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WELCOME FROM GENERAL CHAIR

On behalf of the American Automatic Control Council (AACC) and the Program and Operating Committees, I am delighted to welcome you to the 2005 American Control Conference (ACC). Held under the auspices of AACC, the US National Member Organization of the International Federation of Automatic Control (IFAC), the ACC brings together people working in control, automation, and related areas from the American Institute of Aeronautics and Astronautics (AIAA), American Institute of Chemical Engineers (AIChE), Association of Iron and Steel Engineers (AISE), American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), Institute of Electrical and Electronics Engineers (IEEE), the International Society for Measurement and Control (ISA), and the Society for Computer Simulation (SCS).

This is the first time in the history of the ACC the conference is being held in this beautiful city of Portland, Oregon and I hope you will find the time to enjoy its many attractions. This is the time of the famous Portland Rose Festival and you will have an opportunity to watch the nation's second-largest all-floral parade from the hotel. Nestled in the heart of the Willamette Valley, Portland sits squarely between the Pacific Ocean (90 minutes by car) and the 10,000 plus foot tops of the Cascade Mountain Range (Mount Hood is 1 hour by car). A 45 minute drive east from town will get you to the middle of the Columbia Gorge National Scenic Area, a place of breathtaking beauty which includes the 620-foot Multnomah Falls. Portland's downtown area is scaled to human dimensions. The blocks are short, just 200 feet long. Cafes, restaurants, bookstores, galleries and specialty stores are waiting around every corner. Green suited "Portland Guides" walk through downtown streets day and night answering questions and helping with directions. Tri-Met, Portland's mass transit system, and MAX, Tri-Met's light rail system allow free rides in the Fareless Square, a region encompassing much of the downtown area and extending into the Lloyd District, including the Oregon Convention Center and the Rose Quarter. One hundred acre Washington Park in the west hills above Portland encompasses the International Rose Test Gardens with more than 400 varieties of roses, the peaceful contemplation of the Japanese Gardens and the Oregon Zoo with its world-class elephant exhibit. There are many things to see and do for everyone, from little children to adults, while you are here and I hope you will take advantage of the many tours that we put together for you and your family's enjoyment.

The annual American Control Conference begun in 1982 has always been an outstanding success. Thanks to the dedication and hard work of our volunteers on the operating and program committees and the numerous anonymous reviewers over the past two years, ACC2005 is no exception. We have three full days of great technical papers, a total of over 900 papers from many countries around the world presented in eighteen parallel tracks; three plenary sessions; 12 industry tutorial sessions featuring a one-hour tutorial presentation on an industrially proven but still relatively new technique followed by a series of short presentations from industrial participants discussing the implementation, application, and benefits of the technique and cover a number of topics of high industrial relevance; two interactive sessions; a number of special sessions; three 2 day and three 1 day workshops covering emerging topics to some more established ones; and several social events and organized sightseeing tours.

Our program was designed to respond to your needs whether you are a long term practitioner or new to the controls community. Our goal is to help you understand and advance the state of the art in controls through our papers, tutorials, workshops and exhibits. For over 20 years the ACC has been one of the premier international conferences for controls professionals to come together and share experiences, research and knowledge. I hope you will take full advantage of these three days to learn new things, meet new people, and advance your own knowledge and experiences.

We are glad you are here in Portland at the 2005 ACC and hope you will have a wonderful time and take back happy memories. The following pages of the final program will give you more information about the conference. If you have any questions please do not hesitate to stop by the conference registration desk or ask any volunteer on the operating committee.

Suhada Jayasuriya
General Chair, 2005 ACC

TECHNICAL PROGRAM OVERVIEW

The 2005 ACC technical program is an excellent show case for emerging areas in control as well as traditional control disciplines. The spectrum of topics addressed in the papers should be of interest to the conference attendees with diverse backgrounds and interests. This program shows a continuing upward trend in the number of application papers in numerous areas which include aerospace, automotive industry, power, chemical process, communications, networks, and bio-systems, micro and nano-systems and more. There are many tutorial sessions of two-hour duration on the state of the art work in theory and applications which will provide every attendee with an in-depth understanding of a variety of important current topics. The invited sessions which consist of theme based papers have been organized by well-known experts in topics as diverse as biological modeling, mechatronics, networked systems, MEMS, nano applications, cooperative control etc. This year's program continues to have the valuable forum called the interactive sessions as previous ACCs which facilitates easier and stimulating exchanges between the attendees and the presenter.

The 2005 ACC offers special sessions: technical and informative. These consist of sessions dealing with scanning probe microscopy and synthesis of genetic networks and history of control. There are sessions appealing to attendees young and not too young on NSF funding opportunities and mid-career job change. The 2005 technical program also offers workshops on important and emerging areas of control.

Following is a summary of the papers submitted and accepted.

Number of Papers Submitted		1664
Number of Papers Accepted		921
Regular Papers	730	
Invited Papers	105	
Short Papers	29	
Interactive Papers	6	
Tutorial Papers	51	

PLENARY LECTURES

Plenary 1: Wednesday, June 8, 2005

Control Challenges for the Next Century of Flight

Colonel Michael B. Leahy
Director, Air Vehicles Directorate
Air Force Research Laboratory

Abstract:
The previous century witnessed remarkable advances in the science and technology of flight. We were so successful, that many now view us as masters of the aerospace domain and the supporting science and technology are mature or even sunset. Nothing could be further from the truth. There are many game changing aerospace system concepts within our collective reach as we begin our journey into the second century of flight.

One of the primary missions of the Air Force Research Laboratory is to define our future air forces. We envision alternative futures and then lead the process of discovery, development and transition into war winning solutions. Increasingly those solutions can not be achieved by a single technical advance, but rather by integrating a set of science and technology activities toward enabling a system level capability. As the director responsible for integrated solutions across the air domain, my talk will introduce the future capability vectors we are focused on. Within each of those I will discuss some of the specific controls challenges this community needs to solve to have a game changing impact. Topics range from "traditional" adaptive flight control to flights of intelligent unmanned systems operating in unison with their manned counterparts with applications from micro air vehicles to "airplane like" access to space.

By definition my list of challenges will be incomplete but hopefully stimulating enough to encourage at least a few of the creative minds in the audience to take up the challenge of bringing the next century of flight from vision to reality.

Biography:

Colonel Michael B. Leahy Jr. is currently director of the Air Vehicles Directorate, Air Force Research Laboratory and Commander of the Wright Research Site. He leads the $195 million science and technology development of air vehicles for the United States Air Force. This program is executed by 550 Air Force civilian, military, and contractors comprising three technical divisions in aeronautical sciences, control sciences, and advanced structures as well as an operations and integration division. Colonel Leahy is responsible for planning, programming, and executing programs to sustain the current fleet of aircraft, enable the evolution of unmanned air vehicles into combat roles, and to provide affordable access to space and high speed operations. In addition, Colonel Leahy manages the infrastructure including high performance computing, modeling and simulation facilities, and structural test facility required to support this program.

Colonel Leahy entered the United States Air Force in 1980 as a distinguished graduate of the Stevens Institute of Technology Reserve Officer Training Corps program. His assignments include tours in the laboratory, logistics and product centers, headquarters, and OSD. He began his AF career as an instrumentation engineer on the Airborne Laser Laboratory, was a senior command sponsored civilian institute candidate for his PhD, rose to the rank of associated professor of electrical engineering at the Air Force Institute of Technology, lead the Air Force Material Command Robotics and Automation Center of Excellence, served on the headquarters staff of the Air Force Research Laboratory and was the deputy director for Combat UAVs at the Aeronautical Systems Center before serving at the Defense Advanced Research Projects Agency (DARPA) as the director of the joint DARPA/USAF Unmanned Combat Air Vehicle program. During that time he has published over 50 papers in archival journals and conferences and is the founding editor of the IEEE Robotics and Automation Society Magazine.

Colonel Leahy received his BS from Stevens Institute of Technology in 1980, MS from University of New Mexico in 1983, and Ph.D. from Rensselaer Polytechnic Institute in 1986 all in Electrical Engineering. He is the recipient of numerous awards that include the Defense Superior Service Medal, Meritorious Service Medal with three oak leaf clusters, Air Medal, Air Force Achievement Medal with oak leaf cluster, Air Force Institute of Technology Outstanding Professor of the Year, Air Force Material Command, General (Ret) James Ferguson Engineering Award, Department of the Air Force Federal Engineer of the Year, and Association for Unmanned Systems International Pioneer Award

Plenary 2: Thursday, June 9, 2005

Autonomous Machines: Racing to Win the DARPA Grand Challenge

Richard M. Murray
Control and Dynamical Systems
California Institute of Technology

Abstract:
The DARPA Grand Challenge is a desert road race from Los Angeles to Las Vegas that will take place for the second time on 8 October 2005, with a grand prize of $2 million. Competing teams must build a vehicle that can operate autonomously and drive itself along a 175-mile course -- including dirt roads, trails, open desert and man-made obstacles -- in 10 hours or less.

The competition provides a unique setting for testing ideas in perception, decision making, systems integration and autonomy.

The results from last year's race provide important lessons for information-rich, networked control systems and autonomy in highly uncertain environments. This year's race will feature teams from around the country who are bringing new research approaches to develop machines with human-like capabilities. Particular emphasis will be given to future directions in control, dynamics and systems motivated by this class of applications.

Biography:

Richard M. Murray 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. He is currently a Professor of Control and Dynamical Systems at the California Institute of Technology, Pasadena. Professor Murray's research is in the application of feedback and control to mechanical, information, and biological systems. Current projects include information dynamics in networked feedback systems, analysis of insect flight control systems, autonomous desert racing for fun and profit, and synthetic biology using genetically-encoded finite state machines. Professor Murray is currently developing 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.

Plenary 3: Friday, June 10, 2005

Control of Nonlinear Distributed Process Systems

Panagiotis D. Christofides
University of California, Los Angeles

Abstract:
Over the last ten years, key technological needs in growth areas such as semiconductor manufacturing, nanotechnology and biotechnology have motivated extensive research on analysis and control of complex distributed processes. Examples include film spatial uniformity and microstructure control in the chemical vapor deposition of thin films, temperature profile control in the Czochralski crystallization of high-purity crystals, as well as

control of size distribution in the crystallization of proteins and the aerosol-based production of nanoparticles. From a control point of view, the distinguishing feature of complex distributed processes is that they give rise to nonlinear control problems that involve the regulation of highly distributed control variables by using a finite number of spatially-distributed control actuators and measurement sensors. Thus, complex distributed processes cannot be effectively controlled with control methods which assume that the state, manipulated and to-be-controlled variables exhibit lumped behavior or with linear control algorithms derived on the basis of linear/linearized distributed models.

We have developed a general and practical framework for the synthesis of practically implementable nonlinear feedback controllers for complex distributed processes based on fundamental models that accurately predict their behavior. The key difficulty in developing model-based control methods for distributed processes lies in the infinite-dimensional nature of the process models, which prohibits their direct use for control system synthesis. We have developed nonlinear order reduction techniques for deriving low-dimensional approximations that accurately reproduce the dynamics and solutions of distributed process models. We have used these approximate models for the synthesis of nonlinear feedback controllers via geometric, predictive and Lyapunov-based control methods. The controllers can be readily implemented in practice and enforce the desired control objectives in the infinite-dimensional closed-loop system. We will present applications of the theoretical results to: a) temperature profile control in rapid thermal chemical vapor deposition and crystal growth, b) control of microstructure and composition in thin film growth including an experimental implementation, and c) control of size distribution in crystallization.

Biography:

Panagiotis D. Christofides was born in Athens, Greece, in 1970. He received the Diploma in Chemical Engineering degree in 1992 from the University of Patras, Greece, the M.S. degrees in Electrical Engineering and Mathematics, in 1995 and 1996, respectively, and the Ph.D. degree in Chemical Engineering in 1996 all from the University of Minnesota.

Since July 1996 he has been with the Department of Chemical Engineering at the University of California, Los Angeles, where he is currently Professor. His theoretical research interests include nonlinear control, singular perturbations, and analysis and control of distributed parameter systems, multiscale systems and hybrid systems, with applications to advanced materials processing, particulate processes, biological systems and fluid flows. His research work has resulted in a large number of articles in leading scientific journals and conferences and two books entitled *Nonlinear and Robust Control of PDE Systems: Methods and Applications to Transport-Reaction Processes* (Birkhäuser, 2001) and *Model-Based Control of Particulate Processes* (Kluwer Academic, 2002). He has also co-authored (with N. H. El-Farra) the forthcoming book *Control of Nonlinear and Hybrid Process Systems: Designs for Uncertainty, Constraints and Time-Delays* (Springer, 2005).
A description of his research interests and a list of his publications can be found at http://www.chemeng.ucla.edu/pchristo/index.html.

