subsequently updated for the new model. In this paper, two performance-adaptive PID controller design schemes are introduced. One is that the control performance is evaluated based on the minimum variance index of the control error, and PID parameters are retuned based on the relationship of the generalized predictive control. Another is that the modeling performance is first evaluated, and PID parameters are subsequently calculated based on the LQG trade-off curve obtained for the re-identified process model. The behavior of the performance-adaptive PID control schemes is numerically and experimentally evaluated.

11:00-11:20 WeA1.3

Anti-Windup Adaptive PID Controller Design for Systems with Input Saturation (I), pp. 337-342

Mizumoto, Ikuro — Kumamoto Univ.
Iwai, Zenta — Kumamoto Coll. of Tech.
Fujimoto, Yotaro — Kumamoto Univ.

This paper deals with a design problem of an antiwindup adaptive PID control system for SISO systems. The proposed method utilizes the characteristics of almost strict positive realness (ASPR) of the controlled system. the windup phenomenon will be improved by reducing the magnitude of adaptive gains in integral and derivative action, when the controlled input is saturated. The effectiveness of the proposed method is examined through numerical simulations.

11:20-11:40 WeA1.4

Development of Grey-Box Unscented Kalman Filter for Systems Subjected to Correlated Unmeasured Disturbances (I), pp. 343-348

Bavdekar, Vinay — Indian Inst. of Tech. Bombay, Mumbai
Patwardhan, Sachin — Indian Inst. of Tech. Bombay

The performance of Bayesian state estimators is dependent on accurate characterisation of the uncertainties in the unmeasured disturbances and in the measurements. The structure of the unmeasured disturbance dynamics is seldom known. Moreover, the disturbances could be correlated in time. In this work a constrained optimisation problem based on the MLE framework is presented to identify the dynamics of the process noise and the covariances of both, the measurement noise and the process noise. The unmeasured process disturbances are modelled as entering the process through known inputs. The efficacy of this approach is tested on a continuous fermenter, which is a benchmark simulation case study. The results on the simulation case study reveal that the proposed approach generates reasonably accurate estimates of the noise dynamics and the covariances.

11:40-12:00 WeA1.5

A Feedback Glucose Control Strategy for Type II Diabetes Mellitus (I), pp. 349-352

Sun, Lin — Univ. of British Columbia
Kwok, Ezra K. — Univ. of British Columbia
Gopaluni, Bhushan — Univ. of British Columbia
Vahidi, Omid — Univ. of british columbia

Type II diabetes mellitus is characterized by both insulin resistance and b -cell failure. Although patients with type II diabetes mellitus are not initially dependent on insulin, the introduction of insulin therapy becomes one of the most effective methods of attaining good glycemic control. In this work, a proportional-integral-derivative (PID) controller is implemented to maintain normoglycemia in a simulated Type II diabetic patient using a closed-loop insulin infusion pump. The simulation employs a compartment model, which represents the glucose regulatory system and includes submodels representing the absorption of subcutaneously administered short-acting insulin and gut absorption. The feedback control system returns blood glucose to normoglycemic ranges after a meal disturbance. The settling time is similar to that of a non-diabetic. These results demonstrate the potential use of control algorithms for regulation of blood glucose by insulin for Type II diabetic patients.

WeA2 Wanxia Pavilion

Identification and Estimation (Regular Session)

Chair: Wang, Jiandong — Peking Univ.
Co-Chair: Patwardhan, Sachin — Indian Inst. of Tech. Bombay

10:20-10:40 WeA2.1

On Observer Design for Nonlinear Takagi-Sugeno Systems with Unmeasurable Premise Variable, pp. 353-358

ICHALAL, DALIL — Centre de Recherche en Automatique de nancy (CRAN), CNRS, UMR703
Marx, Benoit — Centre de Recherche en Automatique de Nancy
Ragot, Jose — CRAN-INPL
Maquin, Didier — Inst. National Pol. de Lorraine

In this paper, we propose a method for state estimation of nonlinear systems represented by Takagi-Sugeno (T-S) models with unmeasurable premise variables. The main result is established using the differential mean value theorem which provides a T-S representation of the differential equation generating the state estimation error. This allows to extend some results obtained in the case of measurable premise variables to the unmeasurable one. Using the Lyapunov theory, stability conditions are obtained and expressed in term of linear matrix inequalities. Furthermore, an extension for observer design with disturbance attenuation performance is proposed. Finally, this approach is illustrated on a DC series motor and compared to the existing approaches.

10:40-11:00 WeA2.2

Power System Dynamic State Estimation with Random Communication Packets Loss, pp. 359-362

Tai, Xin — The Univ. of Newcastle
Marelli, Damián — Univ. of Newcastle
Fu, Minyue — Univ. of Newcastle

In this paper power system dynamic state estimation problem is studied considering random communication packet losses. There are two sorts of stochastic processes, i.i.d. process and Markov process, are respectively utilized to model two different communication packet losses cases. The first case only considers packet losses rate, and the second case includes both of packet losses rate and recovery rate. The degradation of the performance of state estimation caused by communication packet losses is analyzed on IEEE 14 buses test system, and numerical results are given.

11:00-11:20 WeA2.3

Identification of Continuous-Time Systems in Closed-Loop Operation Subject to Simple Reference Changes, pp. 363-368

Cheng, Chao — Peking Univ.
Wang, Jiandong — Peking Univ.

This paper proposes a novel identification method for identification of continuous-time linear time-invariant systems working in closed-loop operation. The main idea is to introduce Laguerre functions into the refined instrumental variable method for continuous-time systems. The identification is based on normal operational data associated with step, ramp, staircase or other types of simple reference changes. The proposed method could handle nonzero initial conditions and is applicable directly to raw data. Its effectiveness is demonstrated through simulation and experimental examples.

11:20-11:40 WeA2.4

Robust Initial Alignment for Inertial Navigation Systems with Multiple Types of Disturbances, pp. 369-373

Guo, Lei — Beihang Univ.
Cao, Songyin — Southeast Univ.

In this paper, we consider the initial alignment problem for inertial navigation system (INS) with nonlinear uncertainties. A new robust anti-disturbance filtering method is presented for the concerned initial alignment problem. Different from most previous works only focusing on Gaussian noises, the nonlinear uncertain INS error model with multiple types of disturbances is established, which include the modeled drift noises, Gaussian noises and bounded perturbations. A robust multi-objective filter is constructed for the concerned INS with disturbance rejection and attenuation performance. In the proposed approach, the drift estimations are applied to reject the inertial sensor drifts, H-infinity performance is applied to attenuate norm bounded uncertain disturbances and generalized H2 index is adopted to optimize the estimation error respectively. Finally, simulation for stationary base alignment of an INS is given to show the efficiency of the proposed approach.

11:40-12:00 WeA2.5

Stochastic Gradient Parameter Estimation of Input Nonlinear Systems Using the Filtering Technique, pp. 374-378

Wang, Dongqing — Qingdao Univ.
Ding, Feng — Jiangnan Univ.
Sun, Shouqing — Qingdao Hismile Coll.

