

## A Half Day Workshop Proposal On

# Personalizing Mechatronics Control Education Utilizing an Open-Source Real-Time Control System Rapid Prototyping Platform

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

### Workshop Abstract:

The objective of this workshop is to introduce a new personalizing approach of teaching Mechatronics laboratory to undergraduate students as an introduction to upper division classes. Providing hands-on experience is often a great aid for teaching difficult concepts, however, designing a sufficient experience is in itself, a difficult challenge. Undergraduates have a limited educational experience, and are typically lacking one or more of the foundations of mechatronics: mechanics, circuits, instrumentation, and programming. Specialized mechatronics education equipment is commercially available, but is typically expensive and requires a specialized setup and operating environment. Remote access can provide virtual laboratories that allow students to conduct experiments from anywhere they have internet access, but remove the hands-on component. Some schools have elected to provide students the opportunity to build a setup from the ground up, but the learning curve can be steep and may hinder their exposure to the control system aspect of mechatronics.

In this workshop, a low-cost take-home mechatronics laboratory kit is introduced. This kit is built around the Arduino prototyping platform, an open-source, readily available system with a large user base. By incorporating a variety of low-cost sensors and actuators, the kit is capable of meeting all of the goals of a mechatronics laboratory course, while remaining simple enough for students with uncertain foundations to excel.

### Presenters:

#### **YangQuan Chen, Director**

Mechatronics, Embedded Systems and Automation LAB,  
School of Engineering

**University of California, Merced**, Merced, CA 95343

E-mail: [yqchen@ieee.org](mailto:yqchen@ieee.org); Phone: (209) 228-4672

<http://mechatronics.ucmerced.edu>

**Brandon Stark, Ph.D. Student, LAB Manager** Mechatronics,  
Embedded Systems and Automation LAB, School of  
Engineering

**University of California, Merced**, Merced, CA 95343

E-mail: [bstark2@ucmerced.edu](mailto:bstark2@ucmerced.edu) Phone: (209) 228-4398

<http://mechatronics.ucmerced.edu>

**Zhuo Li, Ph.D. Student,**

Mechatronics, Embedded Systems and Automation LAB,  
School of Engineering

**University of California, Merced,** Merced, CA 95343

E-mail: [zli32@ucmerced.edu](mailto:zli32@ucmerced.edu) Phone: (209) 228-4398

<http://mechatronics.ucmerced.edu>

**Brendan Smith, Ph.D. Student,**

Mechatronics, Embedded Systems and Automation LAB,  
School of Engineering

**University of California, Merced,** Merced, CA 95343

E-mail: [smithbrendanjames@gmail.com](mailto:smithbrendanjames@gmail.com); Phone: (209) 228-4398

<http://mechatronics.ucmerced.edu>

**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, AUVSI, AMA (Academy of Model Aeronautics), AWRA (American Water Resources Association) and ASEE (American Society of Engineering Educators).

**Brandon Stark** is a Ph.D. Student and Lab Manager for the Mechatronics, Embedded Systems and Automation Lab (MESA Lab) at the University of California, Merced. He earned his bachelor's degree in computer engineering from the University of California, Irvine in 2007 with a minor in Art History. He continued his graduate education at the University of Bridgeport and earned a Master of Science degree in Computer Engineering and a Master of Science degree in Electrical Engineering in 2010. He started his Ph.D. studies in Utah State University with the Center for Self-Organizing and

Intelligent Systems before transferring to University of California, Merced to assist in the founding of the Mechatronics, Embedded Systems and Automation Lab (MESA Lab) and continue his research on the topics of Unmanned Aerial Systems: Airworthiness, Regulations and Human Factors. He designed the laboratory course curriculum to the revitalized offering of ME142: Mechatronics at UC Merced to address the knowledge gap between theory and practice of mechanical engineering students.

**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.

**Brendan Smith** is a Ph.D. student in the Mechanical Engineering program working at MESA LAB. He is a winning team member of [Click&Move® Motion and Automation Design Contest](#). He leads a capstone project team of four on glass line automated surveillance swarms ([GLASS](#)). His major research interests include mechatronics, unmanned aerial systems (UAS) for their beneficial use in precision agriculture, environmental monitoring and infrastructure surveillance.

**Expected Background of Participants:**

Basic electronics, programming and mechanics knowledge.

**Expected Audience:**

This workshop is addressed to faculty, PhD students, MS students as well as education specialists from universities and educational institutions interested in developing new approaches towards engineering education.

**Need for the Workshop:**

The current economic environment for education has put significant constraints on the purchasing and maintenance of educational equipments, as well as highlighted the need for efficient classroom use.

**Impact:**

The workshop will provide insight into utilizing low-cost equipment for a flexible hands-on learning environment that addresses the needs of a mechatronics/control laboratory course and the limitations of the current economic educational environment.

**Course Outline:**

**Part 1 (~1/2 Hour): Introduction to the Mechatronics Laboratory Education a)**

Engineering Education Issues

b) Educational Needs and Educational Assessment Method c)

Mechatronics Approach

**Part 2 (~1 Hour): Introduction to the Arduino Prototyping Platform a)**

Introductory Circuits

b) Introductory Programming Examples

**Part 3 (~1 Hour): Sensors and Actuators**

a) Low-Cost Sensors and Integration b)

Low-Cost Actuators and Control

**Part 4 (~1/2 Hour): Arduino IO – Matlab/Simulink Interface a)**  
Arduino as a DAQ  
b) System Identification using an Arduino

**Part 5 (~1 Hour):**  
Sample Closed-loop Real-time Control Systems and Example Setups

**Service web of this Tutorial:**

<https://mechatronics.ucmerced.edu/simubook2013wiley>

**Key Reference:**

Brandon Stark, Zhuo Li, Brendan Smith, YangQuan Chen. "Take-Home Mechatronics Control Labs: A Low-Cost Personal Solution and Educational Assessment" DETC2013-12746 ASME/IEEE MESA 2013, ASME IDETC/CIE, August 4-7, 2013. Portland, OR, USA.

**Expected enrollment: 20 or so.**