Professor Christofides has been a member of the Control Systems Society Conference Editorial Board, the 2004 Program Coordinator of the Applied Mathematics and Numerical Analysis Area of AIChE and the Program Vice-Chair for Invited Sessions for the 2004 American Control Conference. He is currently an Associate Editor of IEEE Transactions on Automatic Control.

Professor Christofides has received the Teaching Award from the AIChE Student Chapter of UCLA in 1997, a Research Initiation Award from the ACS-Petroleum Research Fund in 1998, a CAREER award from the National Science Foundation in 1998, the Ted Peterson Student Paper Award from the Computing and Systems Technology Division of AIChE in 1999 and a Young Investigator Award from the Office of Naval Research in 2001. He has also received twice the O. Hugo Schuck Best Paper Award in 2000 (with A. Armaou) and 2004 (with D. Ni, Y. Lou, L. Sha, S. Lao and J. P. Chang), and the Donald P. Eckman Award in 2004, all from the American Automatic Control Council.

AACC AWARDS FOR 2005

The American Automatic Control Council presents a series of awards each year to recognize important contributions to the field. The roster of award winners this year includes *Gene F. Franklin*, the Richard E. Bellman Control Heritage Award recipient, *Shankar Sastry*, the John R. Ragazzini Award recipient, *George Meyer*, the Control Engineering Practice Award recipient, *Pablo Parrilo*, the Donald P. Eckman Award recipient, and the O. Hugo Schuck Best Paper Award recipients. These award winners, in addition to the Best Student Paper Award winner, will be recognized at the Awards Luncheon.

The 2005 AACC Award Committee Members are:
Masayoshi Tomizuka (Chair)
Michael Safonov (Richard Bellman Control Heritage Award Subcommittee Chair)
Jessy W. Grizzle (John R. Ragazzini (Education) Award Subcommittee Chair)
Kameshwar Poolla (Eckman Award Subcommittee Chair)
Stephen Yurkovich (Control Engineering Practice (CEP) Award Subcommittee Chair)
Faryar Jabbari (O. Hugo Schuck Best Paper Awards Subcommittee Chair)

Richard E. Bellman Control Heritage Award: *Gene F. Franklin*

The **Richard E. Bellman Control Heritage Award** is given for distinguished career contributions to the theory or applications of automatic control. It is the highest recognition of professional achievement for US control systems engineers and scientists. The recipient must have spent a significant part of his or her career in the USA.

Citation: "For his extraordinary lifetime contributions to control theory and its engineering application."

Gene F. Franklin received the Bachelor's degree in Electrical Engineering from Georgia Tech in 1950 the Master of Science in Electrical Engineering from MIT in 1952, and the Doctor of Engineering Science degree in Electrical Engineering from Columbia University in 1955. He was appointed Assistant Professor of Electrical Engineering at Columbia University from 1955-1957 and has been on the Faculty of Electrical Engineering at Stanford University since 1957 where he is now Professor of Electrical Engineering, Emeritus. He was Vice Chairman of the Department of Electrical Engineering from 1989-1994 and was Chairman of the Department for the 1994-1995 He was Director of the Information Systems Laboratory from its founding in 1962 until 1971 and was Associate Provost for Computing for Stanford University from 1971-1975.

He is co-author of three books: *Sampled Data Systems*, *Digital Control of Dynamic Systems* and *Feedback Control of Dynamic Systems*. The Second Edition of the last of these books received the IFAC prize as the best book in the controls area published during the period 1987-1990; the fifth edition is now in preparation. Professor Franklin has supervised the research of over 60 Ph.D. candidates in many aspects of control and systems.

He has for many years been an active member of the IEEE. He joined as a Student Member in April, 1950, and became a Life Fellow of the Institute in January, 1993. He was on the Board of Directors of the CSS from 1982 until 1988 and was Vice President for Technical Affairs for 1985 and 1986. He was General Chairman of the JACC of 1964 and General Chairman of the CDC in 1984. He received the Ragazzini Education Award of the AACC for 1985,.and gave the Bode Lecture at the1994 CDC. He is a Distinguished Member of the CSS and Franklin and Abramovitch were awarded the prize for the best paper published in the CSM in 2003 for their review of the control of disk drives.

John R. Ragazzini (Education) Award: *Shankar Sastry*

The **John R. Ragazzini Award** is given to recognize outstanding contributions to automatic control education in any form. These contributions can be from any source and in any media, i.e., electronic, publications, courses, etc.

Citation: "For outstanding contributions to education in adaptive, nonlinear and hybrid control systems, and robotics through mentoring of undergraduate and graduate students, development of textbooks, course materials, and experimental laboratories."

S. Shankar Sastry is currently the Director of CITRIS (Center for Information Technology in the Interests of Society) an interdisciplinary center spanning UC Berkeley, Davis, Merced and Santa Cruz. He served as Chairman, Department of Electrical Engineering and Computer Sciences, University of California, Berkeley from January, 2001 through June 2004. In 2000, he served as Director of the Information Technology Office at DARPA. From 1996-1999, he was the Director of the Electronics Research Laboratory at Berkeley, an organized research unit on the Berkeley campus conducting research in computer sciences and all aspects of electrical engineering. He is the NEC Distinguished Professor of Electrical Engineering and Computer Sciences and a Professor of Bioengineering.

Dr. Sastry received his Ph.D. degree in 1981 from the University of California, Berkeley. He was on the faculty of MIT as Asst. Professor from 1980-82 and Harvard University as a chaired Gordon McKay professor in 1994. He has held visiting appointments at the Australian National University, Canberra the University of Rome, Scuola Normale and University of Pisa, the CNRS laboratory LAAS in Toulouse (poste rouge), Professor Invite at Institut National Polytechnique de Grenoble (CNRS laboratory VERIMAG), and as a Vinton Hayes Visiting fellow at the Center for Intelligent Control Systems at MIT. His areas of research are embedded and autonomous software, computer vision, computation in novel substrates such as quantum computing, nonlinear and adaptive control, robotic telesurgery, control of hybrid systems, embedded systems, network embedded systems, sensor networks and biological motor control. Most recently he has been concerned with cybersecurity and critical infrastructure protection.

His most recent book "An Invitation to 3D Vision: From Images to Models" co-authored with Y. Ma, S. Soatto, and J. Kosecka was published by Springer Verlag in November 2003.. *Nonlinear Systems: Analysis, Stability and Control* was published by Springer-Verlag in 1999. He has coauthored over 300 technical papers and 9 books, including *Adaptive Control: Stability, Convergence and Robustness* (with M. Bodson, Prentice Hall, 1989) and *A Mathematical Introduction to Robotic Manipulation* (with R. Murray and Z. Li, CRC Press, 1994). He has co-edited *Hybrid Control II*, *Hybrid Control IV* and *Hybrid Control V* (with P. Antsaklis, A. Nerode, and W. Kohn, Springer Lecture Notes in Computer Science, 1995, 1997, and 1999, respectively) and co edited *Hybrid Systems: Computation and Control* (with T. Henzinger, Springer-Verlag Lecture Notes in Computer Science, 1998) and *Essays in Mathematical Robotics* (with Baillieul and Sussmann, Springer-Verlag IMA Series). Dr. Sastry served as Associate Editor for numerous publications, including: *IEEE Transactions on Automatic Control; IEEE Control Magazine; IEEE Transactions on Circuits and Systems; the Journal of Mathematical Systems, Estimation and Control; IMA Journal of Control and Information; the International Journal of Adaptive Control and Signal Processing; Journal of Biomimetic Systems and Materials.*

Dr. Sastry was elected into the National Academy of Engineering in 2001 "for pioneering contributions to the design of hybrid and embedded systems." He was elected to the American Academy of Arts and Sciences (AAAS) in 2004. He is on the Air Force Science Board and is Chairman of the Board of the International Computer Science Institute. He is also a member of the boards of the Federation of American Scientists and ESCHER (Embedded Systems Consortium for Hybrid and Embedded Research). He also received the President of India Gold Medal in 1977, the IBM Faculty Development award for 1983-1985, the NSF Presidential Young Investigator Award in 1985 and the Eckman Award of the American Automatic Control Council in 1990, an M. A. (honoris causa) from Harvard in 1994, Fellow of the IEEE in 1994, the distinguished Alumnus Award of the Indian Institute of Technology in 1999, and the David Marr prize for the best paper at the International Conference in Computer Vision in 1999.

He has supervised over 50 doctoral students to completion and over 50 MS students. His students now occupy leadership roles in several locations and on the faculties of many major universities in the United States and abroad.

Control Engineering Practice Award: *George Meyer*

The **Control Engineering Practice Award** is given to an individual or team for significant contributions to the advancement of the practice of automatic control. The primary criterion for selection is the application and implementation of innovative control concepts, methodology, and technology, for the planning, design, manufacture and operation of control systems. Achievement and usefulness will be evidenced by the benefit to society and by the degree of acceptance by those who use control as a tool. The work on which the nomination is based must have been performed while the nominated individual or at least one member of the team was a resident of the USA.

Citation: "For outstanding achievement in the development of feedback linearization and its application to aerospace systems".

George Meyer received the degrees of B.S., M.S. and Ph.D., all in Electrical Engineering, and all from the University of California at Berkeley. He has been employed by the NASA Ames Research Center since 1963. His research focused on spacecraft attitude control, aircraft flight control, and currently, on air traffic control. The research is typically done in collaboration with several universities through university research grants. He received awards from NASA and IEEE for his contributions to the nonlinear control theory. He is a Fellow of the IEEE.

Donald P. Eckman Award: *Pablo Parrilo*

The **Donald P. Eckman Award** recognizes an outstanding young engineer in the field of automatic control. The recipient must be younger than 35 years on January 1 in the year of the award. Contributions may be technical or scientific publications, theses, patents, inventions, or combinations of the above in the field of automatic control made while the nominee was a resident of the USA.

Citation: “In recognition of pioneering contributions to the development of computational tools for optimization and robust control system design”

Pablo A. Parrilo received an Electronics Engineering undergraduate degree from the University of Buenos Aires, and a Ph.D. in Control and Dynamical Systems from the California Institute of Technology in 1995 and 2000, respectively. He has held short-term visiting appointments at the University of California at Santa Barbara (Physics), Lund Institute of Technology (Automatic Control), and UC Berkeley (Mathematics). From October 2001

through September 2004, he was Assistant Professor of Analysis and Control Systems at the Automatic Control Laboratory of the Swiss Federal Institute of Technology (ETH Zurich). He is currently an Associate Professor at the Department of Electrical Engineering and Computer Science of the Massachusetts Institute of Technology, where he is affiliated with the Laboratory for Information and Decision Systems (LIDS) and the Operations Research Center (ORC).

Prof. Parrilo was a finalist for the Tucker Prize of the Mathematical Programming Society for the years 2000-2003. His research interests include optimization methods for engineering applications, control and identification of uncertain complex systems, robustness analysis and synthesis, and the development and application of computational tools based on convex optimization and algorithmic algebra to practically relevant problems in engineering, economics, and physics.

O. Hugo Schuck Best Paper Awards for 2004

The **O. Hugo Schuck Awards** are given to recognize the best two papers presented at the previous American Control Conference. One award is for a paper emphasizing contributions to theory and the other award is for a paper emphasizing significant or innovative applications. Criteria for selection include the quality of the written and oral presentation, the technical contribution, timeliness, and practicality.

The award winning paper for theory is:

"Output Feedback Sampled-Data Stabilization of Nonlinear Systems," by *H.K. Khalil,* ACC 2004, Paper: ThA13.5.

Hassan K. Khalil received the B.S. and M.S. degrees from Cairo University, Egypt, and the Ph.D. degree from the University of Illinois, Urbana-Champaign, in 1973, 1975, and 1978, respectively, all in Electrical Engineering.

Since 1978, he has been with Michigan State University, East Lansing, where he is currently a University Distinguished Professor of Electrical and Computer Engineering. He has consulted for General Motors and Delco Products.

