Plenary Lectures and CSS Bode Lecture

The CSS Bode Lecture

Title: **Fifty Years of Information Based Control Theory**
Speaker: Professor John Baillieul, Boston University.
Time and Location: Bonnet Creek Ballroom, Thursday, December 15, 8:30-9:30 AM

Abstract: The year 1948 was auspicious for information science and technology. Norbert Wiener's book Cybernetics was published by Wiley, the transistor was invented (and given its name), and Shannon's seminal paper "A Mathematical Theory of Communication" was published in the Bell System Technical Journal. In the years that followed, important ideas of Shannon, Wiener, Von Neumann, Turing and many others changed the way people thought about the basic concepts of control systems. Hendrik Bode himself was a Shannon collaborator in a paper on smoothing and prediction published in the Proceedings of the IRE in 1950. It is thus not surprising that by the time the earliest direct predecessor of CDC (the Discrete Adaptive Processes Symposium) was held in New York in June, 1962, concepts from machine intelligence and information theory were not at all foreign to the control community.

This talk will examine the interwoven evolution of control and information over the past fifty years during which time the IEEE Conference on Decision and Control went from infancy to maturity. The talk will also discuss two new areas in information based control. In collaboration with W.S. Wong, some recent work on control communication complexity has been aimed at a new class of optimal control problems in which distributed agents communicate through the dynamics of a control system in such a way that the control cost is minimized over many messages. Applications of the theory to robot communication through relative motions (e.g. robot dancing and team sports) and to distributed control of semi-classical models of quantum systems will be discussed. The talk will also discuss some recently discovered links between information and the differential topology of smooth random fields (joint work with D. Baronov). The latter work has been applied to a problem of rapid information acquisition in robotic reconnaissance, and it has suggested metrics by which to assess the tradeoff between speed and accuracy.

Biography: John Baillieul's research deals with robotics, the control of mechanical systems, and mathematical system theory. His PhD dissertation, completed at Harvard University under the direction of R.W. Brockett in 1975, was an early work dealing with connections between optimal control theory and what came to be called “sub-Riemannian geometry.” After publishing a number of papers developing geometric methods for nonlinear optimal control problems, he turned his attention to problems in the control of nonlinear systems modeled by homogeneous polynomial differential equations. Such systems describe, for example, the controlled dynamics of a rigid body. His main controllability theorem applied the concept of finiteness embodied in the Hilbert basis theorem to develop a controllability condition that could be verified by checking the rank of an explicit finite dimensional operator. Baillieul’s current research is aimed at understanding decision making and novel ways to communicate in mixed teams of humans and intelligent automata. He was awarded the IEEE

Third Millennium Medal in 2000, and he has held many positions in the Control Systems Society including that of fortieth President. John Baillieul has also held a number of leadership positions in both the Technical Activities Board and the Publication Services and Products Board of the IEEE. He is past IEEE Vice President of Publication Services and Products. John Baillieul is a Fellow of the IEEE and a Fellow of SIAM..

Plenary Lecturers

Title: Potentials and Possibilities of Regularization in System Identification
Speaker: Professor Lennart Ljung, Linköping University, Sweden
Time and Location: Bonnet Creek Ballroom, Monday December 12, 8:30-9:30 AM

Abstract: System identification is about how to build mathematical models of systems from observed input-output signals. As a subarea of Automatic control is about half a century old, and it takes many of its basic ideas from classical statistical techniques. Regularization is, simply put, to allow a considerable amount of freedom in the model, and then curb the flexibility by explicit penalties on the parameters. This is an old and well known technique in the area. But vitalizing encounters with young scientific communities keeps System Identification developing. Two such encounters have had important influence on the understanding the possibilities and potentials of regularization in System Identification. One is the meeting with Machine Learning, Gaussian process regression and renewed focus on Bayesian techniques as well as manifold learning. Another is the meeting with sparsity, compressed sensing and convex optimization. In this talk we illustrate how these two influences have meant additional tools for and insights into the basic identification problems of handling the bias/variance trade-off and finding parsimonious models.

