Ideas and Technology of Control Systems

Monday, December 12, 2011
9:30 am – 2:30 pm
Hilton Orlando Bonnet Creek Hotel

11th Anniversary

This workshop is held in conjunction with the 2011 IEEE Conference on Decision and Control and European Control Conference

control.disp.uniroma2.it/cdcecc2011

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

Organizers: Bozenna Pasik-Duncan, University of Kansas and Chair, AACC and IEEE CSS Control Education Committees

Organizing and Program Committee: Bozenna Pasik-Duncan (Chair), University of Kansas; Richard Murray, California Instiute of Technology; Angela Schoellig, Institute for Dynamic Systems and Control ETH Zurich, Switzerland; Jeannie Falcon, National Instruments; Mark Frei, Flint Hills Scientific, L.L.C.; Tyrone Duncan, University of Kansas

The purpose of this workshop is to increase the general awareness among high school teachers and students of the importance of systems and control technology and its cross-disciplinary nature. 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:

Control Design of Unmanned Aerial Vehicles (UAVs)
Roberto Tempe, Director of Research
IEIIT-CNR
Politecnico di Torino
Torino, Italy

Dr. Tempo's research activities are mainly focused on the study of complex systems with uncertainty. He has been involved in various research projects focused on the design of Unmanned Aerial Vehicles (UAVs) for environmental monitoring, fire detection and prevention, and also natural disaster recognition, see http://staff.polito.it/roberto.tempo/uav.html. He is currently working on the development of tools and algorithms for the computation of PageRank, which is the ranking system used at Google for efficiently listing the search results. PageRank quantifies the importance of webpages by examining the link structure of the entire web. The underlying idea of this ranking system is that pages having incoming links from important pages should be important as well. The main challenge in the computation of PageRank is the size of the web, so that the proposed decentralized randomized algorithms are particularly appealing, see http://staff.polito.it/roberto.tempo/pagerank.html.

Roberto Tempo graduated in Electrical Engineering at Politecnico di Torino, Italy, in 1980. After a period spent at the Dipartimento di Automatica e Informatica, Politecnico di Torino, he joined the National Research Council of Italy (CNR) at the research institute IEIIT, Torino, where he is a Director of Research of Systems and Computer Engineering since 1991. He has held visiting and research positions at Kyoto University, The University of Tokyo, University of Illinois at Urbana-Champaign, German Aerospace Research Organization in Oberpfaffenhofen and Columbia University in New York. Dr. Tempo is author or co-author of more than 170 research papers published in international journals, books and conferences.

He is also a co-author of the book "Randomized Algorithms for Analysis and Control of Uncertain Systems", Springer-Verlag, London, 2005. He is a recipient of the "Outstanding Paper Prize Award" from the International Federation of Automatic Control (IFAC) for a paper published in *Automatica*, and of the "Distinguished Member Award" from the IEEE Control Systems Society. He is a Fellow of the IEEE and a Fellow of the IFAC. Dr. Tempo is currently an Editor and Deputy Editor-in-Chief of *Automatica*, and an Editor at Large of the *Asian Journal of Control*. He has been Editor for *Technical Notes and Correspondence* of the IEEE Transactions on Automatic Control in 2005-2009. In 2010, he served the IEEE Control Systems Society as President and, during the period 2002-2003, as Vice-President for Conference Activities. He was Program Chair of the first joint IEEE Conference on Decision and Control and European Control Conference, which was held in Seville, Spain, in 2005. On these topics he has given several invited lectures at various conferences and workshops, including the recent plenary lectures at the Chinese Control and Decision Conference, Mianyang, China and at the 5th International ICST Conference on Performance Evaluation Methodologies and Tools, Paris, France, both held during Spring 2011.

Joys and Perils of Automation: "Smart Parking" for All

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. See

1. TV interview and story at
http://www.necn.com/09/23/11/JoeBatt-Parkingapp/landing_scitech.html?blockID=566574&feedID=4213

2. Video with how the system and ipHone app works
http://www.bu.edu/buniverse/view/?v=1zqb6NnD

3. Newspaper article
http://news.bostonherald.com/news/columnists/view.bg?articleid=1379225&format=comments#CommentsArea

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.

LEGO Robotics Joins University and High School, Research and Control Education

Alexander L. Fradkov
Institute for Problems of Mechanical Engineering
Russian Academy of Sciences

Lego Mindstorms NXT provides an environment for exciting creative collaboration of teachers and students in control education. In the talk the results of a joint project aimed at organizing such a collaboration involving undergraduate students of St.Petersburg State University and high school students of St.Petersburg Phys&Math Lyceum #239 are presented. The goal of the project is to create a complex of robotics and mechatronics networked devices (mobile robots, carts, pendulum systems, segways, etc) for teaching and research both in universities and in high schools. An interesting and important task is design and testing of proportional, integral and differential controllers. The ideas coming from cooperative work of high school and university students allowed to develop elementary approaches to teaching basics of control theory.