He has published several papers on singular perturbation methods, decentralized control, robustness, nonlinear control, and adaptive control. He is author of the book Nonlinear Systems (Macmillan, 1992; Prentice Hall, 1996 and 2002), coauthor, with P. Kokotovic and J. O'Reilly, of the book Singular Perturbation Methods in Control: Analysis and Design (Academic Press, 1986; SIAM 1999), and coeditor, with P. Kokotovic, of the book Singular Perturbation in Systems and Control (IEEE Press, 1986). He was the recipient of the 1983 Michigan State University Teacher Scholar Award, the 1989 George S. Axelby Outstanding Paper Award of the IEEE Transactions on Automatic Control, the 1994 Michigan State University Withrow Distinguished Scholar Award, the 1995 Michigan State University Distinguished Faculty Award, the 2000 American Automatic Control Council Ragazzini Education Award, and the 2002 IFAC Control Engineering Textbook Prize. He has been an IEEE Fellow since 1989 and was named University Distinguished Professor in 2003.

Dr. Khalil served as Associate Editor of IEEE Transactions on Automatic Control, 1984 - 1985; Registration Chairman of the IEEE-CDC Conference, 1984; Finance Chairman of the 1987 American Control Conference (ACC); Program Chairman of the 1988 ACC; General Chair of the 1994 ACC; Associate Editor of Automatica, 1992-1999; Action Editor of Neural Networks, 1998-1999; and Member of the IEEE-CSS Board of Governors, 1999-2002. Since 1999, he has been serving as Editor of Automatica for nonlinear systems and control.

The award winning paper for applications is:

"Mixture Kalman Filter Based Highway Congestion Mode and Vehicle Density Estimator and its Application," by *X. Sun, L. Munoz and R. Horowitz,* ACC 2004, Paper: ThA05.1.

Xiaotian Sun was born in Shaoxing, China, in 1975. He received his B.S. degree in Electronics Science and Engineering from Nanjing University, China, in 1997, his M.A. degree in Mathematics in 2003, and his Ph.D. degree in Mechanical Engineering in 2005, both from the University of California at Berkeley. His research interests include intelligent control, matrix computation, mathematical optimization, and statistical learning, with applications to control of freeway and other complex networks, micro-electromechanical system (MEMS), and intelligent vehicle and highway systems (IVHS). He is a student member of the IEEE.

Laura Matiana Muñoz received her B.S. in Engineering and Applied Science from the California Institute of Technology in 1997. In 2004, she completed her Ph.D. in Mechanical Engineering at the University of California, Berkeley. She is currently a post-doctoral researcher in the Department of Mechanical Engineering at Berkeley. Her research interests include analysis and design of control systems, nonlinear control, traffic flow modeling, mechatronics, and hybrid systems.

Roberto Horowitz was born in Caracas, Venezuela in 1955. He received a B.S. degree with highest honors in 1978 and a Ph.D. degree in 1983 in Mechanical Engineering from the University of California at Berkeley. In 1982 he joined the Department of Mechanical Engineering at the University of California at Berkeley, where he is currently a Professor. Dr. Horowitz teaches and conducts research in the areas of adaptive, learning, nonlinear and optimal control, with applications to Micro-Electromechanical Systems (MEMS), computer disk file systems, robotics, mechatronics and Intelligent Vehicle and Highway Systems (IVHS). He is a member of IEEE and ASME.

2006 AACC Awards – Nominations Due December 1, 2005

Nominations for the five AACC awards for 2006 are now being solicited. Each award consists of a certificate and an honorarium and will be presented at the Awards Banquet during the 2006 ACC in Minneapolis, Minnesota. Nomination packages should be prepared in accordance with the AACC Award Nomination Form (which can be obtained from the AACC web site at **www.a2c2.org/awards** or from the AACC Secretary, Pradeep Misra) and include the following: biographical information, a statement identifying and evaluating the accomplishments on which the nomination is based (not to exceed two double-spaced pages), a minimum of three and maximum of five reference letters, a current list of publications and patents, and any additional supporting material that could have a bearing on the award. All materials should be collected in a single package and the original together with six (6) copies should be submitted at the same time. The nomination package is due by December 1, 2005, and should be sent to:

Dr. Pradeep Misra
Department of Electrical Engineering
Wright State University
3640 Colonel Glenn Highway
Dayton, OH 45435-0001

Tel: (937) 775-5037
Fax: (937) 775-3936
Email: pmisra@cs.wright.edu

CONFERENCE INFORMATION

Conference Registration

All conference attendees must register. Personal badges will be provided to identify registered participants. All registered participants will receive a CD-ROM containing the conference proceedings. Member and Non-member registration also includes the Awards Luncheon on Thursday, June 9. Registration fees are as follows:

Registration Categories	Advance Registration Fee (before May 2)	On-Site or after May 2 Registration Fee	CD-ROM Proceedings	Awards Banquet
Member	$380	$450	Included	Included
Non-Member	$470	$560	Included	Included
Student/Retiree	$170	$200	Included	No

Workshop Fees	Attending ACC	Not Attending ACC	Student / Retiree
2-day Workshop	$460.00	$580.00	$180.00
1-day Workshop	$300.00	$380.00	$120.00

On- Site Registration

On- site registration may be done at the Registration Desk, located at the Portland Hilton Hotel. Packets for all advance registrations will also be at the registration desk. The Registration Desk will be in operation during the following hours:

Sunday, June 5	4:00 pm – 7:00 pm	**Wednesday, June 8**	7:30 am – 6:00 pm
Monday, June 6	7:30 am – 6:00 pm	**Thursday, June 9**	7:30 am – 3:00 pm
Tuesday, June 7	7:30 am – 6:00 pm	**Friday, June 10**	7:30 am - 12:00 noon

Printed Proceedings

Printed proceedings are not included in any of the registration fees, but can be ordered either when registering in advance or at the conference. The printed proceedings will be mailed after the conference using fourth class or book rate.

Printed Proceedings	$500	**Additional CD- ROMs**	$50

Author's Breakfast

Wednesday June 8th, Thursday June 9th, & Friday June 10th
Location: Salon I, II, & III (which is in the Executive Tower across the street from the Hilton)
Time: 7:00-8:00 AM

Welcome reception
Tuesday, June 7th
Location: Hilton-Grand Ballroom
Time: 6:00-8:00 PM

Closing reception
Friday, June 10th
Location: World Trade Center (121 SW Salmon, Portland OR 97204)
(a short walk from the hotel).
Time: 7:00-9:00 PM

Awards banquet
Thursday, June 9th
Location: Grand Ballroom of the Hilton
Time: 11:30AM-1:30PM

Special Events
Portland Spirit river boat cruise social event:
Thursday, June 9th
Location: aboard the Portland Spirit (Boarding will take place at SW Naito & Salmon Streets. This is within walking distance of the hotel and right across the street from the World Trade Center).
Time: Boarding begins 7:00 PM, cruise departs 7:30 PM, returns 10:00 PM
Reservations: 340 max reservations on a first come first serve basis. Reservations can be made at the time of conference registration.
Fee: $40

Tours:
Deadline: Tour registration forms must be submitted by May 8th

Hotel Information
The Hilton Portland is located at 921 Southwest Sixth Avenue, Portland OR 97204 (The main building is located on SW 6th Ave between SW Salmon & SW Taylor)

Amenities:

Onsite at the Hilton:	Alexander's Lounge
	Bistro 921 Bar
	Porto Terra Bar
	Athletic Club
	24-hour fitness room
	Indoor Waveless lap pool
Offsite at the Hilton:	Southpark Seafood Grill & Wine (2 blocks)
	Higgins Restaurant and Bar (3 blocks)
	Forest Park Biking and Hiking (2 miles)
	Portland Rock Gym (2 miles)
	Heron Lakes Golf Course (4 miles)

Pumpkin Ridge Golf Club (15 miles)
Mt. Hood-skiing (60 miles)
Columbia River Gorge (60 miles)
Beach (90 miles)
Jet Skiing (8 miles)
Jogging Track (1 mile)
Playground (1 mile)

Parking: Daily parking charge: $18 Valet Parking charge: $22

Reservation information:
Rates: $129/single&double, $139/triple&quadruple, plus 12.5% occupancy tax.

Transportation

Bus & Max Light Rail:

1. TriMet bus system
2. Max Light rail-runs directly from the airport to the city center in about 15 minutes. The station is located near the baggage claim area on the lower level of Portland International Airport. This station is in Zone 3. Take Max red line and get off at Pioneer Square North Max Station, and walk .2 miles south to the hotel (approx. 42 minutes)
3. Streetcar-4.8 mile loop route through downtown

All three of these you ride for free in "Fareless Square" a 330 block area of downtown, in which the hotel is situated.

The following links are to TriMet site (including route maps):
http://www.trimet.org/schedule/r100map.htm
http://www.trimet.org/schedule/r193.htm#
http://www.trimet.org/max/index.htm

PDX (Portland International Airport):
Just 20 minutes from downtown, Portland International Airport (PDX) has earned awards for demonstrating that large-scale airports can be both functional and aesthetically pleasing. Currently, 17 passenger airlines, including regularly scheduled and chartered passenger carriers, serve PDX with direct or nonstop service to more than 120 cities worldwide. See more at Portland's Transportation.
Preferred Airline: Continental

Child Care

None through the hotel!

Local attractions & activities

Refer to the following websites or ACC2005 website for details.

Portland Oregon Visitors Association	http://www.pova.com
Portland Chamber of Commerce	http://www.portlandalliance.com
Facts about Portland	http://www.pova.com/visitors/portland_profile.html
City of Portland	http://www.portlandonline.com
Portland Rose Festival	http://www.rosefestival.org

Portland Art Museum	http://www.pam.org
Japanese Garden	http://www.japanesegarden.com
Classical Chinese Garden	http://www.japanesegarden.com
Oregon Zoo	http://www.oregonzoo.org
Oregon Museum of Science and Industry	http://www.omsi.org

Climate & Attire:
Average for June is between 75 degrees for a high and 53 degrees for the low with an average rainfall of 1.5 inches. In short the weather is generally moderate to warm that time of year, but some precautionary long-sleeves and rain gear are recommended.

Local area map: Refer to the back cover.

Student Best Paper Award
There were 265 PaperPlaza submissions for the Student Best Paper Competition. Of these, 76 received advisor nominations and were considered for the award. The nominated papers were reviewed through the usual review process and by a panel of experts chosen from the Program Committee. Based on these reviews, five papers have been selected as finalists for the Student Best Paper Award competition.
The winner of the student best paper competition will be selected at the conference and will be based on both the written paper and the final oral presentation by the student. The first listed author of each paper is the student who will make the oral presentation. The winner will be announced at the *Awards Banquet on Thursday, June 9th, 2005.*

ACC 2005 Student Best Paper Award Finalists

Session: WeB08.5
Bert Pluymers*, J. Anthony Rossiter, J.A.K. Suykens, Bart L.R. De Moor
" Interpolation Based MPC for LTV Systems Using Polyhedral Invariant Sets"
14:50-15:10, Paper No. 179

Session: WeC04.4
Eric Nelson*, Meir Pachter, Stanton Musick
"Projectile Launch Point Estimation from Radar Measurements"
16:45-17:05, Paper No. 496

Session: WeB08.2
Anurag Ganguli*, Jorge Cortes, Francesco Bullo
"Maximizing Visibility in Nonconvex Polygons: Nonsmooth Analysis and Gradient Algorithm Design"
13:50-14:10, Paper No. 914

Session: WeA01.3
Chaohong Cai*, Andrew R. Teel, Rafal Goebel
"Converse Lyapunov Theorems and Robust Asymptotic Stability for Hybrid Systems"
10:10-10:30, Paper No. 1066

Session: WeC06.4
Jongeun Choi, Roberto Horowitz*
"Topology Preserving Neural Networks that Achieve a Prescribed Feature Map Probability Density Distribution"
16:45-17:05, Paper No. 1638

Student Travel Grants

The eligibility and application procedure for the student travel grants were announced on the web, with the deadline of April 1, 2005. At this time, we remind you that the student travel grants will be in the form of reimbursements sent only after the completion of the conference upon receipt of a report on the students' experiences at the conference and proof of registration, hotel and travel expenditures. Students receiving travel grants should plan and document their finances accordingly. Should any questions arise, please contact the Vice Chair for Student Affairs, Professor Kamal Youcef-Toumi at youcef@mit.edu.