Biography: Lennart Ljung received his PhD in Automatic Control from Lund Institute of Technology in 1974. Since 1976 he is Professor of the chair of Automatic Control In Linkoping, Sweden, and is currently Director of the Strategic Research Center "Modeling, Visualization and Information Integration" (MOVIII). He has held visiting positions at Stanford and MIT and has written several books on System Identification and Estimation. He is an IEEE Fellow, an IFAC Fellow and an IFAC Advisor. He is as a member of the Royal Swedish Academy of Sciences (KVA), a member of the Royal Swedish Academy of Engineering Sciences (IVA), an Honorary Member of the Hungarian Academy of Engineering, an Honorary Professor of the Chinese Academy of Mathematics and Systems Science, and a Foreign Associate of the US National Academy of Engineering (NAE). He has received honorary doctorates from the Baltic State Technical University in St Petersburg, from Uppsala University, Sweden, from the Technical University of Troyes, France, from the Catholic University of Leuven, Belgium and from Helsinki University of Technology, Finland. In 2002 he received the Quazza Medal from IFAC, and in 2003 he recieved the Hendrik W. Bode Lecture Prize from the IEEE Control Systems Society, and he was the 2007 recepient of the IEEE Control Systems Award.

Title: Universal Laws and Architectures
Speaker: Professor John C. Doyle, California Institute of Technology
Time and Location: Bonnet Creek Ballroom, Tuesday, December 13, 8:30-9:30 AM

Abstract: This talk will focus on progress towards a more "unified" theory for complex networks involving several elements: hard limits on achievable robust performance ("laws"), the organizing principles that succeed or fail in achieving them (architectures and protocols), the resulting high variability data and "robust yet fragile" behavior observed in real systems and case studies (behavior, data), and the processes by which systems evolve (variation, selection, design). Insights into what the potential universal laws, architecture, and organizational principles are can be drawn from three converging research themes. First, detailed description of components and a growing attention to systems in biology and neuroscience, the organizational principles of organisms and evolution are becoming increasingly. Biologists are articulating richly detailed explanations of biological complexity, robustness, and evolvability that point to universal principles and architectures. Second, while the components differ and the system processes are far less integrated, advanced technology's complexity is now approaching biology's and there are striking convergences at the level of organization and architecture, and the role of layering, protocols, and feedback control in structuring complex multiscale modularity. Third, new mathematical frameworks for the study of complex networks suggests that this apparent network-level evolutionary convergence within/between biology/technology is not accidental, but follows necessarily from their universal system requirements to be fast, efficient, adaptive, evolvable, and most importantly, robust to perturbations in their environment and component part. We have the beginnings of the underlying mathematical framework and also a series of case studies in classical problems in complexity from statistical mechanics, turbulence, cell biology, human physiology and medicine, neuroscience, wildfire, earthquakes, economics, the Internet, and smartgrid. A workshop preceding CDC will explore this in more detail (with Pablo Parrilo).

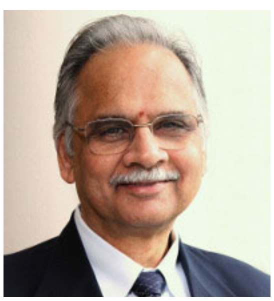
Selected references:

[1] M Chiang, SH Low, AR Calderbank, JC. Doyle (2006) Layering As Optimization Decomposition, *PROCEEDINGS OF THE IEEE*, Volume: 95 Issue: 1 Jan 2007
[2] Alderson DL, Doyle JC (2010) Contrasting views of complexity and their implications for network-centric infrastructures. *IEEE Trans Systems Man Cybernetics—Part A: Syst Humans* 40:839-852.
[3] H. Sandberg, J. C. Delvenne, J. C. Doyle. On Lossless Approximations, the Fluctuation-Dissipation Theorem, and Limitations of Measurements*, IEEE Trans Auto Control*, Feb 2011
[4] Chandra F, Buzi G, Doyle JC (2011) Glycolytic oscillations and limits on robust efficiency. *Science*, Vol 333, pp 187-192.
[5] JC Doyle**,** ME Csete (2011) Architecture, Constraints, and Behavior, *P Natl Acad Sci USA*, in press, available online