Alexander Fradkov born in St.Petersburg, Russia in 1948, graduated from St.Petersburg State University under supervision of Prof. V.A. Yakubovich. IEEE Fellow, President of the International Physics and Control Society. Coauthor of more than 500 journal and conference papers, 16 books and textbooks, including the books:

- Cybernetical Physics: From Control of Chaos to Quantum Control. Springer, 2007.
- Introduction to Control of Oscillations and Chaos. World Scientific, 1998. (with Pogromsky A.Yu)
- Nonlinear and Adaptive Control of Complex Systems. Kluwer, 1999 (with Miroshnik I.V., Nikiforov V.O.).
- Selected Chapters of Automatic Control Theory. Nauka, 1999 (with Andrievsky B.R., in Russian).

Current research interests are in the area of control of oscillatory and chaotic behavior and particularly in Cybernetical Physics: new area aimed at study of physical systems by cybernetic methods. Organized and co-chaired many international conferences in St.Petersburg, including 13 International Baltic Student Olympiads on Automatic Control in 1991–2010 (next one will take place on Sept 21-23, 2011), and a number of olympiads in cybernetics for high school students. IPC Co-Chair of the next IFAC Symposium on Control Education in Nizhnii Novgorod, Russia on June 20-22, 2012. Creator of RUSYCON - Russian Systems and Control Archive –bilingual web resource containing more than 2000 references to useful sources related to systems and control in Russia and worldwide, including links to general references and databases in systems and control, information and educational sites, virtual laboratories and online experiments, sites on nonlinear dynamics, complexity and chaos, etc. Since 1990 he has been the Head of the "Control of Complex Systems" Lab of the Institute of Problems in Mechanical Engineering of Russian Academy of Sciences. He is also a part-time Professor with the Faculty of Mathematics and Mechanics, Saint Petersburg State University and with National Research University of Information Technologies, Mechanics and Optics.

E-mail: fradkov@mail.ru WWW: ipme.ru/ipme/labs/ccs/

Molecular Control Systems and Synthetic Biology

Elisa Franco, Assistant Professor
Department of Mechanical Engineering
University of California, Riverside

All living organisms, from bacteria to humans, must sense external stimuli and implement adequate responses to survive. Therefore, we can say that biological systems are naturally equipped with feedback control mechanisms. For example, animals regulate their food intake and sleep cycle to adapt to seasonal changes in temperature and daylight duration. We can study biological feedback at many different levels: for instance, we can focus on human and animal behavior, on their motion systems, or on their organs and cells. In this talk I will focus on some of the simplest biological systems we can study: single cells and their building blocks – DNA, RNA and proteins. I will describe the cell as a feedback control system, and provide several examples of how scientists try to understand and build sensing, computation and actuation at the molecular level.

Elisa Franco is an Assistant Professor at the University of California, Riverside, in the department of Mechanical Engineering. She received her B.S. and M.S. (Laurea Degree) in Power Systems Engineering (2002), summa cum laude, and a Ph.D. in Automation (2007) from the University of Trieste (Italy). She earned a second Ph.D. in Control and Dynamical Systems, with focus on feedback design in biochemical networks, from the California Institute of Technology (2011).
http://www.engr.ucr.edu/~efranco/Home.html

Autonomous Systems from Racing Cars to Robots to the Transformers

Ufuk Topcu
Postdoctoral Scholar
Control and Dynamical Systems
California Institute of Technology

This talk is on autonomous systems – cars, robots, and aircraft – which can perform desired tasks without human guidance in a priori unknown, unstructured environments. We discuss some of the progress toward building autonomous systems. Examples from robotics and a recent car racing competition demonstrate the technical problems and accomplishments. We conclude with a set of remaining challenges.

Ufuk Topcu is a postdoctoral scholar in Control and Dynamical Systems at the California Institute of Technology. His research is on systematic analysis, design, and verification of networked, information-based systems with applications in autonomy, advanced vehicle technologies, and energy networks. He received his Ph.D. in 2008 from the University of California, Berkeley. http://www.cds.caltech.edu/~utopcu/index.php/Main_Page

Applications of Math and Control Theory to the Problem of Epilepsy

Mark Frei
Flint Hills Scientific, L.L.C.
Lawrence, KS

Epilepsy is the most serious, prevalent neurological disorder spanning all age groups. In this talk, we describe how control theory and mathematical signal analysis have played an invaluable role in the understanding of brain dynamics and have been successfully applied to rapidly and accurately detect and automatically treat epileptic seizures.