SPECIAL SESSIONS

Special Session I: Wednesday: 11:30AM – 1:10PM, *Grand Ballroom I*
Scanning Probe Microscopy
Organizer: Murti V. Salapaka. Iowa State University

Scanning probe microscopy has revolutionized science and engineering in the past decade. As stated in the National Nanotechnology Initiative plan *"These instruments including the scanning tunneling microscopes, atomic force microscopes and near-filed microscopes, provide the eyes and fingers for nanostructure measurement and manipulation"*. There are significant advancements that have to be unraveled in this area where the control expertise can play a pivotal role. In this session the contribution of the control and systems perspectives to this area will be highlighted, and open research issues will be presented. Presenters will include Murti V. Salapaka (Iowa State University), Srinivasa Salapaka (University of Illinois, Urbana Champaign) Anil Gannepalli (Asylum Research), and Abu Sebastian (IBM, Zurich Labs.).

Special Session II: Wednesday: 11:30-1:10PM, *Grand Ballroom II*
Modeling of RNA Expressions
Organizer: Bijoy Ghosh, Washington University

An important area of Systems Biology concerns the problem of controlling photosynthesis by environmental alterations. One is interested in the study of how `Genes Regulate' and one way to do this is to classify a set of co-regulated genes. There are many different criterion in the literature on how to assess that a set of genes are co-regulated, and a well known technique utilizes 'Pearson Correlation Coefficient'. Thus two genes are described as co-regulated, if their expressions over time are close. This session will focus on the construction of 'Dynamic Interaction Model' between co-regulated genes to study the effect of 'temporal causality' between interacting genes. The proposed model is linear, time-varying and captures the temporal interaction between gene clusters. The model is time varying, indicative of the fact that the interaction profile can change over the life cycle of the cell. Our model would utilize recently developed techniques in 'Smoothing Splines' and time series analysis methods that have been shown to be useful in spaces of large dimension such as 'Random Matrix Theory' and 'Sparse Principal Component Analysis.' We believe that the model so developed would find application in the study of the control of photosynthesis.

Special Session III: Wednesday: 6:00-7:30PM, *Grand Ballroom I*
History of Control
Organizer: Daniel Abromovitch, Agilent Labs

This session will focus on early work on control systems carried out in the Soviet Union. Speakers will include Daniel Abromovitch, George Bekey, Petar Kokotovic, and Boris Kogan.

Special Session IV: Wednesday: 6:00-7:30PM, *Grand Ballroom II*
Mid-Career Professional: To Change or Not Change Your Jobs
Organizer: Karlene Hoo and F. Chowdhury, Texas Tech University

This session provides a forum for discussing important aspects of job direction change for the mid-career professional. To make a change or to not make a change? What are the important factors to be considered? There will be presentations from successful mid-career women who changed jobs and moved to other positions, and there will be a question/answer period with audience participation.

Special Session V: Friday: 11:30-1:00PM, *Grand Ballroom I*
NSF Funding Opportunities
Organizers: Kishan Baheti and Mario Rotea, National Science Foundation.

National Science Foundation continues to be the funding source of choice for control systems engineers. However, programs at the NSF are being reorganized continually, and along with that arise new funding opportunities in emerging multidisciplinary areas of national importance. This session will be a forum to discuss such opportunities and challenges.

INTERACTIVE SESSIONS

WeA16:	**Cooperative Control with the MultiUAV Simulation**
	Grand Ballroom I
Organizer:	Ram Venkataraman Iyer (Texas Tech University)
	Phillip R. Chandler, Steven Rasmussen (Wright Patterson Air Force Base)

This session will showcase MultiUAV simulation software which has been developed recently at the Wright Patterson Air Force Base. Wright Patterson is at the forefront of UAV technology research for the Air Force. Software tools demonstrated are aimed at helping research community to test various algorithms in realistic scenarios.

FrA13:	**Control Applications in Ventricular Assist Device Development**
	Broadway I
Organizer:	Yih-Choung Yu (Lafayette College)
	Marwan A Simaan (University of Pittsburgh)

Ventricular assist devices are becoming increasingly reliable, and thought to become an alternative to hear transplants in the near future. Methods of control theory are being increasingly used in the second generation Ventricular assist devices in order to regulate the device output to varying physiological conditions. This session will bring attention to these control issues via poster presentations, simulations, and display of recently developed ventricular assist devices.

INDUSTRY AND APPLICATIONS – TUTORIAL SESSIONS

ThA13:	**Modeling and Control of Systems for Critical Care Ventilation** *Broadway I*
Organizer:	Michael A. Borrello (Trex Enterprise)

In medical practice, critical care ventilation provides a vital life support function for patients that have difficulty or are unable to breath for themselves. The machine providing this function is known as a ventilator. There are presently four or five leading ventilator manufacturers that compete in a worldwide market of about 2.5 billion dollars. With the rising expense of healthcare, cost reduction has been the design priority although manufacturers still look to performance improvements and new features to differentiate their product and maintain a competitive edge in the market. Clinical experts in the field of respiratory care frequently publish studies that evaluate, analyze and compare performance between ventilators. The success or failure of this performance ultimately depends on the controls design.

This tutorial introduces the specific topics in critical care ventilation that concern control engineering, focusing primarily on modeling methods and control techniques for breath delivery. For simple modeling and analysis, fundamental elements of flow resistance, compliance and inertance are discussed and used to build linear lumped parameter models of the lung, patient circuit and ventilator control valves. Static nonlinear characteristics of these elements are further used to extend these models to linear parameter varying (LPV) systems that provide closer approximation suitable for simulation. The basic control functions of flow, mix, volume and pressure and the issues they impose on controls are discussed as well as more advanced applications such as SaO_2 control (blood oxygen saturation), impedance targeted controls, and methods of closed loop ventilation intended to aid or replace higher level decisions made by clinical personnel.

The main tutorial will be followed by three papers prepared by practicing control engineers from the ventilator industry and which address specific selected topics.

ThB02:	**Maximum Likelihood Subspace Identification for Linear, Nonlinear, and Closed-loop Systems** *Senate*
Organizer:	Wallace E. Larimore (Adaptices, Inc.)

Linear subspace system identification involves the direct determination of the state space subspace and estimation of the states based on only observational data, with no knowledge of the process dynamics. This involves reduced-rank regression that is implemented using computationally stable and accurate singular value decomposition calculations. Simple multivariate regression is then used to identify the system dynamics and estimate a parametric model description. This avoids the use of nonlinear iterative parameter optimization that is frequently ill-conditioned and may not produce a useful result. As a result, subspace identification can be completely automated for the identification of high-order multivariable dynamic systems leading to major new online and real-time applications such as online monitoring, fault detection, adaptive and robust control. Extensions of subspace identification to general nonlinear systems have similarly produced major results. However, a major issue over the past two decades has been the lack of theory describing the accuracy of subspace identification compared with other high-accuracy methods such as maximum likelihood (ML), particularly for closed-loop systems. New results on the accuracy of subspace methods are discussed in detail in the first paper. In the 1-hour tutorial paper, the basic concepts of subspace identification are developed for linear systems. Then, new results are discussed that show the canonical variate analysis (CVA) subspace method is equivalent to ML in the case of a large sample size for a linear time-invariant system including the case of closed-loop feedback. These ideas are then extended to very general nonlinear system that has many potential new applications. The second paper in the session develops subspace identification methods for Hammerstein nonlinear feedback systems that are applied to the nonlinear modeling of aircraft wing flutter and to nonlinear modeling of solar wind data. The third paper studies subspace identification of large space structures in both the time and frequency domain. The final paper discusses subspace and regression-based identification in process control applications.

ThB12:	**Mixed-integer Programming for Control – A Tutorial**
	Executive
Organizer:	Arthur Richards (University of Bristol), Jonathan P. How (MIT)

Mixed-integer programming (MIP) is a very general framework for capturing problems with both discrete decisions and continuous variables. This includes assignment problems, control of hybrid or piecewise-affine systems, and problems with non-convex constraints (e.g., collision avoidance in trajectory design). MIP methods naturally handle these types of problems because the integer decision variables can be used to encode discrete/logical decisions (e.g., assignment decisions or ``left'' vs. ``right'' for collision avoidance) in the optimization. Having cast the problem in MIP form, techniques from Model Predictive Control (MPC) can be used to build a feedback control law using the optimization online.

This tutorial will focus on the two major challenges associated with using MIP/MPC for online control. The first is to encode the problem as a MIP optimization that can be embedded in an MPC. Topics covered in this area will include MIP modeling of common problem types and requirements for stability and robustness when used in MPC. The second challenge, often the harder of the two, is to develop modifications to the problem statement to execute these optimizations in real-time. A successful deployment often requires judicious choice of approximation and solution techniques. General approaches will be described including approximations, constraint relaxation and cost-to-go functions, and talks by leading researchers in the field will give more application-specific details.

ThB13:	**Sum of Squares in Industry: An Algorithmic Analysis Approach**
	Broadway I
Organizer:	Antonis Papachristodoulou (Caltech), Stephen Prajna (Caltech), Sonja T. Glavaski (Honeywell)

The sum of squares technique for systems analysis was introduced nearly 5 years ago in Pablo Parrilo's thesis. The main advantage of this methodology is that it provides an algorithmic procedure for *verifying* certain properties that a designed system should enjoy: safety, functionality, performance, etc. This is done by algorithmically constructing proofs/certificates that ascertain these properties, rather than running exhaustive simulations, which is an inconclusive approach. This property is particularly important for safe-critical systems of industrial interest. In the past 5 years, the sum of squares technique has been applied at a theoretical level to answer a series of important questions on systems analysis and design that were impossible to be answered before. Such questions include, but are not limited to, stability and robustness analysis of nonlinear, hybrid, and time-delay systems, estimation of domain of attraction, LPV analysis and synthesis, model validation, safety verification of hybrid systems, nonlinear synthesis. In addition, software tools have been developed for analysis based on this methodology. These theoretical foundations have attracted the interest of industrial partners and the sum of squares methodology has been applied successfully for a series of systems of industrial importance. The objective of this tutorial session is to give an overview of recent progress in sum-of-squares-based systems analysis and present some successful industrial applications of the techniques in an integrated setting. The organizers and contributors of the session are among the leading researchers in the area, and the session will be of interest to a broad spectrum of the ACC audience, including industrial practitioners and people from academia interested in computational methods for analysis of nonlinear, hybrid, and time-delay systems. The session will start with an introductory talk in which we will explain in detail the theoretical background and applicability of the sum-of-squares-based techniques, through a series of illustrative academic examples. The introductory lecture will cover the following areas:

• Introduce the sum of squares decomposition of multivariate polynomials, its algorithmic verifiability through convex optimization and SOSTOOLS, a free software package for sum of squares programming;

• Show how stability and robustness analysis of nonlinear uncertain systems described by ordinary differential equations (ODEs) or differential algebraic equations (DAEs) can be done through the construction of Lyapunov functions by sum of squares programming;

• Address analysis for time-delay systems based on Lyapunov-Krasovskii functionals constructed using the sum of squares technique;

• Present a sum-of-squares-based framework for stability and robustness analysis of switched and hybrid systems;

• Introduce the notion of barrier certificates and discuss how model validation and safety verification can be performed using sum of squares programming.

When the talk is complete, the audience will appreciate the advantages of using the sum of squares technique for systems analysis: other system classes, such as hybrid, nonlinear and time-delay can be analyzed exactly, and more complicated analysis questions can be answered. The rest of the session will continue with four industrial applications of the sum of squares techniques in the following areas:

1) Analysis of aircraft pitch axis stability augmentation system;

2) Safety verification of a controlled hybrid model of a life support system;
3) Determining optimal decentralized decision rules in discrete stochastic decision problems, such as medium-access control in communication systems; and
4) Assessing connection level stability in networks, such as the Internet.
In the first paper, the sum of squares decomposition is used to analyze the stability and robustness of the controlled pitch axis of a nonlinear aircraft model. The controller is a linear time-invariant dynamic inversion based control law designed for the short period dynamics of the aircraft. The closed loop system is tested for its robustness to uncertainty in the location of center of gravity along the body x-axis. The second paper demonstrates the use of barrier certificates as a method to verify safe performance of a hybrid Variable Configuration CO2 Removal (VCCR) system. A simple nonlinear feedback controller was designed that tracks a desired CO2 profile; the aim is to test whether the CO2 and O2 concentrations stay within acceptable limits. For this purpose, the sum of squares decomposition was used to construct a barrier certificate that verifies the safe performance of the system. The third paper considers the problem of determining optimal decentralized decision rules in discrete stochastic decision problems, such as medium-access control in communication systems. A static single-stage problem as well as a dynamic infinite horizon problem are considered. It is known that the static problem is NP-hard, even for the case of two decision makers. Here these complexity results are extended to the dynamic problem. It is shown that both problems have an equivalent formulation as minimization of a bilinear polynomial subject to linear constraints. By forming relaxations of these polynomial optimization problems using sum of squares techniques, suboptimal decentralized decision rules as well as bounds on the optimal achievable value can be computed. The methods are illustrated by an example of decentralized detection. Finally, the authors of the last paper investigate the use of the sum of squares technique to construct Lyapunov functions satisfying Foster's condition for stochastic stability of connection-level models of file transfer requests in the Internet. In particular, they consider the setting where connection arrivals to each route occur according to Poisson processes and the file-sizes have phase-type distributions. The sum of squares methodology is used to numerically establish connection-level stability of linear and star network topologies when the load on each link is less than its capacity.

