Ideas and Technology of Control Systems

Tuesday, December 14, 2010
9:30 am – 2:45 pm
Hilton Atlanta Hotel

10th Anniversary

This workshop is held in conjunction with the 2010 IEEE Conference on Decision and Control

2010 IEEE Conference on Decision and Control

Sponsored by: IEEE CSS (http://www.ieeecss.org/main/) in collaboration with AACC Technical Committees on Control Education, Georgia Institute of Technology, and University of Kansas

Organizers: Bozenna Pasik-Duncan, University of Kansas and Chair AACC and IEEE CSS Control Education Committees
Bonnie Ferri, Georgia Institute of Technology

Organizing and Program Committee: Leyla Conrad, Georgia Institute of Technology
Tyrone Duncan, University of Kansas

The purpose of this workshop is to increase the general awareness of the importance of systems and control technology and its cross-disciplinary nature among high school teachers and students. The workshop activities include presentations by control scholars and graduate students, informal discussions, and the opportunity for teachers to meet passionate researchers and educators from academia and industry. The talks are designed to be educational, inspirational and entertaining showing the excitement of being an engineer.

Presentations include:

Careers in Control and Robotics
Mark Spong, Dean
Erik Jonsson School of Engineering and Computer Science
Lars Magnus Ericsson Chair and the Excellence in Education Chair in Electrical Engineering
University of Texas at Dallas, Richardson
Past President, IEEE CSS

In this talk we will discuss the emerging area of mechatronics and it's application to robotics and control. Mechatronics deals with the integration of mechanical systems, electronics, computer science and control. Many systems, such as automobiles, airplanes, robots and medical devices are examples of mechatronic systems. We will discuss several interesting mechatronics projects that we have designed and built over the years, including self-balancing robots and a robot that plays air hockey against a human. Such projects can prepare students for interesting and exciting careers in engineering.

Mark W. Spong is currently Dean of the Erik Jonsson School of Engineering and Computer Science and holder of the Lars Magnus Ericsson Chair and the Excellence in Education Chair at the University of Texas at Dallas. Prior to 2008 he was at the University of Illinois at Urbana-Champaign. Dr. Spong's main interests are in nonlinear control theory and robotics. He has published more than 250 papers and 4 books in the area. He is Past President of the IEEE Control Systems Society and Past Editor-in-Chief of the IEEE Transactions on Control Systems Technology. His recent awards include the 2007 IROS Fumio Harashima Award for Innovative Technologies, the 2008 IEEE Transactions on Control Systems Technology Outstanding Paper Award, the Senior Scientist Research Award from the Alexander von Humboldt Foundation, the John R. Ragazzini Award and O. Hugo Schuck Award from the American Automatic Control Council, and the IEEE Third Millennium Medal. Dr. Spong is a Fellow of the IEEE and President of Mechatronic Systems, Inc., a company that he founded in 1996.

Joys and Perils of Automation

Christos G. Cassandras
Head, Division of Systems Engineering
Professor of Electrical and Computer Engineering
Center for Information and Systems Engineering (CISE)
Boston University
President Elect, IEEE CSS

One of the definitions of the word "control" is "to govern or direct according to rule" (Merriam-Webster dictionary). In science and engineering, these "rules" have traditionally been dictated by the laws of nature, such as gravity or conservation of mass. Computer technology, however, has enabled us to build complex systems that have become essential to our daily life, from automated factories to computer networks, with intelligent highways and autonomous vehicles just around the corner. The "rules" that these systems must obey are as arbitrary as human imagination can make them (as in designing a video game where one may create a virtual world where anything goes). While this is exciting, it is also dangerous—it takes but one minor "bug" or "virus" to bring a multimillion factory to a standstill, the Internet to crash, or the Mars exploration vehicle to erroneously "think" that its landing legs were deployed, effectively forcing it to commit electronic suicide. Many of the dangers of automation stem from the lack of designers and engineers with appropriate skills that are cultivated through an understanding of what a "system" is and how to evaluate the effectiveness of a controller before deployment. This presentation will illustrate the difference between physical processes subject to the laws of nature and human-made processes that must satisfy human-made rules. We will then show how "automatic control" can be used and demonstrate both its benefits and risks. An application motivated by the trend towards creating "smart cities" is that of "intelligent parking" which will be described and illustrated through movies from laboratory experiments involving miniaturized cities and wireless robots.