For input nonlinear output error moving average systems with a two-segment piecewise nonlinearity, a data filtering based stochastic gradient algorithm is developed to estimate the parameters of this nonlinear system based on the data filtering. The basic idea is to combine the key-term separation principle and the data filtering technique, and to decompose the identification model into two models. The simulation results indicate that the proposed algorithm can give more accurate parameter estimates than existing extended stochastic gradient algorithm.

WeA3 QUNYAN ROOM

Process Control Applications II (Regular Session)

Chair: Kano, Manabu — Kyoto Univ.
Co-Chair: Liu, Fei — Jiangnan Univ.

10:20-10:40 WeA3.1

Extended Fictitious Reference Iterative Tuning and Its Application to Chemical Processes, pp. 379-384

Kano, Manabu — Kyoto Univ.
Tasaka, Kenichi — Kyoto Univ.
Ogawa, Morimasa — Yamatake Corp.
Takinami, Akitoshi — Showa Denko K.K.
Takahashi, Shinichi — Showa Denko K.K.
Yoshii, Seiji — Idemitsu Kosan Co., Ltd.

A new, practical method for direct tuning of PID controllers using operation data under feedback control is proposed. Neither open-loop nor closed-loop identification is required in the framework of direct tuning, but conventional methods have the following problems: iterative experiments are needed, changes of the manipulated variable are not evaluated, and it is difficult to properly determine a reference model without information on a process. In the present work, to solve these problems and make direct tuning practicable for process control, extended fictitious reference iterative tuning (E-FRIT) is proposed. The major advantage of E-FRIT over other direct PID tuning methods is its practicability, which is realized by focusing on real application of E-FRIT to chemical processes. In the proposed algorithm, only the desired closed-loop settling time needs to be determined by users. The great usefulness of E-FRIT is demonstrated through its industrial applications. The MATLAB program of E-FRIT with the latest algorithm is open to the public through its official website; it has been widely used in the process industry in Japan.

10:40-11:00 WeA3.2

Iterative Learning Belief Rule-Base Inference Methodology Using Evidential Reasoning for Delayed Coking Unit, pp. 96-101

Yu, Xiaodong — Tsinghua Univ.
Huang, Dexian — Tsinghua Univ.
Jiang, Yongheng — Dept. of Automation, Tsinghua Univ.
Jin, Yihui — Tsinghua Univ.

The belief rule-base inference methodology using evidential reasoning (RIMER) approach has been proved to be an effective extension of traditional rule-based expert systems and a powerful tool for representing more complicated causal relationships using different types of information with uncertainties. With a predetermined structure of the initial belief rule-base (BRB), the RIMER approach requires the assignment of some system parameters including rule weights, attribute weights, and belief degrees using experts' knowledge. Although some updating algorithms were proposed to solve this problem, it is still difficult to find an optimal compact BRB. In this paper, a novel updating algorithm is proposed based on iterative learning strategy for delayed coking unit (DCU), which contains both continuous and discrete characteristics. Daily DCU operations under different conditions are modeled by a BRB, which is then updated using iterative learning methodology, based on a novel statistical utility for every belief rule. Compared with the other learning algorithms, our methodology can lead to a more optimal compact final BRB. With the help of this expert system, a feed-forward compensation strategy is introduced to eliminate the disturbance caused by the drum-switching

operations. The advantages of this approach are demonstrated through the developed DCU operation expert system modeled and optimized on the field data from a real oil refinery.

11:00-11:20 WeA3.3

On-Line Estimation of Glucose and Biomass Concentration in Penicillin Fermentation Batch Process Using Particle Filter with Constraint, pp. 391-396

Zhao, Zhonggai — Insititute of Automation, jiangnan Univ.
Shao, Xinguang — Univ. of Alberta
Huang, Biao — Univ. of Alberta
Liu, Fei — Jiangnan Univ.

In a penicillin fermentation process, substrate concentration and biomass concentration greatly influence the yield of the targeted product. However, there are few on-line sensors available to measure these variables in real-time. In this paper, a compact mechanism model is employed to simulate the fed-batch process, and a particle filter is introduced to estimate the substrate and biomass states. Particle filters are favorable to handle the state estimation problems with non-linearity, time-varying dynamics, and non-Gaussian distributions. In order to improve the quality of particles, optimization strategies are applied to deal with constraint issues. Furthermore, infrequent lab analyzed state information is incorporated into the estimation procedure and used to correct PF estimate. Simulation results show that the constrained PF approach has better estimation performance than extended Kalman filter in state estimation of this penicillin fermentation batch process.

11:20-11:40 WeA3.4

IMC Based Set-Point Weighted PID Tuning for First Order Delay Unstable Process (FODUP), pp. 397-402

Jeng, Jyh-Cheng — National Taipei Univ. of Tech.
Nasution, Anggi — National Taiwan Univ.
Huang, Hsiao-Ping — National Taiwan Univ.

Present work provides a discussion for synthesizing PID from IMC controller for first order delay unstable process. Recently, Lee, et al. [1] has shown the effectiveness of using MacLaurin series for synthesizing PID controller tuning relation from IMC framework. In this paper, the desired closed loop response based on optimal performance for unit set point input and input disturbance are provided. We also develop the IMC-set point weighting tuning formulation.

11:40-12:00 WeA3.5

Optimal Tuning Rules of the Fractional-Order PID Controllers with Application to First-Order Plus Time Delay Processes, pp. 403-408

Merrikh-Bayat, Farshad — Zanjan Univ.

The aim of this paper is to propose two sets of formulas for optimal tuning the $PI^lambda D^mu$ controllers such that either the ISE or the ISTE performance index (corresponding to the tracking error of the unit step command) is minimized. The proposed formulas are parametric, simple, effective and easy-to-use, and moreover, they can be applied to all processes that can be modelled with a first-order plus time delay transfer function. The tuning rules are obtained by using the so-called dimensional analysis which avoids the complicated numerical optimizations. Two numerical examples are presented which confirm the effectiveness of the proposed tuning formulas.

WeA4 JUYAN ROOM

Advanced Control (Regular Session)

Chair: Feng, Enbo — Canadian Natural Res.
Co-Chair: Xia, Yuanqing — Beijing Inst. of Tech.

10:20-10:40 WeA4.1

Predictive Control Strategy for Burn-Through Point in the Sintering Process, pp. 409-414

Wu, Min — Central South Univ.
Wang, Chun-Sheng — Central South Univ.
Zeng, Yu — the main campus of Central South Univ.
Cao, Weihua — Centrol South Univ.
Lai, Xuzhi — Central South Univ.

This paper presents a predictive control strategy named as generalized predictive control with closed-loop model identification for burn-through point (BTP) in sintering process. The closed-loop model identification method describes the dynamic characteristics of sintering process. Based on the model, the BTP generalized predictive control model predicts BTP accurately and computes the strand velocity. A BTP control system is established and mplemented in an iron and steel plant. The running results show that the system effectively guarantees the stability of sintering process, sufficiently suppresses the fluctuation of BTP, and greatly increases the quantity and quality of sinters.