[6] Gayme DF, McKeon BJ, Bamieh B, Papachristodoulou P, Doyle JC (2011) Amplification and Nonlinear Mechanisms in Plane Couette Flo*w, Physics of Fluids*, in press (published online 17 June 2011)

Biography: John Doyle is the John G Braun Professor of Control and Dynamical Systems, Electrical Engineer, and BioEngineering at Caltech. He has a BS and MS in EE, MIT (1977), and a PhD, Math, UC Berkeley (1984). Current research interests are in theoretical foundations for complex networks in engineering and biology, focusing on architecture, and for multiscale physics. Early work was in the mathematics of robust control, including LQG robustness, (structured) singular value analysis, H-infinity plus recent extensions to nonlinear and networked systems. His research group has collaborated in many software projects, including the Robust Control Toolbox (muTools), SOSTOOLS, SBML (Systems Biology Markup Language), and FAST (Fast AQM, Scalable TCP). Prize paper awards include the IEEE Baker, the IEEE Automatic Control Transactions Axelby (twice), and best conference papers in ACM Sigcomm and AACC American Control Conference. Individual awards include the AACC Eckman, and the IEEE Control Systems Field and Centennial Outstanding Young Engineer Awards. He has held national and world records and championships in various sports. He is best known for having excellent co-authors, students, friends, and colleagues.

Title: Probabilistic Methods in Cancer Biology
Speaker: Professor Mathukumalli Vidyasagar, University of Texas at Dallas
Time and Location: Bonnet Creek Ballroom, Wednesday, December 14, 8:30-9:30 AM



Abstract: Recent advances in experimental techniques have made it possible to generate an enormous amount of `raw ' biological data, with cancer biology being no exception. The main challenge faced by cancer biologists now is the generation of plausible hypotheses that can be evaluated against available data and/or validated through further experimentation. For persons trained in control theory, there is now a significant opportunity to work with biologists to create a virtuous cycle of hypothesis generation and experimentation. In this talk, we discuss four specific problems in cancer biology that are amenable to study using probabilistic methods. These are: reverse engineering gene regulatory networks, constructing context-specific gene regulatory networks, analyzing the significance of expression levels for collections of genes, and discriminating between drivers (mutations that cause cancer) and passengers (mutations that are caused by cancer or have no impact). Some research problems that merit the attention of the controls community are also suggested.

Biography: Mathukumalli Vidyasagar is currently Cecil & Ida Green Chair in Systems Biology at the University of Texas at Dallas. His current research interests are in stochastic processes and their applications to computational biology with special emphasis on cancer biology, and to mathematical finance. He was born in Guntur, India on September 29, 1947. He received the B.S., M.S. and Ph.D. degrees in electrical engineering from the University of Wisconsin in Madison, in 1965, 1967 and 1969 respectively. Between 1969 and 1989, he was a Professor of Electrical Engineering at various universities in the USA and Canada. His last overseas job was with the University of Waterloo, Waterloo, ON, Canada, where he served between 1980 and 1989. In 1989 he returned to India as the Director of the newly created Centre for Artificial Intelligence and Robotics (CAIR) in Bangalore, under the Ministry of Defense, Government of India. In 2000 he moved to the Indian private sector as an Executive Vice President of India's largest software company, Tata Consultancy Services, where he created the Advanced Technology Center, an industrial R&D laboratory of around 80 engineers. In 2009 he retired from TCS and joined the Erik Jonsson School of Engineering & Computer Science at the University of Texas at Dallas, as a Cecil & Ida Green Chair in Systems Biology. In March 2010 he was named as the Founding Head of the Bioengineering Department. He is a Fellow of several scientific societies including IEEE, and has received several awards in recognition of his research, including the IEEE Control Systems Award in 2008. Earlier he had received the Hendrik W. Bode Lecture Prize in 2000, and the Distinguished Service Citation from his alma mater, the University of Wisconsin.

