Yafeng Guo

Conducted fundamental research to solve a practical but challenging state estimation problem and successfully developed an algorithm for it. He investigated the problem of state estimation incorporating infrequent, delayed and integral measurements. Good state estimation is necessary in advance control and fault detection. In chemical processes, there often exist two types of measurements. On one hand, the measurements for process variables such as flow rates and pressures are sampled frequently and are available nearly instantaneously. On the other hand, the measurements for quality variables such as concentration are sampled infrequently and are available with a delay due to time intensive lab analysis. Moreover, due to the interval time taken by chemical sample collection, the measurements for some quality variables have another important characteristic: it is a function of the states of the compositions over a period of time. This work solved this estimation problem with rigorous mathematical proof of its stability and performance. This work has been published in Automatica.

The search for solutions for oil sands development has typically focused on the processes that make up an oil sands operation. We take a different approach by focusing on the systems that control, optimize, and monitor these processes.

Award

Professor Biao Huang received the 2015 Canadian Society of Chemical Engineers (CSChE) Bantrel Award in Design and Industrial Practice. The CSChE awards ceremony will be conducted in the upcoming 2015 CSChE Annual Conference in Calgary October 4-7, 2015.

2015 Spring IRC Progress Meeting and Workshop

Real-time WENCO Weightometer Data Reconciliation, by Yaojie Lu, Yu Miao, and Ruben Gonzalez

In an oil sands operation site, there has been a discrepancy between the amount of ore mined as reported by the WENCO system and the amount of ore processed in the slurry preparation system as reported by the mix box feed weightometer. In order to address this problem, a data reconciliation method based on mass balance is proposed to make the daily feed rate provided by the weightometer consistent with that provided by the WENCO system. Bias between the reconciled weightometer and the WENCO is further reduced by using a novel moving window bias correction method. The corrected weightometer performs significantly better than the raw weightometer as demonstrated through real industrial data validation.

Design and Implementation of Sulfur Content Soft Sensors, by Hao Chen and Ming Ma

The purpose of this project is to improve the accuracy and robustness of an existing HGO sulphur soft sensor. A new soft sensor with new input variables/structure was proposed. This new soft sensor has been implemented in the DCS system since Oct. 2014. The stewardship results from November 2014 to the present shows that the proposed soft sensor significantly outperforms the old one (error reduced 33%, robustness improved 86%).

Integrated SAGD Dynamic Models for Control and Optimization, by Shabnam Sedghi et al.

SAGD is known as one of the most effective in-situ methods to extract oil sands buried deep down the surface. The main goal of this approach is to reduce the viscosity of the bitumen to enable transfer to the surface. SAGD process contains four sections namely steam generator, injection well, steam chamber, and production well. In this project, a simplified control relevant mathematical model of each part of the SAGD process was built. Further, an integrated model for the SAGD process was built by connecting the models of the four sections. This integrated model can be used for advanced control design such as model-based predictive control (MPC) and for optimization. The ultimate goal of this project is plant-wide optimization of SAGD through an automation system.
Abnormal event prediction in a tail gas treatment unit, by Ruben Gonzalez & Rahul Raveendran

Early detection of SO₂ breakthrough is essential to avoid amine poisoning and corrosion in downstream equipment in a Tail Gas Treatment Unit (TGTU), which is fed by multiple upstream Sulphur Recovery Units (SRUs). Kernel Density Estimation (KDE) is proposed as an alternative to Principal Component Analysis (PCA) since KDE does not require any assumptions to be made about the distribution taken by the data and the relationships that the variables have with each other; recall that PCA requires the assumption that the data follows a Gaussian distribution and relationships have to be linear. One difficulty with applying KDE is that it has poor performance in higher dimension and it cannot be used to single out locations of abnormalities (such as measurements that are most affected). Nevertheless, when combined with Bayesian Networks, dimensionality is reduced, and the Bayesian Network effectively singles out the problem sources by making use of process knowledge and causal relationships. In offline validation, the proposed method recognized multiple operating modes, provided early event detection and had reduced false alarms. The algorithm is now considered for real-time implementation.

Optimization of steam generator network in SAGD process, by Rishik Ranjan

SAGD process consists of several water processing and steam generation plants. Steam production rates across different plants may not be well coordinated due to plant outage or slowdown. Operating costs for different steam generators may also vary. The primary objective is to find cost effective optimal distribution of water across the site in the presence of changes in operating constraints by utilizing historical process data. Another objective is to help operators arrive at optimal state by making judicious use of buffer tank capacities and ensuring that production levels are least affected during the transition. The following approach was taken in order to address this problem:
1) Data reconciliation was used to correct raw data and verify first principles based process models.
2) Optimal distribution of water was found using linear programming.
3) A novel set-point changing strategy to arrive at the optimal point was implemented. This was based on dynamic tank and process unit models.