10:40-11:00 WeA4.2

Control of a Nuclear Steam Generator Using Feedback-Feedforward LQG Controller, pp. 415-420

Nishant, Parikh — Pandit Deendayal Petroleum Univ. Raisan, Gandhinager, Indi
Patwardhan, Sachin — Indian Inst. of Tech. Bombay
Bandyopadhyay, Santanu — Indian Inst. of Tech. Bombay
Gudi, Ravindra D. — Indian Inst. of Tech. Bombay

Steam Generator (SG) is a major component in a nuclear power plant. Poor control of a nuclear steam generator can lead to frequent reactor shutdowns or it can damage turbine blades. To avoid such costly reactor shutdowns, there is a need to systematically investigate the problem of controlling the water level in the steam generator. In this work, we have proposed a novel concept of feedback-feedforward Linear Quadratic Gaussian (LQG) control scheme to achieve efcient servo and regulatory control of SG. The benchmark nonlinear dynamic model proposed by Astrom [5] has been simulated using MATLAB to carry out simulation studies. The major disturbance in a steam generator is steam demand and the proposed controller is capable of initiating a feedforward action in response to steam demand changes. This approach employs a Kalman lter for state estimation and uses estimation error feedback to achieve offset free closed-loop behavior. The closedloop responses can be shaped using additional lters introduced to mitigate sudden changes in the setpoint and unmeasured disturbances. Finally, simulation results shows the effectiveness and the improved performance of the proposed method

11:00-11:20 WeA4.3

Control of Tubular Reactor Using Finite-Based I/O Linearization Technique, pp. 421-426

Limpananchaipornkul, Patara — Kasetsart Univ.
Panjapornpon, Chanin — Department of Chemical Engineering, Faculty of Engineering, Kase

This paper proposes a new control technique for a tubular reactor modeled by first-order hyperbolic partial differential equations (PDEs). The concept of Input-Output (I/O) linearization technique is extended to apply to hyperbolic PDEs. The finite difference method is applied in the synthesis of the feedback controller, and the online computational

fluid dynamics (CFD) model is used to predict the state dynamics. The controller is designed to enforce the outputs to follow their corresponding reference trajectories. The performances of the proposed method are simulated with the application of a non-isothermal tubular reactor under the servo and regulatory tests. The results show that the control method successfully forces the output to the desired setpoint.

11:20-11:40 WeA4.4

A New Model Predictive Controller with Swarm Intelligence Implemented on FPGA, pp. 427-432

Luo, Ben — Zhejiang Univ.
Shao, Zhijiang — Zhejiang Univ.
Xu, Zuhua — Zhejiang Univ.
Zhao, Jun — Zhejiang Univ.
Zhou, Lifang — Zhejiang Univ.

Model predictive control (MPC) is an established control strategy used in the process industry. As this technology is increasingly used, its computational efficiency becomes the main hindrance to its application in a wider range of process industries and broader range of higher bandwidth applications, such as in motion control problems. Unlike controllers for process industries, the motion controller must have specific properties, including limited size and high sampling frequency. To meet these requirements, we explore the implementation of a specified new MPC with swarm intelligence, called PSO-MPC, on a field programmable gate array (FPGA) chip. The FPGA chip addresses size constraints, and the PSO-MPC-on-chip strategy satisfies the need for high sampling frequency by exploiting the parallel features of both the PSO-MPC and the FPGA chip.

11:40-12:00 WeA4.5

Quantization Over Network Based on Kalman Filter, pp. 433-438

Liu, Bo — Beijing Inst. of Tech.
Xia, Yuanqing — Beijing Inst. of Tech.
Shang, Jizong — Beijing Inst. of Tech.
Fu, Mengyin — Beijing Inst. of Tech.

This paper is concerned with the quantization strategy and stability analysis of networked control systems with quantized output feedback. Based on Kalman filter, estimated states are obtained through noisy measurement, a simple quantization strategy is proposed to quantize the estimated states. Sufficient condition is given for closed-loop system to be stable. Numerical simulation is given to show the effectiveness of the quantization scheme.

WeFF — NEW CENTURY HALL

Panel Discussion Session: Frontiers in Advanced Control of Industrial Processes (Invited Session)

Chair: Lee, Jay H — KAIST
Organizer: Lee, Jong Min — Seoul National Univ.

14:00-16:00 WeFF.1

Optimal Model-Based Reservoir Management with Model Parameter Uncertainty Updates (I), pp. 439-444

Chen, Yingying — Texas Tech. Univ.
Hoo, Karlene — Texas Tech. Univ.

The objective of this work is to manage water flooding of a reservoir to achieve optimal oil production by employing an optimal model-based control framework that uses uncertain parameter updating and a particular reduced-order model. A Markov chain Monte Carlo method is used to update the proposed distributions of the uncertain parameters. To avoid excessive simulations of the complex reservoir model, the techniques of partial least square regression and the Karhunen-Loeve expansion are used to find the relationships between the uncertain parameters and the system state. To demonstrate this approach, the optimal control of an oil producing reservoir is compared against an uncontrolled reservoir.

14:00-16:00 WeFF.2

Extended Abstract: Managing & Leveraging a Large Control System (I), pp. 445-446

Espejo, Aris — Syncrude Canada Ltd

The control system of any industrial process is key and central to the success of achieving the safe, reliable, predictable and profitable operation of industrial production processes. This presentation examines the attributes of successfully managing and leveraging a large installed base control system in a multi-operational deployment. The challenges currently faced and the methodologies employed to address the issues will be presented.

14:00-16:00 WeFF.3

A New Adaptive MPC System (I), pp. 447-449

Zhu, Yucai — Eindhoven Univ. Tech.

We will introduce a new adaptive MPC control system that, for a given MPC design, can perform controller commissioning and maintenance automatically. Also a method of improving MPC control performance and robustness is proposed and tested.

14:00-16:00 WeFF.4

Nonlinear Bayesian State Estimation: Review and Recent Trends (I), pp. 450-455

Prakash, J — Madras Inst. of Tech.
Gopaluni, Bhushan — Univ. of British Columbia
Patwardhan, Sachin — Indian Inst. of Tech. Bombay
Narasimhan, Shankar — Inst. of Tech. Madras
Shah, Sirish L. — Univ. of Alberta

Process monitoring and control requires estimation of quality variables, which are often not measurable directly. A cost effective approach to monitor these variables in real time is to employ model based soft sensing and state estimation techniques. Dynamic model based state estimation is a rich and highly active area of research and many novel approaches have emerged over last few years. In this paper, we review recent developments in the area of recursive nonlinear Bayesian state and parameter estimation techniques.

