



## CONFERENCE

IEEE International Conference on Mechatronics and Automation

## WORKSHOP TITLE

Cooperative Control and Consensus Building for Multiple Autonomous Vehicles

## WORKSHOP ORGANIZERS (see below for bios)

Wei Ren – Utah State University  
Randal W. Beard – Brigham Young University

**CONTACT INFORMATION:** For more information about the workshop, please contact:

Wei Ren  
Department of Electrical and Computer Engineering  
Utah State University  
Logan, UT 84341-4120  
Phone: 435-797-2831  
Fax: 435-797-3054  
Email: [wren@engineering.usu.edu](mailto:wren@engineering.usu.edu)  
Web: [www.csois.usu.edu/people/weiren](http://www.csois.usu.edu/people/weiren)

**WORKSHOP DURATION:** Half day (3.5 hours)

**Conference Website:** <http://www.ieee-icma.org>

## LIST OF PRESENTERS (see below for bios)

Wei Ren – Utah State University  
Randal W. Beard – Brigham Young University  
Kevin L. Moore – Colorado School of Mines  
YangQuan Chen – Utah State University

## WORKSHOP ABSTRACT AND OBJECTIVES

The increasing power of computational resources makes possible the development of autonomous control systems that are capable of dealing with the complex task of path planning in dynamic and uncertain environments. Autonomous vehicles have applications in military operations, search and rescue, environment monitoring, commercial cleaning, material handling, and homeland security. While single vehicles performing solo missions will yield some benefits, greater benefits will come from the cooperation of teams of vehicles. One motivation for multiple autonomous vehicles is to achieve the same gains for mechanically controlled systems as has been gained in distributed

computation. Rather than having a single monolithic (and therefore expensive and complicated) machine do everything, the hope is that many inexpensive, simple machines, can achieve the same or enhanced functionality, through coordination. There are numerous applications for cooperative control of multiple autonomous vehicles including space-based interferometry, future autonomous combat systems, autonomous household appliances, enhanced surveillance systems, hazardous material handling systems, and active reconfigurable sensing systems.

The purpose of this workshop is overview the state of the art research in cooperative control of multiple autonomous vehicles. The presenters have been actively involved in this area over the past several years. Throughout the workshop the presenters will demonstrate both theoretical and experimental results in cooperative control. In particular, formation and non-formation type cooperative control problems will be introduced. Distributed consensus algorithms and their applications in multi-vehicle coordination will be presented. Recent research in autonomy and cooperation for small unmanned air vehicles will be presented. The approaches for decentralized adaptive scheduling and data exfiltration from unattended ground sensors will be introduced. An overview of a mobile actuator sensor network experimental platform will be given.

## **WORKSHOP AUDIENCE**

The expected audience includes engineers, scientists, postgraduate students, and academics. The workshop will be self-contained so that it is suitable for systems and control researchers and practitioners who may not be familiar with the concept of cooperative control as well as to those with some background in the field.

## **ORGANIZATIONAL DETAILS**

1. Attendees will be given hardcopies of the presentation slides and will be provided electronic copies as well.
2. The organizers and presenters will use electronic projection in PowerPoint or PDF format. We will provide our own computers, but we require the use of an LCD projector. The ability to make extemporaneous comments on a chalkboard or a dry-erase board would also be helpful, though not essential.
3. We would prefer to not have more than 50 attendees.

## **WORKSHOP SCHEDULE (June 25, 2006)**

<b>Time</b>	<b>Topic</b>	<b>Presenter</b>
14:00-14:10	Welcome and Introduction	W. Ren
14:10-14:55	Cooperative control overview: motivations, formation & non-formation control problems, examples Distributed consensus building in multi-vehicle systems: motivations, algorithms, and examples	W. Ren
14:55-15:40	Autonomy and cooperation for small unmanned air	R. Beard

	vehicles	
15:40-16:00	Break	
16:00-16:45	Decentralized adaptive scheduling Data exfiltration from unattended ground sensors	K. Moore
16:45-17:30	Mobile actuator sensor networks: theory & applications	Y. Chen

## ORGANIZER' and PRESENTERS' BIOGRAPHIES

**Wei Ren (Organizer)** is currently an assistant professor in the Department of Electrical and Computer Engineering at Utah State University. He is affiliated with the Center for Self-Organizing and Intelligent Systems (CSOIS). He received the Ph.D. degree in electrical engineering from Brigham Young University, Provo, UT, in 2004. From October 2004 to July 2005, he was a research associate in the Space Systems Laboratory at the University of Maryland, College Park, MD. His research has been focusing on autonomous control system design and cooperative control of multiple autonomous vehicles since 2000. He has author/co-authored over 30 peer-reviewed journal and conference publications in the area of cooperative control of multiple autonomous vehicles. His work on spacecraft formation flying and distributed consensus algorithms for multiple vehicle cooperative control is widely cited in the control and robotics community. He is a member of the IEEE Control Systems Society and the AIAA.

**Randal W. Beard (Co-organizer)** received the B.S. degree in electrical engineering from the University of Utah, Salt Lake City, in 1991, the M.S. degree in electrical engineering in 1993, the M.S. degree in mathematics in 1994, and the Ph.D. degree in electrical engineering in 1995, all from Rensselaer Polytechnic Institute, Troy, N.Y. Since 1996, he has been with the Electrical and Computer Engineering Department at Brigham Young University, Provo, UT, where he is currently an associate professor. In 1997 and 1998, he was a Summer Faculty Fellow at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA. His primary research focus is autonomous control of micro unmanned air vehicles and multiple vehicle coordination and control. He is a senior member of the IEEE, a member of AIAA, and is currently an Associate Editor for the IEEE Control Systems Magazine and the IEEE Control Systems Society Conference Editorial Board. He has authored/co-authored over 100 publications in the area of autonomous systems and cooperative control.

**Kevin L. Moore (Presenter)** received the B.S. and M.S. degrees in electrical engineering from Louisiana State University and the University of Southern California, respectively. He received the Ph.D. in electrical engineering, with an emphasis in control theory, from Texas A&M University. He is currently the G.A. Dobelman Distinguished Chair and Professor of Engineering at the Colorado School of Mines. He was previously a senior scientist at Johns Hopkins University's Applied Physics Laboratory (2004-2005), the Director of the Center for Self-Organizing and Intelligent Systems, and Professor of Electrical Engineering at Utah State University (1998 -2004), and on the faculty at Idaho State University (1989-1998). He is the author of the research monograph *Iterative Learning Control for Deterministic Systems* and co-author of the book *Modeling, Sensing, and Control of Gas Metal Arc Welding*, published by Elsevier. He is an active contributor to the literature of iterative learning control and conducts research in ILC, robotics and industrial control applications, cooperative control, and autonomous systems.

**YangQuan Chen (Presenter)** is presently an assistant professor of Electrical and Computer Engineering Department and the Acting Director for CSOIS (Center for Self-Organizing and Intelligent Systems) at Utah State University. He obtained his Ph.D. from Nanyang Tech. Univ. (NTU), Singapore. Dr Chen has 12 US patents granted and 2 US patent applications published, most related to iterative learning control and

repetitive control. He published over 160 academic papers, two textbooks, one research monograph, and (co)authored over 50 industrial reports. He has been an Associate Editor in the Conference Editorial Board of IEEE Control Systems Society since 2002 and is a founding member of the ASME subcommittee of "Fractional Dynamics" in 2003. He is a senior member of IEEE, a member of ASME and a member of International Society for Information Fusion.