Semi-Plenary Lectures

Title: Decentralized Activation and Decision-making in Networks of Biosensors
Speaker: Professor Vikram Krishnamurthy, University of British Columbia
Time and Location: Bonnet Creek III & VI, Monday December 12, 1:30 PM

Abstract: This talk considers decentralized information processing in a network of biosensors. The individual biosensors are built out of protein molecules imbedded in a synthetic cell membrane. When groups of such sensors can adapt their behavior to locally observed conditions, they can self-organize into a functioning network. The talk comprises of three parts. The first part of the talk illustrates how the theory of global games gives a useful method for analyzing sensor activation algorithms in dense sensor networks. It is shown that the Bayesian Nash equilibrium has a simple threshold structure. The second part of the talk deals with social learning protocols and how quickest time change detection can be achieved. In the third part of the talk we describe how decentralized stochastic approximation algorithms with regret matching can be deployed to guide network behavior to a correlated equilibrium thereby achieving consensus in decision-making. The unifying theme of the talk is how simple local behavior can result in sophisticated global behavior, and how local and global decision makers interact.

Biography: Vikram Krishnamurthy received his Ph.D. from the Australian National University, in 1992. He is currently a professor at the University of British Columbia. His current research interests include stochastic dynamical systems for modeling of biological ion channels, computational game theory, and stochastic optimization and scheduling. Dr Krishnamurthy is an IEEE fellow. He served as distinguished lecturer for the IEEE signal processing society in 2009-2010 and is currently editor in chief of IEEE Journal Selected Topics in Signal Processing.

Title: Taming Dr. Frankenstein: Contract-Based Design for Cyberphysical Systems
Speaker: Professor Alberto Sangiovanni Vincentelli, University of California at Berkeley
Time and Location: Bonnet Creek IX & XII, Monday, December 12, 1:30 PM

Abstract: *Cyber-physical systems* combine a cyber side (computing and networking) with a physical side (mechanical, electrical, and chemical processes). Such systems present the biggest challenges as well as the biggest opportunities in several large industries, including electronics, energy, automotive, defense and aerospace, telecommunications, instrumentation, industrial automation.

Engineers today do successfully design cyber-physical systems in a variety of industries. Unfortunately, the development of systems is costly, and development schedules are difficult to stick to. The complexity of cyber-physical systems, and particularly the increased performance that is offered from interconnecting what in the past have been separate systems, increases the design and verification challenges. As the complexity of these systems increases, our inability to rigorously model the interactions between the physical and the cyber sides creates serious vulnerabilities. Systems become unsafe, with disastrous inexplicable failures that could not have been predicted. Distributed control of multi-scale complex systems is largely an unsolved problem.

A common view that is emerging in research programs in Europe and the US is ``enabling *contract-based design* (CBD),'' which formulates a broad and aggressive scope to address urgent needs in the systems industry. We present a design methodology and a few examples in controller design whereby contract-based design can be merged with platform-based design to formulate the design process as a meet-in-the-middle approach, where design requirements are implemented in a subsequent refinement process using as much as possible elements from a library of available components. Contracts are formalizations of the conditions for correctness of element integration (horizontal contracts), for lower level of abstraction to be consistent with the higher ones, and for abstractions of available components to be faithful representations of the actual parts (vertical contracts).

