A Half Day Tutorial On

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Advanced big data analytics for control performance assessment in Industry 4.0 era

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The 2021 American Control Conference|

http://acc2021.a2c2.org/

May 26-28, 2021 in New Orleans, Louisiana, USA at the **Hilton New Orleans Riverside Hotel**.

1. **Title of tutorial:**

   Advanced big data analytics for industrial control performance assessment

2. **Outline of the tutorial/workshop (topic and description)**

Workshop Abstract (why important and why timely and why good for ACC attendants):
Nowadays the industry is witnessing winds of change. The era of Industry 4.0 transformation approaches. The issues of product throughput maximization, increased environmental protection and efficient energy management that have been pushing systems towards their technological constraints are not enough. A modern plant has to fulfill varying stringent regulations to operate at the edge of technological limitations. It should be accompanied by production horizontal and vertical integration, simulations, autonomous operation and flexibility. Most of these paradigms require the backbone of control engineering technologies and cannot exist without a properly designed and maintained control system. Due to such industrial demands, high control system performance must be closely coupled with the task of an advanced data analytics.

Process improvement is the main *raison d'être* for control systems. The relationship is straightforward. Better control causes higher performance. Despite this clear relation and common understanding of the fact, the majority of the industrial loops is neither well-tuned nor properly designed. Control engineers require tools and indexes that would measure how good the control system is. Moreover they require suggestions for what should be done to improve existing poor situation. The research is ongoing. Its importance did not decrease. During fifty years of the interest several different approaches have been investigated, like data driven or model-based approaches defined using different domains. Simultaneously, as new control strategies have emerged, according assessment approaches have developed as well. Almost each control strategy, starting from SISO PID loops up to advanced control predictive and adaptive algorithms, has been addressed in the research and specific methodologies have been proposed.

Big data perspective poses a new challenge in the CPA data analytics. Advanced statistical and fractional-order data-driven methods allow to incorporate multi-criteria decision support into the assessment task. It has to be noted that CPA task has been initiated by industry, is being done for industry and is perpetually validated by industry.

This tutorial will prepare our ACC2021 tutorial audience with
- *Control Performance Assessment methods,*
- *industrial perspective of the CPA,*
- *Control Performance Study as a CPA application case.*

Topics: Monday May 24 and Tuesday May 25 at the Hilton New Orleans Riverside Hotel.
1) 09:00-09:10. Introduction to the Tutorial Workshop (Paweł D. Domański)
2) 09:10-10:00. Review of the CPA task and algorithms (Paweł D. Domański)

3) 10:00-10:50. Advanced statistical data-driven analytical tools – outliers and anomalies (Paweł D. Domański and YangQuan Chen)
4) 10:50-11:10. Coffee break and free chats.
5) 11:10-11:40. Advanced big-data fractional order signal processing approach (YangQuan Chen)
6) 11:40-12:10 Control Performance Study as a CPA application case in process industry (Paweł D. Domański)
7) 12:10-12:30 Discussions continue to lunch time if needed.

More background information:

- Paweł D. Domański and YangQuan Chen and Maciej Ławryńczuk. "Outliers in Control Engineering – Fractional Calculus Perspective." Book to appear in 2021. De Gruyter. Book Series on "Fractional calculus and its applications in science and engineering"
- Paweł D. Domański. *Control Performance Assessment: Theoretical Analyses and Industrial Practice*. Studies in Systems, Decision and Control Series, Springer Nature Switzerland AG, Cham, 2020. https://www.springer.com/gp/book/9783030235925
- Concepción A. Monje, YangQuan Chen, Blas Vinagre, Dingyu Xue and Vicente Feliu (2010). "*Fractional Order Systems and Controls - Fundamentals and Applications*." Advanced Industrial Control Series, Springer-Verlag http://www.springer.com/engineering/book/978-1-84996-334-3 (1st Edition, 2010, XXVI, 415 p. 223 illus., 19 in color. Hardcover ISBN: 978-1-84996-334-3)
- Sheng, Hu, Chen, YangQuan and Qiu, TianShuang. "*Fractional Processes and Fractional-Order Signal Processing*" Springer. Series: Signals and Communication Technology, 2012. 295 pages. ISBN 978-1-4471-2232-6 http://www.springer.com/engineering/signals/book/978-1-4471-2232-6
- Dingyu Xue and YangQuan Chen. "*Modeling, Analysis and Design of Control Systems in MATLAB and Simulink*" (World Scientific 2014) http://www.worldscientific.com/worldscibooks/10.1142/9260 580pp Nov 2014. ISBN: 978-981-4618-45-8 (hardcover) http://mechatronics.ucmerced.edu/madbook

3. **Duration and sessions**

Half day, Tuesday May 25, 2021, 09:00-12:30 (could be in the afternoon – flexible, perhaps preferred)

4. **Description of the intended audience and the expected learning outcomes**

Graduate students, postdocs, engineers and faculty members dealing with complex process control and monitoring tasks.

Expected learning outcomes:

1) Basic knowledge about Control performance task and its positioning within industrial perspective
2) Advanced statistical approaches, especially focused on the detection of outliers and anomalies.
3) Fractional order approach revealing new perspectives in advanced big data analytics for process control performance assessment.
4) Ability to use advanced methods in the industrial control system life-cycle Control Performance Study.

5. **Desired prerequisite knowledge of the audience**

   1) Basic knowledge of signals and systems, classical control system (Control-I).
   2) PID control tuning, MPC control, control system performance monitoring
   3) (optional) edge computing, deep learning

6. **The tutorial speaker(s)**

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7. **Brief biographies for each tutorial/workshop speaker (no more than 300 words per person)**

Paweł D. Domański was born in Warsaw, Poland in 1967. He received his M.Sc. in 1991, Ph.D. in 1996 and D.Sc. in 2018 all in automatic control from Warsaw University of Technology, Faculty of Electronics and Information Technology. He works in the Institute of Control and Computational Engineering, Warsaw University of Technology from 1991. Apart from scientific research he participated in dozens of industrial implementations of APC and optimization in power and chemical industry. He is the author of more than 100 publications in books, journals and conferences. His main research interest is with industrial APC applications, control performance quality assessment and optimization.

YangQuan Chen earned his Ph.D. from Nanyang Technological University, Singapore, in 1998. He had been a faculty of Electrical Engineering at Utah State University from 2000-12. He joined the School of Engineering, University of California, Merced in summer 2012 teaching "Mechatronics", "Engineering Service Learning" and "Unmanned Aerial Systems" for undergraduates; "Fractional Order Mechanics", "Nonlinear Controls" and "Advanced Controls: Optimality and Robustness" for graduates. His research interests include mechatronics for sustainability, cognitive process control, small multi-UAV based cooperative multi-spectral "personal remote sensing", applied fractional calculus in controls, modeling and complex signal processing; distributed measurement and control of distributed parameter systems with mobile actuator and sensor networks. He is listed in Highly Cited Researchers by Clarivate Analytics in 2018, 2019. He received Research of the Year awards from USU (12) and UCM (20).