WePoPo — NEW CENTURY HALL

Poster Session (Interactive Session)

Chair: Shao, Zhijiang — Zhejiang Univ.
Co-Chair: LI, Bo — Syncrude Canada Ltd

16:00-17:30 WePoPo.1

Research on Industrial Modeling of Ethylene Oxide Hydration Reactor, pp. 456-460

Sun, Fan — East China Univ. of Science and Tech.
Luo, Na — East China Univ. of Science and Tech.
Qian, Feng — East China Univ. of Sci. and Tech.
Qi, Rongbin — East China Univ. of Science and Tech.

Focusing on ethylene oxide (EO) hydration reactor industrial

equipment, the reaction mechanism model is established. Based on the principle of material balance, energy balance and kinetics of the reactions of ethylene oxide with water, partial least squares regression (PLSR) was used in the model to establish a corresponding relationship between the reaction rate constant and the reaction temperature. With kinetic parameters correction by using field data, the results are more tallies with the actual operation. Influences of water/EO molar ratio and inlet temperature on product quality, outlet temperature and energy consumption are analyzed according to the established model. The results showed that the model can preferably reflect the performance of EO hydration reactor and have certain guidance functions to the further advanced control strategies.

16:00-17:30 WePoPo.2

Prediction Intervals of an Alternative Formulation of Partial Least Squares Algorithm, pp. 461-465

Lin, Weilu — East China Univ. of Science and Tech.

Martin, Elaine — Newcastle Univ.

The prediction interval is an important property when applies the partial least squares (PLS) to virtual sensor applications. In this work, we propose a new formulation of PLS, such that after projecting out score vectors, the estimated coefficient matrix is obtained as the product of pseudo inverse of the predictor matrix and corresponding weighting matrices. The new formulation, which facilitates the calculation of Jacobian matrix and can be extended to multivariate PLS, is proved to be equivalent to the nonlinear iterative partial least squares (NIPALS). The prediction interval of the algorithm is developed based on the Jacobian of singular vectors. Industrial case studies demonstrate the utility of the algorithm for univariate PLS.

16:00-17:30 WePoPo.3

Neural Based PID Control for Networked Processes, pp. 466-471

Chen, Junghui — Chung-Yuan Christian Univ.

A neural based PID feedback control method for networked process control systems is presented. As there are some uncertain factors such as external disturbance, randomly delayed measurements or control demands in real networked process control systems, the proposed PID controller is implemented by backpropagation neural networks whose weights are updated via minimizing tracking error entropy of closed loop systems. To demonstrate the potential applications of the proposed strategy, an example of a simulated batch reactor is provided. The proposed design method is shown to be useful and effective in dealing with network process control systems.

16:00-17:30 WePoPo.4

Concurrent Optimization for Parameters of Hybrid Electric Vehicle Based on Non-Dominated Sorting Genetic Algorithms, pp. 472-476

Fang, Licun — Shenzhen Univ.

Xu, Gang — Shenzhen Univ.

Li, Tianli — Shenzhen Univ.

DAWUDA, KIYAARI — F.F DOWN TOWN

The optimizing design of hybrid electric vehicle (HEV) aims at improving fuel economy and decreasing emissions subject to the satisfaction of its drivability. The concurrent optimization for main parameters of powertrain components and control system is the key to implement this objective. However, this problem is challenging due to the large amount of coupling design parameters, conflicting design objectives and nonlinear constraints. A comprehensive methodology based on the Non-dominated Sorting Genetic Algorithms (NSGA) is presented in this paper to achieve parameters optimization for powertrain and control system simultaneously and find the Pareto-optimal solutions set successfully. This optimal solutions set provides a wide range of choices for the design, which can improve the fuel economy and reduce emissions without sacrificing vehicle performance. A case simulation is carried out and simulated by ADVISOR, the results demonstrate the effectiveness of the algorithms proposed in this paper.

16:00-17:30 WePoPo.5

Data Filtering and Auxiliary Model Based Recursive Least Squares Estimation Algorithm for OEMA Systems, pp. 477-481

Wang, Dongqing — Qingdao Univ.

Sun, Shouqing — Qingdao Hismile Coll.

Ding, Feng — Jiangnan Univ.

Song, Guiling — Lanyan Group Ltd.

Based on the filtering theory and the auxiliary model identification idea, we present a filtering and auxiliary model based recursive least squares identification algorithm for an output-error moving average system. The proposed algorithm has a higher computational efficiency compared with the auxiliary model based recursive extended least squares algorithm.

16:00-17:30 WePoPo.6

Treatment Methods of Abnormality in FIR Model Identification, pp. 482-485

Hong, Yan-ping — Zhejiang Univ. of Tech.

He, Xiong-xiong — Zhejiang Univ. of Tech.

Zou, Tao — Zhejiang Univ. of Tech.

Zhao, Dongya — China Univ. of Petroleum

This article mainly focuses on two treatment methods in FIR model identification for the abnormality in measured data set. One is called linear interpolation method(LIM), whose essence is to rebuild the data set according to linear interpolation after detecting the abnormal data. The other is the method of identification based on segments of data(ISDM). The idea is to remove the abnormal data and divide the original data set into two or more inconsecutive data sets, then perform model identification using those data sets respectively, finally merge the results with different weighted means. The guidelines of the proposed methods are enumerated. The two methods are illustrated with FIR model identification, and simulations with the Shell heavy oil fractionator model verify the feasibility and effectiveness.

16:00-17:30 WePoPo.7

Multiobjective Fault Detection Observer Design for a Class of T-S Fuzzy NonLinear Systems, pp. 486-491

Zhang, Dengfeng — Nanjing Univ. of Science and Tech.

Han, Xiaodong — China Acad. of Space Tech.

Wang, Hong — Univ. of Manchester

Wang, Zhiquan — Nanjing Univ. of Science & Tech.

This article presents the design of fault detection fuzzy observer with multiple performance constraints for a class of nonlinear system with Takagi-Sugeno fuzzy form. The multiobjective optimization and consistency analysis are applied to meeting the desirable transient behavior, steady output variance and H_ index performance requirements. Thus, the rapidity of response to fault detection, robustness to noisy disturbances and sensitivity to faults are guaranteed simultaneously. One advantage of our design is that the determination of detection threshold makes full use of the information in the stage of observer design. Meanwhile, the multiple fuzzy Lyapunov function and the slack of variables are used for decreasing the conservatism of conventional single Lyapunove function method. Simulation results indicated the effectiveness of the proposed method.

16:00-17:30 WePoPo.8

Mnemonic Enhancement Real-Time Optimization with Modified

Barycentric Interpolation for Process Systems, pp. 492-497

Fang, Xueyi	State Key Lab. of Industrial Control Tech. Zhejiang
Shao, Zhijiang	Zhejiang Univ.
wang, zhiqiang	State Key Lab. of Industrial Control Tech. Zhejiang

A high-efficient real-time optimization method for process systems - the mnemonic enhancement optimization (MEO) with incremental Delaunay triangulation and modified barycentric interpolation is developed. It improves the performance of process real-time optimization (RTO) systems further, compared with the traditional method of RTO for starting point generation and the MEO method with zeroorder approximation. Based on the repetitive nature of RTO, MEO turns the problem sequence into a kind of parametric optimization problem solved repetitively when the parameters change and takes advantages of this feature to accelerate the solution process of optimization. In this work, it is proved that the approximation error of the MEO method converges to zero with probability 1 as the experience accumulates. And a modified barycentric interpolation scheme using more empirical information than that in the previous study to estimate the optimum is suggested. The multi-dimensional incremental Delaunay triangulation algorithm is hired to maintain the geometric structure of the empirical database and provide suitable nodes for MEO approximation. A numerical case study on a depropanizer and debutanizer distillation sequence validates the proposed method and shows the reductions of 65% and 26% in the solution time of optimization, compared with the traditional method in RTO and the MEO method in our previous study, respectively.

