

## A Half Day Workshop Proposal On

# Fractional Order Motion Controls: How Motion Control Can Benefit from using Fractional Calculus?

The 19th World Congress of the International Federation of Automatic Control | Cape Town, South Africa | 24-29 August 2014

### Workshop Abstract:

This tutorial is based on a recent research monograph "[Fractional Order Motion Controls](#)" (Wiley, 2013, ...). There is an increasing interest in fractional order dynamic systems and controls in recent research literature, not only because of their novelty but also due to their practical values. Fractional calculus is a generalization of calculus from integer order to fractional order and the controller designs developed based on fractional calculus has a greater opportunity to provide more accurate models and superior control performances. In this workshop, theoretical concepts on fractional order motion controls will be presented. Real world implementations such as UAV flight control and hard disk drive servo control will be demonstrated to illustrate its practical importance.

### Presenter(s):

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### Presenter(s) Biographical Sketch:

- **YangQuan Chen** was a faculty member of ECE Dept. of Utah State University before he joined UC Merced in Fall 2012. He earned his Ph.D. from Nanyang Technological University, Singapore in 1998, MSc. from Beijing Institute of Technology in 1989 and BS. from University of Science and Technology of Beijing in 1985. His current areas of research interests include: distributed measurement and distributed control of distributed parameter systems using mobile actuator and sensor networks, smart mechatronics and process controls, applied fractional calculus in controls, signal processing and energy informatics, multi-UAV based personal cooperative remote sensing and real time water management and irrigation control. Dr. Chen is an Associate Editor on the Conference Editorial Board of the Control Systems Society of the IEEE (since 2002), an Associate Editor on the International Society of Automation (ISA) Editorial Board for the American Control Conference (since 2004) and an Associate Editor on the Conference Editorial Board of the Robotics and Automation Society of the IEEE (since 2012). He served as the General Chair for IEEE/ASME Int. Conf. on Mechatronics and Embedded Systems Applications (MESA) 2010, Qingdao, China and the Program Chair for the ASME/IEEE Int. Conf. on MESA, Las Vegas, NV, 2007 and MESA09 San

Diego, CA, 2009 and Program Co-Chair for the IEEE International Conference on Mechatronics and Automation for 2006 and 2007. He was the TC Chair for MESA under ASME DED, Chair for MES for IEEE ITSS, and is a member of IFAC TC2.2. He serves as an Associate Editor for Acta Montanistica Slovaca, Fractional Calculus and Applied Analysis (FCAA), ASME J. of Dynamic Systems, Measurement and Control, International Journal of Advanced Robotic Systems, IFAC journal of Mechatronics, ISA Transactions, IEEE Transactions on Control Systems Technology (TCST), and IFAC journal Control Engineering Practice (CEP). Dr. Chen is a member of Editorial Advisory Board of An International Journal of Optimization and Control: Theories & Applications (IJOCTA). He won IFAC Journal of Control Engineering Practice Best Paper Award at 2011 IFAC World Congress. Since 2012, Dr. Chen serves as TC Co-Chair for IEEE RAS Technical Committee on Aerial Robotics and Unmanned Aerial Vehicles. Dr. Chen is a senior member of IEEE, a member of ASME, AUUSI, AMA (Academy of Model Aeronautics), AWRA (American Water Resources Association) and ASEE (American Society of Engineering Educators).

- **Zhuo Li** received the B.S. in Automation from University of Science and Technology of China (USTC), 2009, and the M.S. in Electrical Engineering from Temple University, Philadelphia, 2011. Now, he is pursuing the Ph.D. degree in UC Merced. Being involved in a joint project with Lam Research, Zhuo has a research focus on Cognitive process control and MIMO fractional order control for plasma etching processes. He has personal interests in flash animations, GUI design, wireless sensor networks and game theory, etc.
- **Yan Li** received the B.S. degree in mathematics and applied mathematics from Jinan University, Jinan, China, in 2003, and the Ph.D. degree in applied mathematics from Shandong University, Jinan, China, in 2008. From 2007 to 2008, he was supported by the China Scholarship Council as an exchange Ph.D. student with the Department of Electrical and Computer Engineering, Utah State University, Logan. He is currently an Associate Professor of School of Control Science and Engineering at Shandong University, Jinan, China. His current interests include applied fractional calculus in field robotics.

#### **Expected Background of Participants:**

Basic knowledge of LTI (linear time invariant) systems, classic and modern controls such as feedback controls, frequency domain analysis (like gain phase margins, gain crossover and phase crossover frequencies) and PID controllers.

#### **Expected Audience:**

#### **Need for the Workshop:**

..... "[Fractional Order Motion Controls](#)" Wiley, 2013, .....

#### **Impact:**

#### **Course Outline (4 hours):**

*Session 1A: Overview and Introduction*

#### **Part 2: Fractional Order Velocity Controls**

*Session 2A: Fractional Order PI Controller Designs for Velocity Systems*

*Session 2B: Tuning Fractional Order PI-Controllers*

#### **Part 3: Fractional Order Position Controls**

*Session 3A: Fractional Order PD Controller Designs for Position Systems*

*Session 3B: Tuning Fractional Order PD Controllers*

Part 4: Stability and Feasibility

*Session 4A: Stability and Design Feasibility of Robust PID Controllers for FOPTD systems*

*Session 4B: Stability and Design Feasibility of Robust FOPI Controllers for FOPTD system*

Part 5: Fractional Order Disturbance Compensations

*Session 5A: Fractional Order Disturbance Observer*

*Session 5B: Fractional Order Adaptive Compensation*

□ *Adaptive Feed-Forward Cancellation*

□ *Adaptive Compensation for Cogging Effect*

□ *Adaptive Learning Compensation*

Part 6: Effects of Fractional Order Controls on Nonlinearities

*Session 6A: Fractional Order PID Control of a DC-Motor with Elastic Shaft*

*Session 6B: Fractional Order Ultra Low-Speed Control*

Part 7: Fractional Order Motion Control Applications

*Session 6A: Lateral Fractional Order Control of a small UAV*

*Session 6B: Fractional Order PD Controller Synthesis and Implementation on an HDD*

**Expected enrollment: 10-20.**