ThC12:	**Adaptive Control of Rapidly Time-Varying Systems**
	Executive
Organizer:	Kumpati S. Narendra, Robert N. Shorten, and Matthias J. Feiler
	(Yale University)

New classes of problems are arising in the highly competitive industrial word, where time variations in the parameters of processes to be controlled are both large and rapid. The tutorial deals with the control of such dynamical processes. The objective of the tutorial is to discuss the many forms that such control problems can take, and describe methods that are currently being investigated which assure stability and satisfactory performance.

The tutorial will consist of three parts. In the first part, based on the prior information that is available concerning the controlled process, different formulations of the control problem will be presented. Examples from electrical, mechanical, chemical, and aeronautical systems will be described, which will be addressed in the following parts of the tutorial.

The second part of the tutorial will deal with switching (hybrid) systems. The principal assumption here is that the parameter values of the constituent systems are known. The main thrust of this part is to discuss the theory of stability of linear systems whose parameters vary discontinuously, and provide a mathematical framework for reviewing the major results. Quadratic and non-quadratic Lyapunov functions, as well as linear matrix inequalities, will be used to investigate the stability of switching systems. This part will conclude with the formulation of problems in which the switching laws are state dependent, and those in which the constituent systems are unstable. Applications will be chosen from communication networks where the techniques developed provide the basis for design.

The third part of the tutorial will deal with adaptive systems in which the process parameters are unknown and vary discontinuously. The principal objective is not merely to assure the stability of the overall system, but also to answer the question whether the methods suggested can maintain overall performance even as the operating conditions change discontinuously. In contrast to the second part, the parameters of the controlled process are assumed to be unknown and multiple models are used to estimate the plant parameters. The resulting control consequently involves both switching and tuning. A series of increasingly more complex problems, based on decreasing prior information concerning the process, are formulated, and in each case both stability and performance issues are discussed. The tutorial will conclude with a description of the improvement that can be achieved in different control systems using the above methodologies.

ThC14:	**Automotive Powertrain Controls: Fundamentals and Frontiers**
	Galleria II
Organizer:	Jing Sun (University of Michigan)
Contributors:	Julia Buckland (Ford), Kenneth Butts (Toyota Technical Center), Jeffrey Cook (Ford), Kumar Hebbale (GM), Ilya Kolmanovsky (Ford), Zongxuan Sun (GM)

This tutorial session brings together the powertrain control specialists from different areas to give a comprehensive overview of this rich and dynamic research and development topic. Technical leaders from three major automotive companies, Ford, GM, and Toyota, are joining the effort to provide technical perspectives from several different viewpoints: modeling, design, calibration and processes. Fundamentals will be reviewed, frontiers will be explored, and methodologies and tools will be discussed. The one-hour tutorial presentation will focus on technical fundamentals of engine control, for both gasoline and diesel engines. Three 20-minute presentations will concentrate on advanced transmission control, emission control, and processes/tools of engine control development. The goal of this tutorial session is to expose the fundamental and challenging powertrain control problems to those from academia, and to provide a forum to learn and discuss advanced design and analysis tools for others from industries.

ThC16:	**Cooperative Electronic Attack using Unmanned Air Vehicles**
	Grand Ballroom I
Organizer:	Mark J. Mears (Air Force Research Laboratory)

Cooperative Control of air vehicles for Electronic Attack is focus of this paper. The utility of Electronic Attack is described in the context of integrated air defense systems which rely on RADAR sites that act as a network to gather information about potential airborne threats. General concepts for use of multiple vehicles against RADAR systems are described and formulated in terms of cooperative path planning and resource allocation. Then some approaches to solving the technical problems are described. Although the interests expressed in this paper are motivated by capabilities that might be afforded by many unmanned autonomous vehicles, the concepts are relevant for manned aircraft working in concert with groups of air vehicles.

FrA11:	**Control and Pointing Challenges of Antennas and Telescopes**
	Studio
Organizer:	Wodek Gawronski (Caltech)

This session presents the control and pointing problems encountered during design, testing, and operation of antennas, radio-telescopes, and optical telescopes. This collection of challenges helps to evaluate their importance, and is a basis for discussion on the ways of improvement of antenna pointing accuracy.

The session presentation is based on the authors' extensive experience with the NASA Deep Space Network antennas, Very Large Telescope, Nordic Optical Telescope, ALMA Telescope, Multiple Mirror Telescope, The Large Millimeter Telescope, APEX Telescope, ESA Deep Space Antennas, and others.

We discuss telescope control system models (obtained from the finite element analysis and system identification); disturbances (wind and motor cogging torque acting on a telescope structure); performance of the position controllers of antennas (PI, LQG, and H_∞); nonlinearities of the antenna control system (rate and acceleration limits, friction, backlash); pointing error sources (thermal and gravity deformations, atmospheric refraction, encoder errors); pointing error calibration; conical scanning, and monopulse tracking.

We present an integrated (or mechatronic) approach to the design of telescope subsystems, with the focus on structural design, axes mechanisms, active surfaces, sensor placement, and system identification with application to the surface and pointing control.

The session presents our experience in the analysis and testing of the 12m ALMA telescope, in the adaptive correction of the periodic tracking errors, and the current and future work in servo development at the Multiple Mirror Telescope.

FrA16:	**Adaptive Flight Control**
	Grand Ballroom I
Organizer:	Eugene Lavretsky and Kevin A. Wise (Boeing Phantom Works)

This presentation describes the development and application of a direct adaptive / reconfigurable model following flight control design concept for manned and unmanned military aircraft. The design methodology is theoretically justified and derived based on the fundamentals of the Lyapunov Stability Theory. The adaptive control architecture includes a fixed robust baseline controller that is augmented by an online feed-forward neural network. While the former is designed to yield consistent nominal system performance, the latter provides for adaptation and reconfiguration in the presence of system uncertainties (e.g., battle damage), control failures, and environmental disturbances. Adaptation benefits and closed-loop system tracking performance are demonstrated in a flight simulation environment that incorporates an unmanned aircraft model data. The adaptive reconfigurable control design architecture employs radial basis functions (RBF) and feed-forward neural networks (NN). The inner-loop flight control adaptive design is performed. Through both theory and simulation it is verified that the adaptive controller provides bounded tracking and guarantees a uniform ultimate boundedness of all the signals in the corresponding closed-loop system.

The presentation material consists of two parts and it is organized as follows. In the first part, robust control design and analysis methods are introduced and a summary of theory and lessons learned in developing robust linear control is presented. This section summarizes the authors' vast experience of applying robust optimal control methods to aircraft and missiles within the Boeing Phantom Works. The second part begins with an overview of the Lyapunov stability theory, followed by an introduction to the design and analysis of classical linear in parameters adaptive control systems. Subsequently, approximation properties of artificial neural networks and their application to the design of direct adaptive systems are presented. Key design points are discussed and illustrated through various simulation examples. The presentation culminates in demonstration of applying direct adaptive neural control to autopilot design for an unmanned aircraft.

FrB16:	**Introduction to the Multi-UAV Simulation and Its Application to Cooperative Control Research**
	Grand Ballroom I
Organizer:	Steven Rasmussen (General Dynamics)

This tutorial session will introduce the MultiUAV simulation and its application to unmanned air vehicle (UAV) cooperative control problems. MultiUAV is capable of simulating many UAVs, targets and threats as well as communications between vehicles. It has been used to evaluate cooperation during missions such as wide area search and destroy; lethal intelligence, surveillance, and reconnaissance; and suppression of enemy air defenses. In addition, cooperative control algorithms based on ideas ranging from capacitated transshipment network flow to stochastic search have been evaluated with the MultiUAV simulation. The Mathworks' Simulink symbolic programming language is used to organize and control MultiUAV. Subfunctions are constructed in MATLAB's script language and in C++. Using Simulink and

MATLAB in this manner makes the MultiUAV simulation very accessible to researchers. MultiUAV was developed by the United States Air Force's Control Science Center of Excellence and is distributed freely to the public.

FrB18:	**Industry Needs for Embedded Control Education**
	Parlor C
Organizer:	Jim Freudenberg (University of Michigan) ,
	Bruce Krogh (Carnegie Mellon University)

In this tutorial session we describe the needs of industry for engineers capable of working in the highly multidisciplinary field of embedded control systems, and ways in which two universities (University of Michigan and Carnegie Mellon) are developing courses to train students to meet these needs.

The session should be of interest to (i) people from industry who want an update on embedded controls in the automotive industry and on recent curricular developments in the embedded control field, (ii) people from academia who want to learn about the embedded control field and how it might impact curriculum at their institutions, and (iii) a general audience who simply wants to know about embedded control systems, what they are, and why they are important.

FrC16:	**Active-Vision Control Systems for Complex Adversarial 3-D Environments**
	Grand Ballroom I
Organizer:	Eric N. Johnson (Georgia Tech), Anthony J. Calise (Georgia Tech),
	Allen Tannenbaum (University of Minnesota), Stefano Soatto (UCLA),
	Naira Hovakimyan (Virginia Tech), Anthony Yezzi (Georgia Tech)

This tutorial session covers methods that utilize 2-D and 3-D imagery (e.g., from LADAR, visual, FLIR, acoustic-location) to enable aerial vehicles to autonomously detect and prosecute targets in uncertain complex 3-D adversarial environments, including capabilities and approaches inspired by those found in nature, and without relying upon highly accurate 3-D models of the environment. These capabilities of autonomous sensing and control are enabling Unmanned Aerial Vehicle (UAV) and guided munition operations: in a clandestine/covert manner; in close proximity to hazards, structures, and/or terrain; and in uncertain/adversarial 3-D environments. The critical technical innovations include:

1. Knowledge-based segmentation;
2. Adaptation and estimation in geometric active contours;
3. Adaptive control frameworks for active vision systems;
4. Multi-grid and polygonal methods for optical flow;
5. Imaging sensors designed to produce sensor information for control.

Several related active-vision control systems that utilize these methods are discussed, as is the advances made in these technical areas to support these systems. The key challenges relate to the use of non-traditional vision-derived information for control, accommodating the properties of real-world imagery (noise, lighting, occlusions, drop-out, etc.), and the requirement to perform computations in real time.

In addition, a robust and productive simulation and flying testbed activity is discussed. This ensures that these methods are sound in the sense that they are: (1) implementable in real-time, (2) capable of practical use in the field, and (3) based on realistic/achievable sensor capabilities. Results discussed including a glider flown with vision only, formation and cooperative flight using vision only, vision-aided inertial navigation, and automated visual search.

TUTORIAL WORKSHOPS

Workshop 1: June 6 & 7, 2005 (2 days), *Broadway I*
Practical Techniques in Control Engineering
Dennis S. Bernstein (University of Michigan)
Carl R. Knospe (University of Virginia)

This course will provide a bridge between recent developments in control theory and their practical application in the laboratory and industry. Beginning with an overview of fundamental tradeoffs and issues that affect control-system performance, the course will systematically cover topics in linear and nonlinear modeling, linear and nonlinear controller synthesis, and robust and adaptive tuning. Controller implementation issues such as saturation, quantization, and state constraints will also be discussed. The theoretical foundation of each topic will be reviewed along with a discussion of practical ramifications and limitations. The course is suitable for students, instructors, and researchers who wish to obtain a broad perspective of the control engineering enterprise as well as control engineers from all industrial applications seeking a coherent, self-contained overview of recent developments relevant to control practice.