16:00-17:30 WePoPo.9

Study on Control Strategy and Simulation for ISG_Type Parallel Hybrid Electric Vehicle, pp. 498-502

Zhang, Baishun	ShenzhenUniversity
Xu, Gang	Shenzhen Univ.
Fang, Licun	Shenzhen Univ.

A reasonable control strategy for Parallel Hybrid Electric Vehicle can achieve optimal energy distribution so as to obtain good fuel economy and lower emissions. The article uses CRUISE to establish a powertrain model for ISG_Type Parallel Hybrird Electric Vehicle, adopting MATLAB / stateflow to develop powertrain control strategy, then conduct joint simulation. In this paper, logic threshold control strategy based on engine optimization is proposed. According to different PHEV(Parallel Hybrid Electric Vehicle) operating modes, adopting reasonable torque distribution algorithm to make engine work along optimal operation line. By using simulation platform CRUISE, simulation for the control strategy based on NEDC driving cycles is conducted. The results indicate that hybrid electric vehicle has better fuel economy and emissions than traditional vehicle.

16:00-17:30 WePoPo.10

An Effective Dynamic Optimization Method Based on Modified Orthogonal Collocation and Reduced SQP, pp. 503-507

LIU, Xinggao	Zhejiang Univ.
Chen, Long	Zhejiang Univ.

An effective dynamic optimization solution method based on the modified orthogonal collocation (mOC) and reduced successive quadratic programming (rSQP) is proposed, where the mOC is proposed to decrease the approximation error of the discrete optimal problem while traditional OC method converts the dynamic optimization problem to a regular but discrete nonlinear programming (NLP) problem, and the rSQP method is introduced to solve the resulting NLP problem in the reduced space of the independent variables. A classic benchmark of dynamic optimization problem is explored as demonstration, where the detailed comparative researches between the literature reports and the proposed method are carried out. The research results illustrate the efficiency of the proposed method.

16:00-17:30 WePoPo.11

Research on Multivariable Control Performance Assessment Techniques, pp. 508-511

Huang, Qizhen	Zhejiang Univ.
Zhang, Quanling	Zhejiang Univ.

To avoid the problem of estimating a general interactor, an improved computational method for user-specified benchmark is presented in this paper. The improved user-specified benchmark together with the historical benchmark are then specified as two parallel benchmarks to form an integrated performance assessment strategy, which can detect any change in the performance of a control system and identify the potential improvement that can be made to the performance of the control system. Simulated examples are provided to illustrate the validity of the proposed methods.

16:00-17:30 WePoPo.12

Design and Placement of Light Monitoring System in Museums Based on Wireless Sensor Networks, pp. 512-517

Zhang, YuWei	the State Key Lab. of Industrial Control Tech. Zheji
Ye, Wei	the State Key Lab. of Industrial Control Tech. Zheji

We present the design and placement of system for light monitoring in museums based on wireless sensor networks (WSN). A two-tiered sensor network architecture is formed according to the real light environmental requirements. The proposed system satisfy the requirement from nodes with different function by providing respective hardware structures including sensor nodes (SNs), aggregation nodes (ANs) and the base station (BS). It also supports the given sensor placement algorithm for the determination of nodes locations to prolong network lifetime as while improve system connectivity on account of the data acquisition fidelity. We further describe the system architecture, hardware composition, system modeling, as well as the placement algorithm. With the obtained experimental results, the performance of sensor nodes is evaluated by investigating the major characteristics, and the performance of placement algorithm is verified.

16:00-17:30 WePoPo.13

Two Degree-Of-Freedom of Generalized Predictive Control for MIMO Systems Based on State Space Approach, pp. 518-523

Yanou, Akira	Okayama Univ.
Masuda, Shiro	Tokyo Metropolitan Univ.
Deng, Mingcong	Tokyo Univ. of Agriculture and Tech.
Minami, Mamoru	Univ. of Fukui

Generalized Predictive Control(GPC) can achieve a robust tracking to step-type reference signal because of integral compensation in it. But if there is neither modeling error nor disturbance, it does not need the integral compensation for tracking to step-type reference signal. And the integral compensation may cause a slow transient response or generate an extra control input. Although the authors have proposed a design method of two degree-of-freedom GPC for SISO systems and m-input m-output systems, the design method has not been considered for MIMO systems, which has different number of inputs and outputs. Therefore, this paper explores a design method of two degree-of-freedom GPC for MIMO systems and its effectiveness is evaluated.

16:00-17:30 WePoPo.14

Feasibility and Soft Constraint of Steady State Target Calculation Layer in LP-MPC and QP-MPC Cascade Control Systems, pp. 524-529

Zou, Tao	Zhejiang Univ. of Tech.
Li, Haiqiang	Zhejiang Univ. of Tech.
Zhang, Xianxia	Shanghai Univ.
Gu, Yong	Zhejiang Univ.
Su, Hongye	Zhejiang Univ.

This paper mainly focus on the feasibility and soft constraint of steady state target calculation, which is one of inherent problem of predictive control. By using two-stage method, the state target calculation can be solved effectively. To guarantee the existence of feasibility domain, weighting and priority policies are presented to determine the feasibility and adjust soft constraints. Simulation results validate the effectiveness of the proposed approach

16:00-17:30 WePoPo.15

Estimation of Atmospheric 3rd Line Diesel Oil Solidifying Point Via Adaptive Kernel Based Relevance Vector Machine, pp. 530-534

Tao, Yong	Tsinghua Univ. P.R.China
Jiang, Yongheng	Dept. of Automation, Tsinghua Univ.
Huang, Dexian	Tsinghua Univ.

Atmospheric 3rd line diesel oil solidifying point is an important quality index, which cannot be measured in real time, in petroleum industry. Due to the great nonlinear characteristic of distillation columns, common statistic methods, such as PCR and PLS, based on linear projection, are not able to estimate such a quality index effectively. In this paper, Adaptive kernel based Relevance Vector Machine (aRVM) is introduced to build a nonlinear soft sensor model. This soft sensor is then applied to a real solidifying point estimation experiment, with comparison to other nonlinear models such as KPLS, SVM and typical RVM. The result reveals that aRVM shows better performance than KPLS, SVM and models a much sparser representation than SVM and typical RVM.