Biography: **Alberto Sangiovanni Vincentelli** holds the Edgar L. and Harold H. Buttner Chair of Electrical Engineering and Computer Sciences at the University of California at Berkeley. He was a co-founder of Cadence and Synopsys, the two leading companies in the area of Electronic Design Automation. He is a member of the Board of Directors of Cadence, Sonics, and Accent. He was a member of the HP Strategic Technology Advisory Board, and is a member of the Science and Technology Advisory Board of General Motors and of the Technology Advisory Council of UTC. He is a member of the High-Level Group, of the Steering Committee, of the Governing Board and of the Public Authorities Board of the EU Artemis Joint Technology Undertaking. He is member of the Scientific Council of the Italian National Science Foundation (CNR) and a member of the Executive Committee of Italian Institute of Technology. He received, among others, the Kaufman Award of the Electronic Design Automation Council for “pioneering contributions to Electronic Design Automation” and the IEEE/Royal Society of Edinburgh Wolfson James Clerk Maxwell Medal “for groundbreaking contributions that have had an exceptional impact on the development of electronics and electrical engineering or related fields". He holds an Honorary Doctorate from University of Aalborg, Denmark. He is an author of 880 papers, 15 books and 3 patents. He is a Fellow of the IEEE and a Member of the National Academy of Engineering.

Title: The Smart Grid: Overview, Issues, and Challenges
Speaker: Professor S. Massoud Amin, University of Minnesota
Time and Location: Bonnet Creek III & VI, Tuesday, December 13, 1:30 PM

Abstract: Recent policies combined with potential for technological innovations and business opportunities, have attracted a high level of interest in smart grids. The potential for a highly distributed system with a high penetration of intermittent sources poses opportunities and challenges. Any complex dynamic infrastructure network typically has many layers, decision-making units and is vulnerable to various types of disturbances. Effective, intelligent, distributed control is required that would enable parts of the networks to remain operational and even automatically reconfigure in the event of local failures or threats of failure. A major challenge is posed by the lack of a unified mathematical framework with robust tools for modeling, simulation, control and optimization of time-critical operations in complex multicomponent and multiscaled networks. Mathematical models of such complex systems are typically vague (or may not even exist); moreover, existing and classical methods of solution are either not available, or are not sufficiently powerful. From a strategic R&D viewpoint, how to retrofit and engineer a stable, secure, resilient grid with large numbers of such unpredictable power sources? What roles will assets optimization, increased efficiency, energy storage, advanced power electronics, power quality, electrification of transportation, novel control algorithms, communications, cyber and infrastructure security play in the grid of the future? What are the emerging technologies to enable new products, services, and markets? In this presentation, we will present an overview of smart grids and recent advances in distributed sensing, modeling, and control, particularly at both the high-voltage power grid and at consumer level. Such advances may contribute toward the development of an effective, intelligent, distributed control of power system networks with a focus on addressing distributed sensing, computation, estimation, controls and dynamical systems challenges and opportunities ahead.

Biography: Massoud Amin holds the Honeywell/H.W. Sweatt Chair in Technological Leadership, is the director of the Technological Leadership Institute and is a professor of Electrical and Computer Engineering at the University of Minnesota. Before joining Minnesota in 2003, he directed all Infrastructure Security R&D after 9/11 and served as Area Manager of Security, Grid Operations/Planning, Energy Markets, Risk and Policy Assessment at the Electric Power Research Institute (EPRI) in Palo Alto. Prior to that he served as head of mathematics and information sciences at EPRI, pioneered R&D and coined the term smart grids in 1998 and worked on self-repairing energy infrastructures, where he led the development of over 24 technologies transferred to industry. He is author or co-author of over 190 peer reviewed papers, and the editor of 7 collections of manuscripts. Board appointments include the Board of Directors of the Texas RE (2010-present), Board on

Infrastructure and the Constructed Environment (BICE) at the U.S. National Academy of Engineering (2001-2007), and the Board on Mathematical Sciences and Applications (BMSA) at the National Academy of Sciences (2006-2009). He is on seven editorial boards, is the founding chairman of the IEEE Smart Grid Newsletter, and serves as chair of the CSS TC-SG. He is a fellow of the ASME, was three times Professor of the Year at Washington University in St. Louis (1992-95), and was inducted into the University of Minnesota's Academy of Distinguished Teachers in 2008. At EPRI he received several awards, including six EPRI Performance Recognition Awards for leadership in three areas, and received the 2002 President's Award for the Infrastructure Security Initiative, and twice received the Chauncey Award, the Institute's highest honor.