Christos G. Cassandras is Head of the Division of Systems Engineering and Professor of Electrical and Computer Engineering at Boston University. He is also co-founder of Boston University's Center for Information and Systems Engineering (CISE). He received degrees from Yale University (B.S., 1977), Stanford University (M.S.E.E., 1978), and Harvard University (S.M., 1979; Ph.D., 1982). In 1982-84 he was with ITP Boston, Inc. where he worked on the design of automated manufacturing systems. In 1984-1996 he was a faculty member at the Department of Electrical and Computer Engineering, University of Massachusetts/Amherst. He specializes in the areas of discrete event and hybrid systems, stochastic optimization, and computer simulation, with applications to computer and sensor networks, manufacturing systems, and transportation systems. He has published over 280 refereed papers in these areas, and five books. He has guest-edited several technical journal issues and serves on several journal Editorial Boards. He has recently collaborated with The MathWorks, Inc. in the development of the discrete event and hybrid system simulator SimEvents. Dr. Cassandras was Editor-in-Chief of the *IEEE Transactions on Automatic Control* from 1998 through 2009 and has also served as Editor for Technical Notes and Correspondence and Associate Editor. He is the 2011 President-Elect of the IEEE Control Systems Society (CSS) and has served as Vice President for Publications and on the Board of Governors of the CSS. He has chaired the CSS Technical Committee on Control Theory, and served as Chair of several conferences. He has been a plenary speaker at various international conferences, including the *American Control Conference* in 2001 and the *IEEE Conference on Decision and Control* in 2002. He is the recipient of several awards, including the Distinguished Member Award of the IEEE Control Systems Society (2006), the 1999 Harold Chestnut Prize (IFAC Best Control Engineering Textbook) for *Discrete Event Systems: Modeling and Performance Analysis*, and a 1991 Lilly Fellowship. He is a member of Phi Beta Kappa and Tau Beta Pi. He is also a Fellow of the IEEE and a Fellow of the IFAC.

Synthetic Biology and Biomolecular Programming

Richard Murray, Everhart Professor
Control and Dynamical Systems and Bioengineering
California Institute of Technology

Biological systems make use of feedback in an extraordinary number of ways, on scales ranging from molecules to cells to organisms to ecosystems. In this talk I will give a brief overview of some of the uses of feedback inside cells and introduce the fields of synthetic biology and molecular programming. Synthetic biology has emerged over the last decade as a rapidly expanding field of research in which artificial sequences of DNA are inserted into cells to create useful circuits. Applications of synthetic biology include new methods for developing medicines and biofuels, as well as concepts for cleaning up environmental toxins. Molecular programming is an offshoot of synthetic biology in which nanoscale patterns and structures are built from DNA molecules (including "DNA origami"). Both of these areas are undergoing rapid advances as researchers from around the world explore new opportunities for programming biological systems.

Richard Murray, Thomas E. and Doris Everhart Professor of Control and Dynamical Systems; Director, Information Science and Technology, is an expert in dynamics and control of complex systems. He received the B.S. degree in Electrical Engineering from California Institute of Technology in 1985 and the M.S. and Ph.D. degrees in Electrical Engineering and Computer Sciences from the University of California, Berkeley, in 1988 and 1991, respectively. Professor Murray's research is in the application of feedback and control to mechanical, information, and biological systems. Current projects include integration of control, communications, and computer science in multi-agent systems, information dynamics in networked feedback systems, analysis of insect flight control systems, and biological circuit design. Professor Murray has recently developed a new course at Caltech that is aimed at teaching the principles and tools of control to a broader audience of scientists and engineers, with particular emphasis on applications in biology and computer science.