16:00-17:30 WePoPo.16

A Hybrid Tabu Search for Steelmaking-Continuous Casting Production Scheduling Problem, pp. 535-540

Zhao, Yue	Northeastern Univ.
Jia, Fengyong	Northeastern Univ.
Wang, Gongshu	Northeastern Univ.
Wang, Liangjun	Northeastern Univ.

In this paper, we study the steelmaking-continuous casting (SCC) production scheduling problem. Considering the constraints of the practical technological requirements and the objective of minimizing the total waiting time of jobs, we formulate a mathematical programming model. Due to the complexity of the model, we solve it by a decomposition strategy, i.e. jobs are allocated and sequenced on machines first, and the time table of all jobs is then established. We propose a tabu search algorithm to deal with the allocation and sequencing decisions and use a linear programming model to establish the time table of jobs. For tabu search algorithm, we design three different neighborhood structures, including the insertion neighborhood, the restricted neighborhood whose size is changeable, and a kick strategy based on swap move. We test the proposed algorithm on a set of real problems, and the computational results demonstrate the effectiveness of the proposed algorithm.

16:00-17:30 WePoPo.17

Scheduling of Multi-Pipeline Crude Oil Blending Based on Constrained Ordinal Optimization, pp. 541-546

Bai, Liang	Tsinghua Univ.
Jiang, Yongheng	Dept. of Automation, Tsinghua Univ.
Huang, Dexian	Tsinghua Univ.

Blending can help refineries, which have to deal with different types of crude oil, obtain a qualified feedstock. In this paper, a novel scheduling strategy of multi-pipeline crude oil blending based on constrained ordinal optimization (COO) is proposed. The objective is to keep the property of feedstock, mainly described by the true boiling point (TBP) data, consistent and suitable. Firstly, a MINLP scheduling model is established. Then, an efficient COO algorithm based on a two-level optimization structure is proposed. Finally, the whole scheduling strategy is validated by a real case study.

16:00-17:30 WePoPo.18

A Robust Parallel Adaptive Genetic Simulated Annealing Algorithm and Its Application in Process Synthesis, pp. 547-552

Xu, Qiaoling	FuZhou Univ.
zhao, chao	FuZhou Univ.
zhang, denfeng	School of Mechanical Engineering,Nanjing Univ. of Science a
an, aimin	School of Electrical Engineering and Information Engineering,

A robust hybrid genetic algorithm which can be used to solve process synthesis problems with Mixed Integer Nonlinear Programming (MINLP) models is developed. The proposed hybrid approach constructs an efficient genetic simulated annealing (GSA) algorithm for global search, while the iterative hill climbing (IHC) method as a local search technique is incorporated into GSA loop to speed up the convergence of the algorithm. In order to efficiently locate quality solution to complex optimization problem, a self-adaptive mechanism is developed to maintain a tradeoff between the global and local search. The computational results indicate that the global searching ability and the convergence speed of this hybrid algorithm are significantly improved. Further, the proposed algorithm is tailored to find optimum solution to HENS problem, The results show that the proposed approach could provide designers with a least-cost HEN with less computational cost comparing with other optimization methods.

16:00-17:30 WePoPo.19

Signal Reconstruction and Frequency Estimation of a Biased and Noisy Sinusoidal Signal, pp. 553-558

Ren, Zhengyun	Donghua Univ.
Zheng, Da	Univ. of Alberta

Based on the sampled data of a sinusoidal signal corrupted by unknown constant bias and noise with non-zero mean, a simple and novel approach is proposed to reconstruct the sinusoidal signal having same frequency as the original signal but free from unknown constant bias.Moreover, the noisy component of reconstructed signal have a zero mean no matter what the mean value of noisy component of original signal is. Then, an extended Kalman Filter is employed to estimate the frequency of the new sinusoidal signal. Simulation results show that the proposed method is suitable for fast and reliable frequency estimation of unknown noisy sinusoidal signal whose frequency changes abruptly.

16:00-17:30 WePoPo.20

PIλ Dμ Controller Design for Fractional Order Systems with Random Parameters, pp. 559-564

Pham, Duong	Yeungnam Univ.
Lee, Moonyong	Yeungnam Univ.

The mathematical representation of the plant dynamics can suffer from random uncertainties due to modeling errors, nonlinearities, manufacturing tolerances and operating conditions. Parametric robust stability and performance of a fractional order system can be inferred from the evolution of statistical characteristic of system states under the influences of random perturbations. The statistical analysis problem for a system with parametric uncertainties is to determine how specific random distribution in the plant parameters map to the range of responses. The Wienner-Askey polynomial chaos provides a framework for the statistical analysis of dynamical systems, with computational cost far superior to Monte Carlo simulations. Hence, in this work, we design robust PIλDμ controller for fractional order system with random parameter uncertainties by using Wienner-Askey polynomial chaos.

16:00-17:30 WePoPo.21

Design and Application of Digital Management System for the Sinter Raw Material Plant, pp. 565-570

Yan, Cai	Central South Univ.
Wang, Shaoli	Central South Univ.
Wu, Min	Central South Univ.
Wang, Chun-Sheng	Central South Univ.
Lai, Xuzhi	Central South Univ.

To solve the problems existed in iron and steel enterprise material plant, such as complex sources resulting in variety of materials, inaccurate inventory statistics leading to high cost, unpredictable external factors affecting material plant, etc., a digital management system is introduced in this paper. Firstly, the practical requirements and the process of material plant are analyzed. Based on the analysis, the new grid management and material balance methods are developed. Applying these methods, a new management system for material plant is designed, whose system configuration, hardware architecture, data flow, and functions of modules are introduced in details. Such system has been implemented in a large-scale iron and steel corporation sinter raw material plant. The operation results show that, this system has excellent capabilities and a promising application future in industries.

16:00-17:30 WePoPo.22

Model Predictive Control Performance Assessment Using a Prediction Error Benchmark, pp. 571-574

Zhang, Rongjin	Zhejiang Univ.
Zhang, Quanling	Zhejiang Univ.

Model predictive control technology can now be found widely in a variety of applications including petroleum, chemical and papermaking industries. An approach is proposed to decide a benchmark and monitor model predictive control performance on-line. A performance measure based on multi-step prediction error benchmark is shown to be more realistic without the requirement of process models or interactor matrix. A practical on-line monitoring strategy is presented which emphasizes the use of routine operating data plus the order of the interactor matrix to determine when it becomes worthwhile to re-identify the plant dynamics and re-install the model predictive control application.

16:00-17:30 WePoPo.23

Application of HSE Management Method in Implementation of APC for Petrochemical Plant, pp. 575-579

Wang, Changmin	Lanzhou Petrochemical Corp.
cao, wei	Lanzhou Petrochemical Corp.
li, haitao	Lanzhou Petrochemical Corp.