Operators may use this framework as a decision-making tool in the presence of varying plant constraints.

Control System Performance Analysis and Solutions (PATS) Toolbox, by Hariprasad Kodamana

Poorly performing controllers are of little use in process industry and in order to enhance the operational benefits they should be re-tuned or reconfigured. Controller Performance Monitoring (CPM) is the analysis of routine operating data to determine whether the controller is optimally controlling the process and the actuator or the sensor is functioning correctly. CPM would help reduce the variance of the operation as an implication of improved safety and better profit. CPM is broadly classified into two categories (i) supervisory performance assessment which involves the performance analysis of the supervisory layer and (ii) regulatory performance assessment which involves the performance analysis of the regulatory layer. To this end, the IRC team at the U of A has developed a Performance Analysis Technologies and Solutions (PATS) toolbox. The PATS toolbox has a user-friendly GUI and gives qualitative, quantitative and visual information about various performance indices. The whole toolbox is easy to analyze and operate, and provides both regulatory and supervisory assessment solutions. The toolbox involves various sub-components like univariate and multivariate performance assessment, valve stiction detection and compensation, and an industrially relevant performance indices tool which could be embedded in the PI process book of excel, in MPC performance assessment considering LQG benchmark, and in constraint variability. In a nutshell, PATS provides state-of-the-art solutions for controller performance assessment and could be customized according to industrial needs.

Emulsion Flow and Water Content Soft Sensor Development for SAGD, by Yanjun Ma and Ruomu Tan

In SAGD process, measurements of the produced fluids from production well, known as emulsion, are employed in production optimization to achieve quality targets more efficiently. Vx meters, installed on the production well of each well pair, provide fast-rate measurement of emulsion flow rate and its water content. However, in most wells where Vx meter is not available, emulsion flow and water content typically can only be measured once every few weeks which is not sufficient for subsequent control and optimization. Hence two types of soft sensors are developed correspondingly for emulsion flow rate and water content estimation by synthesizing fast-rate and slow-rate measurements of process variables. These soft sensors have proven to be promising by evaluation through real process data, and the algorithm is now considered for real-time implementation.
**Introducing a researcher**

**Elham Naghoosi**

Began her PhD in Dr. Huang’s group in 2012. Her contributions in practical projects include soft-sensor design, investigating caustic control guideline to evaluate the influence of caustic on bitumen recovery rate as well as developing tools for automatic oscillation detection and diagnosis in process variables. Theoretical studies more focused on developing reliable causality analysis and fault diagnosis algorithms have led to publications in high ranked journals such as JPC, IEEE on CST and IECR. She has also played a key role in running the process control laboratory.

**Nima Sammaknejad**

After receiving his MSc degree in Process Control from Sharif University of Technology, Iran, he joined Prof. Huang’s group to pursue his PhD. His research focus has been on process identification and fault diagnosis during the PhD program. He has been involved in both theoretical and industrial research subjects. He has designed and implemented a model for on-line estimation of the critical velocity in slurry pipelines to avoid pipeline plugging. He has also designed a soft sensor to predict the Light Gas Oil (LGO) quality in a distillation column. Results of his research have been published in reputed journals and proceedings such as AIChE, Computers and Chemical Engineering (CACE), IEEE and International Federation of Automatic Control (IFAC).

**News and Events**

The 9th International Symposium on Advanced Control of Chemical Processes (ADCHEM 2015) forum held from 7th until 10th of June, Whistler, BC.

The 1st Canada China Process Systems Engineering Forum was held on May 12 at the University of Alberta.

IRC Spring workshop was held on May 7, 2015 at the University of Alberta under the name: Improve Process Operation Efficiency Through Process Control & Optimization.

Petroleum Experts has donated Integrated Production Modelling toolkit (IPM) equivalent of £1,335,161.50 to the University of Alberta through this IRC program.

**Recent Sample Journal Publications**


O. Namaki, B. Huang, Bayesian Control Loop Diagnosis by Combining Historical Data and Process Knowledge of Fault Signatures, IEEE Transactions on Industrial Electronics, Vol. 62, No. 6, June 2015.


**Contact**

Professor Biao Huang Ph.D., P. Eng.

CME, University of Alberta 7th Floor, ECERF Edmonton, AB, T6G 2V4, Tel.: 780-492-9016, Fax: 780-492-2881, E-mail: biao.huang@ualberta.ca, Web: oilsandscontrol.ualberta.ca

IRC Advisory Committee and sponsors:


Newsletter prepared by Fadi Ibrahim & Chandy Somajaji.