Robotic Science Explorers for Understanding Climate Change

Ayanna Howard, Associate Professor
School of Electrical and Computer Engineering
Georgia Institute of Technology

Recently, it has been discovered that the giant ice sheets covering Greenland and Antarctica have been shrinking at an accelerated rate. While it is believed that these regions hold important information related to global climate change, there is still insufficient data to be able to accurately predict the glacial behavior and the subsequent global ramifications. In order to obtain a denser set of measurements, a group of autonomous robotic rovers could be deployed to these locations, mitigating the cost, effort, and danger of human presence. In this presentation, we discuss a robust Arctic rover platform, methods for navigating arctic terrain, and developing schemes to deploy multiple robotic scientific explorers to these science sites of interest.

Ayanna Howard is an Associate Professor in the School of Electrical and Computer Engineering at the Georgia Institute of Technology. Her area of robotics research, which addresses aspects of interaction with humans and the surrounding environment, has resulted in over 100 peer-reviewed publications in a number of projects – from scientific rover navigation in glacier environments to assistive robots for the home. To date, her unique accomplishments have been highlighted through a number of awards and articles, including highlights in USA Today, Upscale, and TIME Magazine, as well as being named a MIT Technology Review top young innovator of 2003, receiving the Georgia-Tech Faculty women of distinction award in 2008, and recognized as NSBE educator of the year in 2009.

Demonstrations using LEGO NXT
Meghan Kerry
Product Marketing Engineer
National Instruments

Learn how the fundamentals of control theory can be applied to everything from a LEGO NXT robot to industrial machines. This presentation will include an overview and live demonstration of a LEGO NXT Segway, and videos of real-world control applications including robot swarms and human transporters.

National Instruments transforms the way engineers and scientists around the world design, prototype, and deploy systems for test, control, and embedded design applications. Using NI open graphical programming software and modular hardware, customers at more than 30,000 companies annually simplify development, increase productivity, and dramatically reduce time to market. From testing next-generation gaming systems to creating breakthrough medical devices, NI customers continuously develop innovative technologies that impact millions of people.

Interactive Demos of Control Systems
Bonnie Ferri, Professor
School of Electrical and Computer Engineering
Georgia Institute of Technology

Motors are one of the most commonly controlled systems. Students will learn how mathematical equations can describe motors, and they will have a chance to experiment with motor controllers using LEGO NXT kits.

Dr. Bonnie Ferri is a Professor in Electrical and Computer Engineering at Georgia Tech. She received her BS degree in Electrical Engineering from the University of Notre Dame in 1981, her MS in Mechanical and Aerospace Engineering from Princeton University in 1984, and her Ph.D. in Electrical Engineering from Georgia Tech. She works in embedded computing and control systems and has won a number of teaching awards, including the Harriet B. Regis award from the IEEE Education Society. Dr. Ferri was an Elected Member of the Board of Governors for the IEEE Control Systems Society, Technical Chair for the 1998 American Control Conference, Associate Editor of IEEE Transactions on Education, and Associate Editor of IEEE Control Systems Magazine. She served as the Chair of the IEEE Control Systems Society Technical Committee on Controls Education.

Control the Unstable: A Case Study in Fluid Flows
Anuradha Annaswamy, Senior Research Scientist
Massachusetts Institute of Technology
General Chair, 2008 ACC

Anuradha Annaswamy has held faculty positions at several universities including Yale, Boston University, and MIT. She is currently the director of the Active Adaptive Control Laboratory and a Senior Research Scientist in the Department of Mechanical Engineering at MIT. Her research interests pertain to adaptive control theory and applications to aerospace and automotive systems, active control of noise in thermo-fluid systems, active emission control, and control of smart buildings and smart grid.