Refining units are easy to be flammable and explosive. There will be great security risk in applying advanced process control (APC) system online in refining units. The method of HSE management, which emphasizes hazard analysis and risk control, will greatly decrease the possibility of the risk of the APC project. Experiences in previous APC projects and HSE management method are summarized in this paper; system risk analysis method and node risk analysis method are also used. Particular risk analyses are carried out for each step of the implementation of the project. The behaviors of both the APC system control and the operation of the staff are standardized. Corresponding emergency plan for potential hazard incident is established and personnel trains are reinforced, which is very effective in accident prevention and emergency response. This method has made great profit in Lanzhou Petrochemical APC project of 400 thousands of tons per year aromatics extraction and as a result APC system is successfully startup safely only once.

16:00-17:30 WePoPo.24

Adaptive Compound Control for Test Turntable, pp. 580-584

Wang, Mao	Harbin Inst. of Tech.
wei, yanling	harbin Inst. of Tech.
shen, liqun	harbin Inst. of Tech.

In this paper, A model reference adaptive compound control algorithm is proposed for the test turntable system with unknown or slowly time-variant parameters. The combination of the general classical feedback correction and the adaptive feedforward compensation can ensure that the test turntable system always gets good performance of the output tracking the input and retains the capability of disturbances suppression. The model reference adaptive compound control law based on the Popov stability theory is designed rigorously in a systematic fashion. Numerical simulation results verify the adaptive compound control algorithm is designed to guarantee the system stability and the servo performance as well as the expansion of system bandwidth, and the tracking accuracy of test turntable system is improved.

16:00-17:30 WePoPo.25

Economic Performance Assessment of Process Control: A Probability Optimization Approach, pp. 585-590

zhao, chao	FuZhou Univ.
Xu, Qiaoling	FuZhou Univ.
zhang, denfeng	School of Mechanical Engineering,Nanjing Univ. of Science a
an, aimin	School of Electrical Engineering and Information Engineering,

In this paper, a probability optimization approach for economic performance assessment of the constrained process control under uncertainty is presented. Performance evaluation problems are formulated as the stochastic problems which incorporate the uncertainties in both process operation and economic objective. Such problem formulation helps to identify the opportunity of improving the profitability of the process by taking appropriate risks. Both the steady state economic benefit and the optimal operation conditions can be obtained by solving the defined economic optimization problems. Further, the proposed method uses the LQG benchmark other than conventional minimum variance control (MVC) benchmark to estimate potential of variance reduction, which results in a more reasonable performance assessment. The proposed algorithm is also illustrated by a simulated example of the model predictive control system.

16:00-17:30 WePoPo.26

Direct Synthesis Decoupling Control for TITO Processes with Time Delays, pp. 591-596

Shen, Yuling	Shanghai Jiao Tong Univ.
Li, Shaoyuan	Shanghai Jiao Tong Univ.
Cai, Wen-Jian	Nanyang Tech. Univ.

In this paper, a direct synthesis approach is proposed to design ETF based multivariable decoupling controllers. This new scheme is different from two existing ETF based decoupling schemes which involves the following steps: (1) by uniquely determine the ETFs for every transfer function element, the inverse matrix of transfer function matrix is approximated; (2) selecting the desired closed-loop system transfer function such that the resulted controllers are stable, causal and proper; (3) deriving the achievable full-matrix decoupling controller by specifying the tuning parameters. The effectiveness of the proposed design approach is verified by two multivariable industrial processes, which shows that it results in better overall system performance than other two ETF based schemes.

16:00-17:30 WePoPo.27

Robust Fault Diagnosis with Disturbance Rejection Performance for Non-Gaussian Stochastic Distribution Systems, pp. 597-602

Cao, Songyin Southeast Univ.

Guo, Lei Beihang Univ.

In this paper, an enhanced robust fault diagnosis scheme is provided for the non-Gaussian stochastic distribution systems (SDSs). The available driven information for fault diagnosis is the probability density functions (PDFs) or the statistic information set of the output rather than the output value. A mixed neural network (NN) model with modeling error is established, where a static NN is applied to model the output PDFs and a dynamic NN is used to describe the relationships between the input and the weighting. The concerned problem is transformed into the fault diagnosis problem of the weighting system presented by an uncertain nonlinear system with unknown external disturbance. The statistic information driven composite observer for SDSs is constructed by combining a fault diagnosis observer with a disturbance observer, with which the fault can be diagnosed and the disturbance can be rejected simultaneously. Finally, simulations for the particle distribution control problem are given to show the efficiency of the proposed approach.

16:00-17:30 WePoPo.28

On-Line Batch Process Monitoring Using a Consecutively Updated Hierarchical Kernel Partial Least Squares Model, pp. 603-608

Zhang, Yingwei Northeastern Univ.

Hu, Zhiyong Northeastern Univ.

In the paper, a new approach, a consecutively updated hierarchical kernel partial least squares (UHKPLS) model was proposed. Using multiway partial least squares (MPLS) monitor industrial batch processes has followed disadvantages: 1) MPLS is a linear projection method, which cannot effectively capture the nonlinear features existing in most batch processes. 2) It is limited that complete batch process data is indispensable while the MPLS is applied in batch process monitoring. Hierarchical kernel partial least squares (HKPLS) can solve these problems. But HKPLS is a fixed-model monitoring technique, which gives false alarms when it is used to monitor real processes whose normal operation involves slow changes. So an on-line batch monitoring method that uses a consecutively updated hierarchical kernel partial least squares (UHKPLS) model was proposed to solve these problems. The proposed method was applied to monitoring fed-batch penicillin production. The simulation results clearly show that the ability of the proposed method which eliminates the many false alarms and provides a reliable monitoring chart.

16:00-17:30 WePoPo.29

Information System Integration Model of Manufacturing Enterprise Based on Object Process Methodology, pp. 609-614

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Manufacturing industry needs a more effective and unified information system to meet market demand changes and societal/environmental requirements. The international standard ISO/IEC 62264 (an adoption of ISA SP95) presents an integrated framework for business planning & logistics, manufacturing operation management, and control. The information system integration models proposed in this standard are based on UML (Unified Modeling Language). OPM (Object Process Methodology) is a new modeling approach with much more advantages comparing to UML. This paper re-builds the information system integration models in ISO/IEC 62264 based on OPM. The application in an oil refinery factory verifies the effectiveness of these models and the convenience of OPM.

16:00-17:30 WePoPo.30

Automated Optimization of Process Plant Using Particle Swarm Optimization, pp. 615-620

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Nowadays general purpose process plant simulators are used widely in industry and in academia, reason being process model can be developed more rigorously with less endeavor and the graphical user interface makes the realization of model less time consuming. During the development phase of a process model we often have a lot of variables that has to vary to get the best solution among several candidates. The automation potential of the simulator can be exploited to look for the best solution by varying these variable under some optimization scheme. In this study the Particle Swarm Optimization was used to optimize the process plant under the automation of process simulator Hysys. In the case study LNG liquefaction plant was used to optimize and results shows the method can save energy and improves the process efficiency.