Mark G. Frei is co-founder of Flint Hills Scientific, L.L.C., Lawrence, Kansas. He specializes in real-time quantitative analysis, filtering, identification and control of complex systems and signals and in algorithm development for intelligent medical devices. He is an inventor on over 30 patents, including several involving epileptic seizure detection. Prior to joining FHS, Dr. Frei was a post-doctoral fellow at the University of Kansas, in the Kansas Institute for Theoretical and Computational Science, the Comprehensive Epilepsy Center, and the Department of Mathematics. He received his Ph.D. in mathematics from K.U., with research specialties in the fields of modeling, prediction, and adaptive control of complex systems, and has authored or co-authored several scientific articles. He received his M.S. in applied mathematics/electrical engineering from the University of Southern California and B.A. in mathematics from UCLA. Prior to his doctoral training at the University of Kansas, Dr. Frei was a member of the technical staff of TRW, Inc. in Redondo Beach, CA. http://www.fhs.lawrence.ks.us/

An Overview of Capstone Design Programs

Bahram Shafai, Professor
Electrical and Computer Engineering and
Director of the ECE Capstone Design Program
Northeastern University

The goal of this session is to give an overview of the capstone design program and to show sample design projects completed by past undergraduate students at Northeastern University, Boston. The selected projects consider all aspects of design for electromechanical systems including sensors, signal processing, programming, communications, and control. One such design is related to Brain Computer Interface, in which a user can control a robot movement by looking at various quadrants on a computer screen.

Bahram Shafai received the Diplomas (BS and MS) in Electrical Engineering from the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland in 1976 and 1978; and the Ph.D. degree in Electrical Engineering from the George Washington University in 1985. He joined Northeastern University in 1985 and served as the Director of the Communications and Digital Signal Processing Center (CDSP) from 1990 to 1992. Currently, he is a Professor in the Department of Electrical and Computer Engineering and the Director of the ECE Capstone Design Program at Northeastern University.
He served as session chairman and as a member of organizing committee in various IEEE organized conferences such as CDC and ACC as well as World Congresses of IFAC and WAC. He was an Associate Editor of *Computer and Electrical Engineering: An International Journal*. Over the past few years, he served as Associate Editor, Conference Editorial Board of Control Systems Society and a member of organizing committee for CDC in several capacities. Currently, he is the Associate Editor for *IEEE Transactions on Systems Journal*. He is active within control systems and signal processing societies and published numerous papers in both areas. He is the co-author of a book and several edited volumes in robust control. His research interests include robust multivariable control systems, digital signal processing, and communications. Currently, he is conducting research in observer-based fault detection, robust stability of time-delay systems, distributed control of multi-agent systems, adaptive signal processing, fuzzy and robust control with applications. http://www.bahramshafai.com/#/+-HOME-01-00/

A Cube That Balances Itself on a Corner
Sebastian Trimpe, Doctoral Student
Institute for Dynamic Systems and Control
ETH Zurch, Switzerland

When you put an ordinary cube on one of its corners and let it go, it will fall. The Balancing Cube is different - you can put it on any of its corners, and it will balance. Six rotating mechanisms located on each of the cube's faces make balancing possible. Multiple times every second, the mechanisms sense the cube's motion, compute corrections based on these measurements, and rotate accordingly. It is through this continual feedback pro≠cess of sensing, computing, and adjusting that the system as a whole is able to balance. The fundamental concept of feedback control is illustrated in this presentation by discussing how the Balancing Cube works.

Sebastian Trimpe works with Prof. Raffaello D'Andrea as a doctoral student at ETH Zurich in Switzerland. His current research interests are in distributed and networked estimation and control. Sebastian received the B.S. degree in General Engineering Science in 2005 and the M.S. degree in Electrical Engineering two years later, both from Hamburg University of Technology, Germany. In 2007, he spent eight months as a research scholar at the University of California, Berkeley. He is recipient of the General Engineering Award for the best undergraduate degree, a scholarship from the German National Academic Foundation, and the triennial best interactive paper prize from the International Federation of Automatic Control. http://www.idsc.ethz.ch/people/staff/trimpe-s

Control Systems – from LEGO to Industrial Machines
Margaret Barrett
Academic Marketing Engineer for Controls, Robotics, and Mechatronics
National Instruments

Are you a creative problem solver? Using a LEGO NXT robot, learn how you can apply the engineering concepts you are learning to solve some of the world's most complex engineering problems. We will discuss how LabVIEW graphical programming and the latest technology is used to solve engineering problems and the world's greatest challenges. Through math, science and engineering, find out how you have the ability to change the world of tomorrow.

Margaret Barrett joined ELP in August 2008 after graduating from Texas A&M with a degree in Biomedical Engineering. She worked on our high precision data acquisition products team where she established herself as the department expert in NI ELVIS II+ and Multisim. Margaret has actively pursued a career in NI's Academic Marketing department by continually taking on key projects with that group, such as assisting with the NI ELVIS II+ product launch and writing a book now offered by NI on how to instruct students on LabVIEW and NI ELVIS. Margaret is now a Team Manager in the ELP department, a position that she has held for the past year. http://www.ni.com/

How to Control Unmanned Vehicles
Leor Grebler, Academic Solutions Advisor
Quanser

Autonomous vehicles are becoming more researched and it won't be long before most cars, trucks, and planes drive themselves. This presentation will cover some of projects Quanser has worked on for autonomous vehicles and will demo the building of a controller for an unmanned car using a virtual driving simulator.

Leor Grebler is an academic solutions advisor with Quanser. He 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. http://www.quanser.com/english/html/home/fs_homepage.html

Discussion, Workshop Evaluation and Closing Remarks
Bozenna Pasik-Duncan

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. http://www.math.ku.edu/ksacg/Bozenna.html

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