Dr. Annaswamy has received several awards including the George Axelby Outstanding Paper award from IEEE Control Systems Society in 1988, the Presidential Young Investigator award

from the National Science Foundation in 1991, the Hans Fisher Senior Fellowship from the Institute for Advanced Study at Technical University of Munich in 2008, and the Donald Groen Julius Prize for 2008 from the Institute of Mechanical Engineers. Dr. Annaswamy is a Fellow of the IEEE and a member of AIAA.

Energy Management in Homes and Commercial Buildings
Datta Godbole, Lab Director
Honeywell Labs

Dr. Datta Godbole leads "Knowledge Systems" Research Lab in Automation and Control Solutions division of Honeywell. His team's responsibilities include research, development and prototyping of advanced technologies in user interfaces, controls, data analytics & optimization for next generation Honeywell products. Honeywell Automation and Control Solutions, offers products and services to improve safety, security, energy & operational efficiency of residential, commercial and industrial customers. Datta holds Ph.D. in Electrical Engineering & Computer Science from University of California at Berkeley.

Flying Robots on Stage—Control and Learning for Aerial Acrobatics
Angela Schoellig, Doctoral Student
Institute for Dynamic Systems and Control
ETH Zurich, Switzerland

This talk is about creating mathematic algorithms that allow machines to learn from experience, play together, and push the boundaries of their capabilities. We visualize the power of the developed algorithms by performing complex flight maneuvers with small agile aerial robots.

Angela Schoellig is pursuing her PhD in engineering with Professor Raffaello D'Andrea at the Institute for Dynamic Systems and Control (IDSC) at ETH Zurich, Switzerland. One of her research interests is cooperative learning in autonomous systems and investigating the benefits of information sharing in this context. Angela is currently also working on a rhythmic flight performance with multiple aerial robots. Showing cutting-edge mathematics in action and sharing scientific knowledge in a public context are important facets of her work.

Angela received her M.Sc. in Engineering Science and Mechanics from the Georgia Institute of Technology (USA) in 2007 and her graduate degree in Engineering Cybernetics from the University of Stuttgart (Germany) in 2008. Her past research experience includes topics such as optimal control of hybrid systems and dynamics of networked systems with communication delays. She has also worked at the European Aeronautic Defense and Space Company (Germany), where she developed distributed estimation and control methods for satellites. For her graduate studies, Angela received scholarships from the German National Academic Foundation, the Cusanuswerk, and the German Academic Exchange Service. She was finalist of the 2008 IEEE Fellowship in Robotics and Automation, which supports students who are expected to have a significant impact on the future of robotics and automation. Her research interests lie in the area of system dynamics, learning and control.

Typical Day at Sea? A Venture into the World of Autonomous Sailing

Katrina Legursky, Doctoral Student
Aerospace Engineering
University of Kansas

A sailing yacht is a complex dynamic system that operates in a very noisy environment, be it winds, waves, or anything that may be encountered on the open ocean. An explanation of the uniqueness and complexity of yacht dynamics will be presented along with a discussion of applications for autonomous sailboats.

Katrina Legursky is a third year doctoral student and Self Fellow pursuing a Ph.D. in aerospace engineering. She received a B.S. (2008) in physics and astronomy with minors in mathematics and art from Benedictine College in Atchison, Kan. During her academic career she has participated in the Cryogenic Dark Matter search, the Meridian UAV project, and taught two summers of aerospace engineering camps for high school students. Her current research interests lie in the dynamics and control of sailing yachts. She is an avid sailor who participates in a local race program and serves as a youth sailing instructor.