16:00-17:30 WePoPo.31

Input/output Linearization Control with Two-Degree-Of-Freedom Structure for Uncertain Processes, pp. 621-625

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In this work, a new method to control the processes with the unmeasured input disturbance and random noise parametric uncertainty is proposed. The control structure of two-degree-of-freedom is used for enhancing the setpoint regulation and the load disturbance rejection. The tracking controller is designed by input/output linearization technique with the disturbance-free model. Based on the high gain technique, the disturbance rejection controller uses the difference between estimated and the actual outputs to eliminate the effect of the uncertainty. Simulation studies have been constructed to evaluate the control performance of the proposed control method, which is applied through the applications of a continuous stirred tank reactor that exhibits uncertainty.

16:00-17:30 WePoPo.32

Series Solution Approach for Designing the Approximate Input-Output Linearization Controller, pp. 626-631

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A new approach to an approximate input-output (I/O) linearization controller for nonlinear processes that exhibit non-minimum phase behavior is presented. The I/O feedback controller is formulated in the form of the series solution. The Taylor series method is applied to truncate the time derivatives of outputs around the steady state pair corresponding to the desired set-point. The reduced-order state observer is used to estimate the unmeasured process states. The series solution of the feedback controller is more applicable to implement into the digital control hardware that has limitations on the memory and instruction capability. To illustrate the control performance, the proposed method is applied to an example of a continuous stirred tank reactor (CSTR) that exhibits non-minimum phase behavior. The simulation results show that the controller can force the output to the desired set-point asymptotically.

16:00-17:30 WePoPo.33

MPC Economic Performance Assessment Based on Equal-Grid LQG Benchmark, pp. 632-637

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Model Predictive Control technology as the most typical method of Advanced Process Control has been developed rapidly and applied widely in process industry. Weather MPC controllers operate well or not affect the enterprise benefit directly, therefore it is significant to carry out economic performance assessment and optimization. As a pragmatic method, LQG benchmark introduces manipulated variables together with controlled variables into quadratic dynamic index, which is more suitable for industrial application than Minimum Variance Control benchmark. However, traditional LQG benchmark is regressed from an unbalanced distribution of discrete points set, which causes unnecessary calculation and poor regression in more important parts of points set. To avoid this, the relationship between manipulated variables variance and controlled variables variance was calculated, an equal-grid LQG benchmark was introduced and added in two layers MPC optimization problem as an equation constraint, then the optimal MPC setting values or reference trajectory could be obtained. The economic performance assessment and simulation results for delayed coking furnace show the effect of proposed methods.

16:00-17:30 WePoPo.34

Closed-Loop Identification of Multivariable Equation Error Model with Unknown Disturbances, pp. 638-643

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Closed-loop identification for industrial processes has been widely studied in the past decades. Multivariable equation error models (ARX) are frequently used for closed-loop modeling with input and output measurements. When unmeasured disturbances (errors) exist in the equation error models, the traditional prediction error methods are used to identify the models by treating the disturbances as filtered white noises, which is not the case for many disturbances and thus seriously deteriorating the estimation results. In this paper, a recursive least squares estimation with unknown disturbances (RLSE-UD) approach is introduced to estimate the parameters of multivariable equation error models, as well as the unmeasured disturbances. No prior information of the unknown disturbances is required for RLSE-UD and the estimator is proven unbiased and consistent. Simulation results demonstrate that the RLSE-UD approach is capable of identifying the parameters of multivariable equation error models and unmeasured disturbances in closed-loop cases well.

16:00-17:30 WePoPo.35

An Integrated Strategy of Product Quality Control and Optimization with Feedforward Compensation for High-Purity Distillation Process, pp. 644-649

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High-purity distillation is a typical process with long transition time, strongly coupled variables and frequent disturbances, and it is a challenge to control and optimize the distillation process. Considering that the distillation process can be logically divided into two coupled sub-process, namely fractionation and split, which are slow and fast process respectively. We have proposed a product quality control scheme to control the split ratio and the temperatures of the top and bottom tray to eliminate all disturbances except feed composition and stabilize the product quality, and then the production operation can be optimized to obtain as much economical product as possible with least energy consumption. However, since the slowness of the fractionation process, the optimization has to work with a long period. During the period between twice optimizations, the feed composition would fluctuate without treatment. In this paper, a new integrated strategy with feedforward compensation is presented to overcome the feed composition fluctuation further based on the original. Thus, the product quality is much steadier with less margin, and then we can optimize the process further. The stability condition of product quality control is given by theorems. The 'UniSim Design' based simulation tests show the benefit and efficiency of the new integrated strategy.

16:00-17:30 WePoPo.36

Performance Assessment of PID Controller with Time-Variant Disturbance Dynamics, pp. 650-655

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A method is proposed for performance assessment of PID control loops subject to time-varying disturbance dynamics, which is often observed in industrial processes. The proposed method optimizes overall performance of the processes and presents a PID tradeoff curve which provides a useful lower bound on the achievable performance of the PID controller in terms of both the most significant disturbance rejection and the representative disturbance rejection. One can choose an optional benchmark to assess the PID control performance according to the tradeoff curve. The developed performance assessment technique is illustrated by simulation and industrial examples.

16:00-17:30 WePoPo.37

SVM-Based Prediction of the Product Formation for Industrial 2-Keto-L-Gulonic Acid Cultivation, pp. 656-661

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2-keto-L-gulonic acid (2-KGA), a key precursor in the synthesis of L-ascorbic acid, is produced by mixed fermentation of Bacillus megaterium and Gluconobacter oxydans with L-sorbose as substrate. For such mixed cultivation, the mechanistic modelling is difficult because the interactions between the two strains are not well known

yet. Therefore, data-driven modelling is studied in this paper. The rolling learning-prediction (RLP) based on support vector machine (SVM) is practiced to predict the product formation. To satisfy the online application demand, pseudo-on-line prediction is carried out using the data from commercial scale 2-KGA cultivations. The prediction approach receives data in sequence and the training database of the SVM is updated with statistical analysis of the product formation after the termination of a batch. The robustness of the prediction approach is further tested by adding extra noises to the process variables.

16:00-17:30 WePoPo.38

Cost of Energy Analysis of Integrated Gasification Combined Cycle (IGCC) Power Plant with Respect to CO2 Capture Ratio under Climate Change Scenarios, pp. 662-665

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This paper presents the results of cost of energy (COE) analysis of integrated gasification combined cycle (IGCC) power plant with respect to CO2 capture ratio under climate change scenarios. In order to obtain process data for COE analysis, IGCC power plant and IGCC with carbon capture and sequestration (CCS) power plant have been simulated and modeled using Aspen Plus, and verified using various materials such as related reports, papers and simulation guide lines. The concept of 20-year levelized cost of energy (LCOE), and climate change scenarios suggested by International Energy Agency (IEA) are adopted to compare the COE of IGCC power plants with respect to CO2 capture ratio more realistically. In this study, LCOEs which consider fuel price and CO2 price changes with respect to the climate change scenarios are proposed in order to increase the reliability of economic comparison. And results of proposed LCOEs of IGCC without CCS power plant and IGCC with CCS (30% and 70% capture-mole basis- of CO2 in syngas stream) power plant are presented.