Monday, June 6, 2005

1. Defining the Issues and Challenges in Control Engineering
    1. Course Overview (8:30-8:45)
    2. Control-System Design: Strategy, Physics, Architecture, and Hardware (8:45-9:30)
    3. Plant Properties and Achievable Performance (9:30-10:30)

    Break (10:30-10:45)
2. Developing Linear Models for Control
    1. Linear Plant Modeling: Representation and Properties (10:45-11:30)
    2. Empirical Linear Modeling: System Identification (11:30-12:30)

    Break (12:30-1:30)
3. Synthesizing Linear Controllers for Performance and Robustness
    1. Uncertainty Measures and Robust Synthesis (1:30-3:15)

    Break (3:15-3:30)

4. Reducing Model Dependence in Controller Synthesis
    1. Minimal-Information Control: The Art and Science of PID Tuning (3:30-4:15)
    2. Adaptive Control: What Do You Need to Know, and How Well Do You Need to Know It? (4:15-4:45)
    3. Adaptive Stabilization and Command Following (4:45-5:30)

Tuesday, June 7, 2005

5. Developing Nonlinear Models for Control
    1. Nonlinear Plant Modeling: Model Properties and Structure (8:30-9:00)
    2. Nonlinear Identification Methods for Block-Structured Models (9:00-10:00)
6. Inexact Approaches to Nonlinearity
    1. Treating Nonlinearity as Uncertainty: Absolute Stability, LMIs, and IQCs (10:00-10:30)

    Break (10:30-10:45)

    2. Treating Nonlinearity as Linearity: Gain Scheduling, LPVs, and Frozen Linear Methods (10:45-12:15)

    Break (12:15-1:15)
7. Exact Approaches to Nonlinearity: Part I (1:15-2:15)
    1. Feedback Linearization: Methods and Pitfalls
8. Exact Approaches to Nonlinearity
    1. Backstepping: A Constructive Nonlinear Approach (2:15-2:45)
9. Implementing Real Control Systems in Real Hardware
    1. Facing the Reality of Constraints: Traditional and Modern Approaches (2:45-3:15)

    Break (3:15-3:30)
10. Fitting the Pieces Together
    1. Adaptive Disturbance Rejection with Applications to Noise and Vibration Control (3:30-4:30)
    2. A Case Study for Controller Design and Implementation: Active Chatter Control (4:30-5:30)

Workshop 2: June 6 & 7, 2005 (2 days), *Broadway II*

Engineering Applications in Genomics

Aniruddha Datta (Texas A & M University)

Genomics concerns the study of large sets of genes with the goal of understanding collective function, rather than that of individual genes. Such a study is important since cellular control and its failure in disease result from multivariate activity among cohorts of genes. Very recent research indicates that engineering approaches for prediction, signal processing, and control are quite well suited for studying this kind of multivariate interaction. The aim of this workshop will be to provide the attendees with a state of the art account of the research that has been accomplished in this field thus far and to make them aware of some of the open research challenges.

The workshop will provide a tutorial introduction to the current engineering research in genomics. The necessary Molecular Biology background will be presented and techniques from signal processing and control will be used to (i) unearth intergene relationships (ii) model genetic regulatory networks and (iii) alter (i.e. control) their dynamic behavior. The workshop will be divided into two parts. On the first day, we will focus on building up the necessary molecular biology background. NO PRIOR EXPOSURE TO MOLECULAR BIOLOGY WILL BE ASSUMED. On the second day, we will discuss the application of engineering approaches for attacking some of the challenging research problems that arise in genomics related research. A more detailed description of the material to be covered on each day follows.

Monday, June 6, 2005

1. Review of Organic Chemistry: Sugars, Fatty Acids, Amino Acids and Nucleotides (1 hour 45 minutes)
2. DNA, RNA and Proteins: Transcription, Translation, the Genetic Code, Chromosomes and Gene Regulation (2 hours)
3. Genetic Variation, Genetic Engineering: Recombinant DNA Technology and Microarrays (1 hour 45 minutes)
4. Procaryotes, Eucaryotes, Eucaryotic Cell Structure, Cell Cycle, Mitosis, Meiosis, Apoptosis, Cancer as the breakdown of Cell Cycle control (2 hours)

Tuesday, June 7, 2005

5. Analysis of cDNA Microarray Images (1 hour 45 minutes)
6. Unearthing Genomic Relationships using the Coefficient of Determination (2 hours)
7. Models of Genetic Regulatory Networks (1 hour 45 minutes)
8. Intervention and Control in Genetic Regulatory Networks (2 hours)

Workshop Materials

Detailed notes covering the material on the first day will be handed out at the workshop. The material for the second day will consist of the following journal articles, copies of which will be included in the workshop notes.

1. Chen, Y., Dougherty, E. R. & Bittner, M. L. (1997). Ratio-Based Decisions and the Quantitative Analysis of cDNA Microarray Images. Journal of Biomedical Optics, Vol. 2, No. 4, 364-374.
2. Kim, S., Dougherty, E. R., Bittner, M. L., Chen, Y., Sivakumar, K., Meltzer, P., & Trent, J. M. (2000). A General Framework for the Analysis of Multivariate Gene Interaction via Expression Arrays. Biomedical Optics, Vol. 4, No. 4, 411-424.
3. Shmulevich, I., Dougherty, E. R., Kim, S., & Zhang, W. (2002a). Probabilistic Boolean Networks: A Rule-based Uncertainty Model for Gene Regulatory Networks. Bioinformatics, 18, 261-274.
4. Shmulevich, I., Dougherty, E. R., & Zhang, W. (2002c). Gene Perturbation and Intervention in Probabilistic Boolean Networks. Bioinformatics, 18, 1319-1331.
5. Shmulevich, I., Dougherty, E. R., & Zhang, W. (2002d). Control of Stationary Behavior in Probabilistic Boolean Networks by Means of Structural Intervention. Biological Systems, Vol. 10., No. 4, 431-446.
6. Datta, A., Choudhary, A., Bittner, M. L., & Dougherty, E. R. (2003). External Control in Markovian Genetic Regulatory Networks. Machine Learning, Vol. 52, 169-191.

7. Datta, A., Choudhary, A., Bittner, M. L., & Dougherty, E. R. (2004). External Control in Markovian Genetic Regulatory Networks: The Imperfect Information Case. Bioinformatics, Vol. 20, No. 6, 924-930.

Workshop 3: June 6 & 7, 2005 (2 days), *Broadway III*

Recent Advances in Subspace System Identification: Linear, Nonlinear, Closed-Loop, and Optimal with Applications

Wallace E. Larimore (Adaptics, Inc.)

This workshop presents a first principles development of subspace system identification (ID) using a fundamental statistical approach. This includes basic concepts of reduced rank modeling of ill-conditioned data to obtain the most appropriate statistical model structure and order using optimal maximum likelihood methods. These principles are first applied to the well developed subspace ID of linear dynamic models; and using recent results, it is extended to closed-loop linear systems and then general nonlinear closed-loop systems.

The fundamental statistical approach gives expressions of the multi-step likelihood function for subspace identification of both linear and nonlinear systems. This leads to direct estimation of the parameters using singular value decomposition type methods that avoid iterative nonlinear parameter optimization. The result is statistically optimal maximum likelihood parameter estimates and likelihood ratio tests of hypotheses. The parameter estimates have optimal Cramer-Rao lower bound accuracy, and the likelihood ratio hypothesis tests on model structure, model change, and process faults produce optimal decisions.

The extension to general nonlinear systems determines optimal nonlinear functions of the past and future using the theory of maximal correlation. This gives the nonlinear canonical variate analysis. New results show that to avoid redundancy and obtain Gaussian variables, it is necessary to determine independent canonical variables that are then used in the likelihood function evaluation. This gives a complete likelihood theory for general nonlinear stochastic system with continuous dynamics and possibly feedback.

These new results greatly extend the possible applications of subspace ID to closed-loop linear and nonlinear systems for monitoring, fault detection, control design, and robust and adaptive control. The precise statistical theory gives tight bounds on the model accuracy that can be used in robust control analysis and design. Also precise distribution theory is available for tests of hypotheses on model structure, process changes and faults. Potential applications include system fault detection for control reconfiguration, autonomous system monitoring and learning control, and highly nonlinear processes in emerging fields such as bioinformatics and nanotechnology. Applications are discussed to monitoring and fault detection in closed-loop chemical processes, identification of vibrating structures under feedback, online adaptive control of aircraft wing flutter, and identification of the chaotic Lorenz attractor.

The intended audience includes practitioners who are primarily interested in applying system identification techniques, engineers who desire an introduction to the concepts of subspace system identification, and faculty members and graduate students who wish to pursue research into some of the more advanced topics.

Monday, June 6, 2005

<u>Linear Systems With Feedback</u>

8:30-9:15	*Overview of Subspace Systems Identification*
	Approaches and Algorithms
	Positivity, Stability, Accuracy, Computation
9:15-10:00	*Rank of a Stochastic Dynamic System*
	Statistical Rank
	Canonical Variate Analysis (CVA)
	Rank as Minimal State Order
Break	
10:30-11:15	*Subspace Maximum Likelihood Estimation*
	Multi-step Likelihood Function
	State Space Regression Equations
11:15-12:00	*Statistical Model Order/Structure Selection*
	Kullback Information and Akaike Information
	Accuracy of Estimated Model
Lunch Break	
1:00-2:00	*Comparison of Alternative System Identification Approaches*
	Model Structure Selection and Parameter Estimation
	Computational Issues and Software
2:00-2:45	*Optimal Identification of I/O and Closed-loop Systems*
	Removing Effect of Future Inputs
	Model Nesting and Sufficient Statistics
3:15-4:00	*Process Monitoring Using CVA*
	Low Rank Process Characterization by CVA
	Testing Hypotheses of Process Change
Break	
4:00-4:45	*Process Monitoring Applications*
	Tennessee Eastman Challenge Problem
	Comparison with SPC and PCA Methods
4:45-5:30	*Identification and Control Applications*
	Vibrating Structures
	On-line Adaptive Control of Aircraft Wing Flutter

Tuesday, June 7, 2005

<u>Nonlinear Systems</u>

8:30-9:15	*Overview of Nonlinear System Identification Methods*
	Hammerstein and Wiener Systems
	Nonlinear State Space Models
9:15-10:00	*Nonlinear Canonical Variate Analysis*
	Nonlinear Functions of Past and Future
	Multivariate Reduction by Maximal Correlation

Break

10:30-11:15 *Maximal Correction and Projection*
Definition and Properties
Outline of Function Space Concepts

11:15-12:00 *Minimal State Rank and Independent CVA*
Redundancy Problem with CVA
Optimal Transformations to Gaussian Variables

Lunch Break

1:00-2:00 *Likelihood Function for Nonlinear Systems*
Multi-step Likelihood
Optimality of Independent CVA

2:00-2:45 *Optimality in Closed Loop*
Remove Future Inputs with NARX
Model Nesting and Nonlinear Regression

3:15-4:00 *Comparison with Other Methods*
Neural Networks, Statistical Learning
Support Vector Machines

Break

4:00-4:45 *Computational Methods*
Alternating Conditional Expectation (ACE)
Kernel based Computation

4:45-5:30 *Lorentz Attractor Identification*
Nonlinear Dynamics and Noise
Computation and Identification Accuracy

Workshop 4: June 7, 2005 (1 day), *Galleria III*

Scheduling, Cycle-Time Reduction, and Debottlenecking of Batch Processes

Charles Siletti (Intelligen, Inc., Mt. Laurel, NJ)

Cycle-time reduction in batch processes can often be challenging. There are many cases where utilization and up-time are misleading indicators of a true cycle-time limit. This workshop will cover cycle-time reduction and capacity debottlenecking in batch processes. First, we will review basic cycle-time calculations and bottleneck identification. We will then show how to use scheduling software to reduce cycle-time in multi-product plants with resource constraints. Finally, we will focus on variability and upsets and approaches to minimizing their effect on cycle-time.

Part I (Morning)

- ✧ Batch Process Basics: Cover definition & examples of batch, semi-batch, and continuous processes.
- ✧ Cycle Time in Batch Processes: Discuss cycle-time and cycle-time limits.
- ✧ Bottleneck Identification: Discuss how to calculate and use the following statis-tics: uptime, utilization, and throughput increase potential.
- ✧ Cycle Time Reduction Strategies: Discuss how to break bottlenecks.
- ✧ Example 1: A batch process with dedicated equipment. This example is taken from a biotech process.

- ✧ Example 2: A batch process with multi-purpose equipment. This example is a chemical synthesis process.

Part II (Afternoon)

- ✧ Review example: Recap of the morning.
- ✧ Downtime/Shift Constraints: How operating hours affect cycle-time.
- ✧ QA/QC Time: How the lab affects cycle-time
- ✧ Auxiliary Equipment: How small items can limit capacity.
- ✧ Multiple Processes: Can two simultaneous processes share equipment?
- ✧ Uncertainty: Do you need to add "slack" contingencies? How much?