Food Processing Controls

Doug Britton, Senior Research Engineer
Program Manager, Agricultural Technology Research Program
Georgia Tech Research Institute

We often don't think about all the processes and engineering jobs that are involved in making things that we use every day. Food is a great example of this. Not only do you need farmers to grow the crops and animals, but you also need processing plants to take the crops and animals and make them into the various foods we eat. Building and operating food processing plants require a lot of different skills, and engineers and scientists have important jobs with respect to making it all work. In the old days, it took a lot of people to work in the food processing plants, but today the modern food processing plant has a lot of automated equipment that does all sorts of tasks. Using automation and controls, food processing plants can produce more food, faster and cheaper than ever before. So the next time you eat a hamburger, or a pizza, or drink some milk, remember that it took a lot of engineering to make that food and get it to you.

Dr. Douglas F. Britton is the Program Manager for the Agricultural Technology Research Program at Georgia Tech. As a Senior Research Engineer with the Georgia Tech Research Institute he Sensors, he works in the Sensors and Systems Group within the Food Processing Technology Division. His research interests include the areas of image and signal processing, generalized Gaussian decompositions, pattern recognition, artificial neural networks, fuzzy logic techniques, and computer and machine vision systems design. Application areas include the development of image processing algorithms to inspect non-uniform/natural product for real-time automatic grading. He has been instrumental in the development of several imaging based systems related to food processing including citrus, baked goods, whole birds and a variety of other poultry related products. Dr. Britton received the B.S. degree in Engineering from LeTourneau University in Longview, Texas, the M.S. degree in Electrical Engineering from the University of Tennessee, and the Ph.D. in Electrical Engineering from the Georgia Institute of Technology. He is a member of the Institute of Electrical and Electronics Engineers (IEEE) and the American Society of Agricultural and Biological Engineers (ASABE).

Wiimotes and Rocket Ships – Learning to Engineer and to Make Problems Simple
Leor Grebler, Academic Solutions Advisor, Quanser
Amirpasha Javid, Research & Development Engineer, Quanser

This presentation will demonstrate some of the tools Quanser uses for teaching future engineers how to control very complex systems. It will cover a day in the life of a Quanser engineer, look at some unmanned vehicles and robotics projects, and show how engineers simplify problems in order to solve them.

As an academic solutions advisor with Quanser, Leor has visited over 70 universities across North America to discuss haptics, robotics, UAVs, mechatronics, and engineering education. He is a big technophile and loves learning and talking about cutting edge technology and engineering research. He holds bachelors in Aerospace Engineering and is a native of Ottawa, Canada.

Pasha attended the University of Toronto and completed his bachelors in Electrical Engineering on 2007, specializing in control engineering, and has been working with Quanser since graduating. His hobbies include winter driving, mixing music, playing soccer and reading academic papers. His technical interests include robotics, unmanned ground and submersible vehicles and, of course, haptics!

Discussion, Workshop Evaluation and Closing Remarks
Bozenna Pasik-Duncan and Bonnie Ferri

Bozenna Pasik-Duncan received her Ph.D. and Habilitation Doctorate degrees from Warsaw School of Economics in 1978 and 1986, respectively. Currently she is Professor of Mathematics, Courtesy Professor of EECS and Investigator in Information and Telecommunications Technology Center at University of Kansas. Her research interests are primarily in stochastic systems and adaptive control and their applications to telecommunication networks, finance, actuarial sciences and biomedicine. Her other interests include interdisciplinary and international research and education in STEM at all levels: K-12, undergraduate, graduate and postgraduate. Dr. Pasik-Duncan is an IEEE Fellow, Distinguished Member of the CSS and recipient of the IEEE Third Millennium Medal. She is a recipient of numerous prestigious teaching awards including national awards. She is author or co-author of more than 150 technical papers and 3 books. She is a strong advocate for women in STEM, and was recently inducted to The KU Women's Hall of Fame. She is the chair of Technical Committees on Control Education of the IEEE CSS, AACC and IFAC, the chair of the IFAC Harold Chestnut Control Engineering Textbook Prize Selection Committee and Editor-in- Chief of IFAC Control Resources Publications.