Workshop 5: June 7, 2005 (1 day), *Broadway IV*

Real Time Optimization by Extremum Seeking Control

Miroslav Krstic, University of California, San Diego
Kartik Ariyur, Honeywell Aerospace Electronic Systems
Andrzej Banaszuk, Dobrivoje Popovic, United Technologies Research Center
Eugenio Schuster, Lehigh University

Extremum seeking control, a popular tool in control applications in the 1940-50's, has seen a resurgence in popularity as a real time optimization tool in aerospace and automotive engineering. This workshop will present the theoretical foundations and selected applications of extremum seeking.

In addition to being an optimization method, extremum seeking is a method of adaptive control, usable both for tuning set points in regulation/optimization problems and for tuning parameters of control laws. It is a non-model based method of adaptive control, and, as such, it solves, in a rigorous and practical way, some of the same problems as neural network and other intelligent control techniques.

The first half of the workshop will teach the attendees the extremum seeking algorithms, the basics of their stability analysis, the design guidelines. Both single-parameter and multivariable problems will be covered, as well as both the continuous and discrete time implementations. A novel "slope seeking" extension applicable to some unstable plants will be introduced. An application of extremum seeking to minimize limit cycles caused by actuator limitation will be presented.

In the second half of the workshop, applications to aerospace and propulsion problems (formation flight, combustion instabilities, flow control, compressor rotating stall), automotive problems (anti-lock braking, engine mapping), bioreactors, and charged particle accelerators will be presented.

Presented by researchers who spearheaded the revival of extremum seeking, the workshop will be one well integrated mini-course, designed as such by organizers who have been working jointly on these problems since 1996, rather than patched up from distinct pieces of research by an ad hoc team.

The workshop will be of interest to a broad audience of ACC attendees interested in nonlinear and adaptive control (from IEEE CSS), in optimization (from SIAM and INFORMS), as well as to industrial control engineers working on applications in electrical, mechanical (ASME), aerospace (AIAA), chemical (AIChE), and biomedical engineering.

8:00-9:00	History of extremum seeking, introductory algorithm for a static map, elements of stability analysis (Krstic)
9:00-9:50	ES in the presence of plant dynamics, ES compensators for performance improvement, ES with internal model principle for tracking parameter changes (Ariyur)
Break	
10:20-11:10	Multi-parameter ES and slope seeking (Ariyur)
11:20-12:00	Limit cycle minimization via ES, discrete time ES (Krstic and Ariyur)
Lunch	
13:30-13:45	Application to anti-lock braking (Ariyur)
13:45-14:05	Control of combustion instabilities (Banaszuk)
14:05-14:35	Control of flow separation in diffusers (Banaszuk)
14:35-15:00	Formation flight optimization via ES (Ariyur)
Break	
15:30-16:00	Compressor rotating stall control (Krstic and Ariyur)
16:00-16:30	Automotive engine mapping (Popovic)
16:30-16:45	Bioreactor optimization (Krstic and Ariyur)
16:45-17:00	Beam matching in particle accelerators (Schuster)

Workshop 6: June 7, 2005 (1 day), *Council*

A New Paradigm for Real-Time Operator Training for the Process Industries

Charles Cutler and Matthew Hetzel, (Cutler Technology Corporation, San Antonio, TX)

With the rise of multivariable advanced control, the operators spend less time operating process units. With less hands-on time, operator skills have degraded. This effect has increased the need for operator training. This need is often met with an operator training simulator. CTCSim is a program that can function as an off-line training simulator as well as an on-line "operator advisor." This program will keep a FIR model continuously adapted to the process unit. The operator may then use the model to quickly determine an appropriate course of action to take when a process change is required and the unit is operated without advanced control. The FIR model is identified from plant step-test data using another program called UPID. UPID allows the identification of an open-loop FIR model from closed-loop data. The algorithm used to remove the PID dynamics from a closed-loop model will be presented.

CONFERENCE EXHIBITS

The exhibits will be located in the Pavilion at the Plaza Level. The exhibits area will have coffee and access to free internet. A preliminary list of confirmed exhibitors includes:

- IEE Inspec http://www.iee.org/publishing

The IEE is an innovative international organization for electronics, electrical, manufacturing and IT professionals, with specifically tailored products, services and qualifications to meet the needs of today's technology industry. The IEE supports knowledge and education that will underpin engineering in the 21st century.

- Mathworks http://www.mathworks.com

The MathWorks is the world's leading developer of technical computing software for engineers and scientists in industry, government, and education. With an extensive product set based on MATLAB® and Simulink®, The MathWorks provides software and services to solve challenging problems and accelerate innovation in automotive, aerospace, communications, financial services, biotechnology, electronics, instrumentation, process, and other industries.

- National Instruments http://www.ni.com

National Instruments revolutionizes the way engineers work by delivering virtual instrumentation solutions built on rapidly advancing commercial technologies, including industry-standard computers and the Internet.

- Springer http://www.springeronline.com

Welcome to the new Springer! In 2004 Kluwer Academic Publishers and Springer-Verlag merged under the new Springer brand becoming the ambitious global player in the world of scientific, technical and medical publishing. Visit our booth at ACC and receive 20% off all titles and free journal samples.

- Quanser Inc. http://www.quanser.com

Quanser is a world leader in education and research-based advanced systems for real-time control design and implementation. The company's flexible and modular products provide a robust and cost-effective means of teaching control theory, while their high-performance industrial products improve productivity, reduce development time and accelerates your time to market.

- Adaptics Inc. http://www.adaptics.com

ADAPTx

Adaptics, Inc, develops and markets the ADAPTx Automated Multivariable System Identification Software. ADAPTx is completely automatic - supply the measured data and ADAPTx automatically determines a model, including state order and structure as well as a stochastic model of system disturbances.

- ECP Educational Control Products http://www.ecpsystems.com

ecp Educational Control Products

ECP provides state of the art laboratory equipment for feedback control & system dynamics education. Since shipping our first system more than 12 years ago, we have continuously refined and expanded ECP's product line based on feedback from our customers and a rigorous development and test program.

- National Science Foundation http://www.nsf.gov

National Science Foundation WHERE DISCOVERIES BEGIN

The National Science Foundation (NSF) is an independent federal agency "to promote the progress of science; advance the national health, prosperity, and welfare; and to secure national defense. NSF is the major source of federal backing in many fields such as mathematics, computer science and the social sciences. NSF's goal is to support the people, ideas and tools that together make discovery possible.

- Taylor & Francis http://www.taylorandfrancisgroup.com/

Taylor & Francis Taylor & Francis Group

Building on two centuries' experience, the Taylor & Francis Group (now incorporating CRC Press and Marcel Dekker) publishes more than 1,000 journals and around 1,800 new books each year, with a books backlist in excess of 20,000 specialist titles. For further information please visit our website at http://www.taylorandfrancisgroup.com/

The hours for the exhibitor booths are as follows:

Exhibition hours

Wednesday, June 8	9:00 AM – 5:00 PM
Thursday, June 9	9:00 AM – 5:00 PM
Friday, June 10	9:00 AM – 12:00 PM

MINI-CONFERENCE

One Day Mini-Conference on
"The Cross-Boundary Nature of Control, its Beauty and Power"
Tuesday, June 7, 2005, *Galleria I & II*

Organizer: Bozenna Pasik-Duncan, University of Kansas,
Chair, AACC Committee on Control Education
Chair, IEEE CSS Committee on Control Education
Co-Chair, IFAC Committee on Control Education

Sponsors: American Automatic Control Council
American Control Conference 2005
IEEE Control Systems Society
IFAC Committee on Control Education
USA National Science Foundation

For the first time ever, this mini conference will bring together high school students, college students, both undergraduate and graduate, high school teachers, faculty and practitioners.

The purpose of the Conference is to promote an increased awareness among students and teachers of the importance and cross-boundary nature of control and systems technology.

The program includes lectures by distinguished, cutting-edge researchers and technology innovators, research posters prepared by undergraduate students, hands-on projects prepared by graduate students, formal and informal discussions with all levels representatives of academia and the industry control community. This one day mini-conference is open to all participants of the ACC.

ACC PAST AND PRESENT

Year	*Date*	*General Chair*	*Program Chair*	*Location*
1982	June 14-16	Michael Robins	Yaakov Bar-Shalom	Arlington, VA
1983	June 22-24	Harish S. Rao	Peter Dorato	San Francisco, CA
1984	June 6-8	Herbert E. Rauch	Leonard Shaw	San Diego, CA
1985	June 19-21	Yaakov Bar-Shalom	David Wormley	Boston, MA
1986	June 18-20	Ed Stear	Daniel Alspach	Seattle, WA
1987	June 10-12	Thomas F. Edgar	Jason L. Speyer	Minneapolis, MN
1988	June 15-17	Wayne J. Book	Hassan Khalil	Atlanta, GA
1989	June 21-23	H. Vincent Poor	Marija Ilic	Pittsburgh, PA
1990	May 23-25	Dagfinn Gangaas	Eliezer Gai	San Diego, CA
1991	June 26-28	Timothy L. Johnson	Masayoshi Tomizuka	Boston, MA
1992	June 21-26	Dale E. Seborg	B. Ross Barmish	Chicago, IL
1993	June 2-4	Abraham H. Haddad	Bruce H. Krogh	San Francisco, CA
1994	June 29-July 1	Hassan Khalil	Jeffrey Kantor	Baltimore, MD
1995	June 21-23	Masayoshi Tomizuka	A. Galip Ulsoy	Seattle, WA
1996	**No ACC held due to IFAC World Congress in San Francisco, CA**			
1997	June 4-6	Naim A. Kheir	Stephen Yurkovich	Albuquerque, NM
1998	June 24-26	Joe H. Chow	Bonnie S. Heck	Philadelphia, PA
1999	June 2-4	Stephen Yurkovich	Pradeep Misra	San Diego, CA
2000	June 28-30	A. Galip Ulsoy	Suhada Jayasuriya	Chicago, IL
2001	June 25-27	Bruce H. Krogh	B. Wayne Bequette	Arlington, VA
2002	May 8-10	Russ Rhinehart	Eduardo Misawa	Anchorage, AK
2003	June 4-6	B. Wayne Bequette	Anuradha Annaswamy	Denver, CO
2004	June 30-July 2	Jason L. Speyer	Lucy Y. Pao	Boston, MA
2005	June 8-10	Suhada Jayasuriya	S.N. Balakrishnan	Portland, OR

2005 American Control Conference

TECHNICAL PROGRAM

Program at a Glance

Tutorial session
Interactive session

2005 ACC Technical Program Wednesday June 8, 2005

Track 1	Track 2	Track 3	Track 4	Track 5	Track 6	Track 7	Track 8	Track 9	Track 10
Grand Ballroom II	Senate	Galleria III	Broadway II	Galleria I	Broadway III	Forum	Directors	Council	Broadway IV

08:15-09:15 WePPL Plenary Ballroom
Plenary Lecture I: Control Challenges for the Next Century of Flight
Colonel Michael B. Leahy

Track 1	Track 2	Track 3	Track 4	Track 5	Track 6	Track 7	Track 8	Track 9	Track 10
09:30-11:30 **WeA01** Uncertain Switched and Hybrid Systems	09:30-11:30 **WeA02** Stability of Linear Systems	09:30-11:30 **WeA03** Networked Control Systems I	09:30-11:30 **WeA04** Trajectory Planning and Tracking for UAVs	09:30-11:30 **WeA05** Analysis and Control of Nonlinear Systems I	09:30-11:30 **WeA06** Learning Control Theory	09:30-11:50 **WeA07** Manufacturing Systems and Supply Chain	09:30-11:30 **WeA08** Optimization Methods and Applications	09:30-11:30 **WeA09** Model Predictive Control	09:30-11:30 **WeA10** Optimal Control and Filtering for Stochastic Systems
13:30-15:30 **WeB01** Stability of Hybrid Systems	13:30-15:30 **WeB02** Linear Parameter Varying Systems	13:30-15:30 **WeB03** Networked Control Systems - Delays and Robustness	13:30-15:30 **WeB04** Underwater Vehicles	13:30-15:30 **WeB05** Analysis and Control of Nonlinear Systems II	13:30-15:30 **WeB06** Learning Control	13:30-15:30 **WeB07** Mechanical Systems and Mechatronics	13:30-15:30 **WeB08** Optimization Algorithms	13:30-15:30 **WeB09** Nonlinear Model Predictive Control	13:30-15:30 **WeB10** Optimal Control Theory
15:45-17:45 **WeC01** Switched and Hybrid Systems	15:45-18:05 **WeC02** Linear System Design	15:45-17:45 **WeC03** Networked Control Systems - Stability and Identification	15:45-17:45 **WeC04** Tracking	15:45-17:45 **WeC05** Theory and Applications of Nonlinear Control	15:45-17:45 **WeC06** Neural Network Theory	15:45-17:45 **WeC07** Mechanical Systems and Robotics	15:45-17:45 **WeC08** Optimization and Control	15:45-17:45 **WeC09** Modeling and Identification of Process Control	15:45-17:45 **WeC10** Optimal Control Applications

Tutorial session
Interactive session

2005 ACC Technical Program Wednesday June 8, 2005

Track 11	Track 12	Track 13	Track 14	Track 15	Track 16	Track 17	Track 18	Special Session	Special Session
Studio	Executive	Broadway I	Galleria II	Parlor A	Grand Ballroom I	Parlor B	Parlor C	Grand Ballroom I	Grand Ballroom II
08:15-09:15 WePPL Plenary Ballroom Plenary Lecture I: Control Challenges for the Next Century of Flight Colonel Michael B. Leahy									
09:30-11:30 **WeA11** Missile Guidance Control	09:30-11:30 **WeA12** Analysis and Control of Stochastic Systems	09:30-11:30 **WeA13** Biomodeling and Control I	09:30-11:30 **WeA14** Automotive Applications I	09:30-11:30 **WeA15** Fault Detection and Accomodation - Applications	09:30-11:30 **WeA16** Cooperative Control with the MultiUAV Simulation	09:30-11:30 **WeA17** Fuzzy Logic and Control I	09:30-11:30 **WeA18** New Techniques in Command Shaping for Vibration Suppression		
								11:30-1:10 **Special Session I**	11:30-1:10 **Special Session II**
13:30-15:30 **WeB11** Spacecraft Attitude Control	13:30-15:30 **WeB12** Control of Population Balance Systems	13:30-15:30 **WeB13** Biomodeling and Control II	13:30-15:30 **WeB14** Automotive Applications II (Engines)	13:30-15:30 **WeB15** Fault Detection and Accomodation	13:30-15:30 **WeB16** Cooperative Control Methods and Applications	13:30-15:30 **WeB17** Fuzzy Logic and Control II	13:30-15:30 **WeB18** Control Applications I		
15:45-18:05 **WeC11** Aircraft Control and Applications	15:45-17:45 **WeC12** Probabilistic Methods and Stochastic Optimization	15:45-17:45 **WeC13** Bioengineering	15:45-17:45 **WeC14** Automotive Applications III	15:45-17:45 **WeC15** Fault Detection in Uncertain Systems	15:45-17:45 **WeC16** Cooperative Control Theory	15:45-17:45 **WeC17** Intelligent Control Using Neural Networks	15:45-17:45 **WeC18** Control Applications II		
								6:00-7:30 **Special Session III**	6:00-7:30 **Special Session IV**

Tutorial session

Interactive session

2005 ACC Technical Program Thursday June 9, 2005

Track 1	Track 2	Track 3	Track 4	Track 5	Track 6	Track 7	Track 8	Track 9	Track 10
Grand Ballroom II	Senate	Galleria III	Broadway II	Galleria I	Broadway III	Forum	Directors	Council	Broadway IV

08:15-09:15 ThPPL Plenary Ballroom
Plenary Lecture II: Autonomous Machines - Racing to Win the DARPA Grand Challenge
Richard M. Murray

	09:30-11:30 **ThA02** LMIs in Estimation and Control	09:30-11:30 **ThA03** Stability and Control of Communica-tions Networks	09:30-11:30 **ThA04** Multi-Agent Coordina-tion and Control	09:30-11:30 **ThA05** Stability of Nonlinear Systems I	09:30-11:30 **ThA06** Machine Learning and Classifica-tion	09:30-11:30 **ThA07** Modeling, Identification and Control of Mechanical Systems	09:30-11:30 **ThA08** Advanced Control for Ships in the 21st Century	09:30-11:30 **ThA09** Modeling and Control for Industrial and Material Processing Applications	09:30-11:30 **ThA10** Adaptive Linear Control

11:30-1:30 Grand Ballroom of the Hilton
Awards Banquet

	13:30-15:30 **ThB02** Maximum Likelihood Subspace Identification for Linear, Nonlinear, and Closed-Loop Systems	13:30-15:30 **ThB03** Communica-tion Networks	13:30-15:30 **ThB04** Spacecraft Formation and Control	13:30-15:30 **ThB05** Theory and Applications of Sliding Mode Control	13:30-15:30 **ThB06** Imaging, Modeling, and Control of Microscale Systems	13:30-15:30 **ThB07** Stability, Control and Modeling of Mechanical Systems	13:30-15:30 **ThB08** Control of Atomic Scale Surface Processes	13:30-15:30 **ThB09** Model Reduction I (Theory)	13:30-15:30 **ThB10** Adaptive Control and Signal Processing

15:45-17:45 **ThC01** Robust Control Design	15:45-17:45 **ThC02** H Infinity Filtering and Control	15:45-17:45 **ThC03** Networked Control Systems II	15:45-17:45 **ThC04** UAV Autonomy and Formation Control	15:45-17:45 **ThC05** Nonlinear Control Applications	15:45-17:45 **ThC06** Mechatro-nics Applications	15:45-17:45 **ThC07** Control and Identification of Large Structural Systems	15:45-17:45 **ThC08** Batch Control	15:45-17:45 **ThC09** Model Reduction II	15:45-17:45 **ThC10** Direct Adaptive Control

Tutorial session

Interactive session

2005 ACC Technical Program Thursday June 9, 2005

Track 11	Track 12	Track 13	Track 14	Track 15	Track 16	Track 17	Track 18	Special Session	Special Session
Studio	Executive	Broadway I	Galleria II	Parlor A	Grand Ballroom I	Parlor B	Parlor C	Grand Ballroom I	Grand Ballroom II
08:15-09:15 ThPPL Plenary Ballroom Plenary Lecture II: Autonomous Machines - Racing to Win the DARPA Grand Challenge Richard M. Murray									
09:30-11:30 **ThA11** Aerospace Applications	09:30-11:30 **ThA12** Intelligent Vehicles and Highway Systems	09:30-11:30 **ThA13** Modeling and Control of Systems for Critical Care Ventilation	09:30-11:30 **ThA14** Automotive Applications IV	09:30-11:30 **ThA15** Fault Tolerant Systems		09:30-11:30 **ThA17** Intelligent Control Applications	09:30-11:30 **ThA18** Computational Methods for Optimal Filtering and Control		
11:30-1:30 Grand Ballroom of the Hilton **Awards Banquet**									
13:30-15:30 **ThB11** Robust and Adaptive Control of Aerospace Vehicles	13:30-15:30 **ThB12** Mixed-Integer Programming for Control - a Tutorial	13:30-15:30 **ThB13** Sum of Squares in Industry: An Algorithmic Analysis Approach	13:30-15:30 **ThB14** Power Systems - Electric and Automotive Applications	13:30-15:30 **ThB15** Fault Diagnosis		13:30-15:30 **ThB17** Control of Hybrid Systems	13:30-15:30 **ThB18** Computational Methods for Stability of Time-Delay Systems		
15:45-17:45 **ThC11** Control for Disk Drives	15:45-17:45 **ThC12** Adaptive Control of Rapidly Time-Varying Systems	15:45-17:45 **ThC13** Modeling and Control for Biological Systems	15:45-17:45 **ThC14** Automotive Powertrain Controls: Fundamentals and Frontiers	15:45-17:45 **ThC15** Fault Detection / Accomodation - Theory and Applications	15:45-17:45 **ThC16** Cooperative Electronic Attack	15:45-17:45 **ThC17** Control of Networks - Applications	15:45-17:45 **ThC18** Constrained Control		

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Tutorial session
Interactive session

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08:15-09:15 FrPPL Plenary Ballroom
Eckman Lecture III: Control of Nonlinear Distributed Process Systems
Panagiotis D. Christofides

09:30-11:30 **FrA01** Robust Stability and Control	09:30-11:30 **FrA02** Estimation and Filtering I	09:30-11:30 **FrA03** Autonomous Systems and Networks	09:30-11:30 **FrA04** Unmanned Vehicles	09:30-11:30 **FrA05** Feedback Lineariza-tion Theory and Applications	09:30-11:30 **FrA06** Micro-Motion Control of Mechanical Systems	09:30-11:30 **FrA07** Observers I	09:30-11:30 **FrA08** Analysis and Control of Industrial Processes	09:30-11:30 **FrA09** Visual Servos	09:30-11:30 **FrA10** Robust Adaptive Control

13:30-15:30 **FrB01** Robust Control	13:30-15:30 **FrB02** Estimation and Filtering II	13:30-15:30 **FrB03** Sliding Mode Control I (Theory)	13:30-15:30 **FrB04** UAV's: Control, Estimation and Applications	13:30-15:30 **FrB05** Stability of Nonlinear Systems II	13:30-15:30 **FrB06** Modelling and Control of MEMS in Industrial Applications	13:30-15:30 **FrB07** Observers II	13:30-15:30 **FrB08** PI/PID Control	13:30-15:30 **FrB09** Analysis and Control of Time-Delay Systems	13:30-15:30 **FrB10** Robust and Optimal Control

15:45-17:45 **FrC01** Control and Optimization of Distributed Processes	15:45-17:45 **FrC02** Filtering Applications	15:45-17:45 **FrC03** Sliding Mode Control II - Theory and Applications	15:45-17:45 **FrC04** Multiple Unmanned Air Vehicles	15:45-17:45 **FrC05** Control of Output Feedback Nonlinear Systems	15:45-17:45 **FrC06** Vibration, Analysis and Control	15:45-18:05 **FrC07** Control Theory and Applications	15:45-17:45 **FrC08** Observer Design and Applications	15:45-17:45 **FrC09** Large / Distributed Systems	15:45-17:45 **FrC10** Output Feedback Tracking and Control

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Track 11	Track 12	Track 13	Track 14	Track 15	Track 16	Track 17	Track 18	Special Session	Special Session
Studio	Executive	Broadway I	Galleria II	Parlor A	Grand Ballroom I	Parlor B	Parlor C	Grand Ballroom I	Grand Ballroom II
08:15-09:15 FrPPL Plenary Ballroom Eckman Lecture III: Control of Nonlinear Distributed Process Systems Panagiotis D. Christofides									
09:30-11:30 **FrA11** Control and Pointing Challenges of Antennas and Telescopes	09:30-11:30 **FrA12** Stability of Switched Systems	09:30-11:30 **FrA13** Control Applications in Ventricular Assist Device Develop-ment	09:30-11:30 **FrA14** Modeling and Control of Advanced Automotive Propulsion Systems	09:30-11:30 **FrA15** Distributed Parameter Systems	09:30-11:30 **FrA16** Adaptive Flight Control	09:30-11:30 **FrA17** Discrete Event Systems	09:30-11:30 **FrA18** Control of Wireless Communica-tions Networks		
								11:30-1:10 **Special Session V**	
13:30-15:30 **FrB11** Control of Underwater Vehicles	13:30-15:30 **FrB12** Power and Energy	13:30-15:30 **FrB13** Design of Biological Feedback Circuits	13:30-15:30 **FrB14** Modeling and Control of Automotive Powertrain Systems	13:30-15:30 **FrB15** Identification I	13:30-15:30 **FrB16** Introduction to the MultiUAV Simulation and Its Application to Cooperative Control Research	13:30-15:30 **FrB17** Advanced Controls for Manufactur-ing	13:30-15:30 **FrB18** Industry Needs in Embedded Control Education		
15:45-17:45 **FrC11** Mobility and Locomotion	15:45-17:45 **FrC12** Discrete-Time Systems: Design and Applications	15:45-17:45 **FrC13** Autonomous Systems	15:45-17:45 **FrC14** Advances in Automotive Sensing and Actuation	15:45-17:45 **FrC15** Identification II	15:45-17:45 **FrC16** Active-Vision Control Systems for Complex Adversarial 3-D Environ-ments	15:45-17:45 **FrC17** Advances in Nonlinear Control	15:45-17:45 **FrC18** Control Education		

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