Title: Approximate Bisimulation: A Bridge Between Computer Science and Control Theory
Speaker: Professor George J. Pappas, University of Pennsylvania
Time and Location: Bonnet Creek IX & XII, Tuesday, December 13, 1:30 PM

Abstract: Fifty years ago, control and computing were part of a broader system science. After a long period of intra-disciplinary development which resulted in control and computing being distant from each other, embedded and hybrid systems have challenged us to unite the, now developed, theories of continuous control and discrete computing on a broader system theoretic basis. In this talk, we will present a notion of system approximation that applies to both discrete and continuous systems by developing notions of approximate language inclusion, approximate simulation, and approximate bisimulation relations. We define a hierarchy of approximation pseudo-metrics between two systems that quantify the quality of the approximation, and capture the established notions in computer science as zero sections. Algorithms are developed for computing the proposed pseudo-metrics, both exactly and approximately. The exact algorithms require the generalization of the fixed point algorithms for computing simulation and bisimulation relations, or dually, the solution of a static game whose cost is the so-called branching distance between the systems. Approximations for the pseudo-metrics can be obtained by considering Lyapunov-like functions called simulation and bisimulation functions. Our approximation framework will be illustrated in in problems such as safety verificaion problems for continuous systems, approximating nonlinear systems by discrete systems, and hierarchical control design.

Biography: George J. Pappas is the Joseph Moore Professor in the Department of Electrical and Systems Engineering at the University of Pennsylvania. He also holds a secondary appointment in the Departments of Computer and Information Sciences, and Mechanical Engineering and Applied Mechanics. He is member of the GRASP Lab and the PRECISE Center for embedded systems. His research focuses on control theory and in particular, hybrid systems, embedded systems, hierarchical and distributed control systems, with applications to unmanned aerial vehicles, distributed robotics, green buildings, and biomolecular networks. He is a Fellow of IEEE, and has received various awards such as the 2010 Antonio Ruberti Young Researcher Prize, the 2009 George S. Axelby Award, and the 2004 National Science Foundation PECASE Award.

Title: Are stochastic dynamics the Foundation of Intelligence?
Speaker: Professor Weibo Gong, University of Massachusetts, Amherst
Time and Location: Bonnet Creek III & VI, Wednesay, December 14, 1:30 PM

Abstract: Concept abstraction is an important component of intelligence. Scientists today still do not know how the brain accomplishes it. In this talk we compare some recent mathematical results about random walks on manifolds and graphs with the features of concept abstraction processes to seek understanding of the algorithms involved.

Biography: Weibo Gong received his Ph.D. in Engineering Sciences from the Division of Applied Sciences at Harvard University in 1987, and since has been with the Department of Electrical and Computer Engineering at University of Massachusetts, Amherst. He is now a full professor of Electrical and Computer Engineering and an adjunct professor of the Department of Computer Science at the same campus. Dr. Gong has received the IEEE Control Systems Society George Axelby outstanding paper award in 1997, University of Massachusetts Amherst Engineering College outstanding senior faculty award in 2002, and the University of Massachusetts Amherst Chancellor's medal in 2009. He is an IEEE Fellow since 1998. Dr. Gong is active in IEEE control systems society. He is the Program Chair for the 2004 IEEE Conference on Decision and Control. Dr. Gong's research interests include network modeling and control, stochastic dynamic systems, communication security, and the foundational algorithms for intelligence.

Title: Control of Distributed Systems
Speaker: Professor Jan H. van Schuppen, CWI, Amsterdam, The Netherlands
Time and Location: Bonnet Creek IX & XII, Wednesday, December 14, 1:30 PM

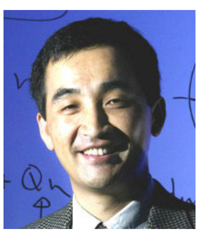
Abstract: A distributed systems consists of an interconnection of two or more subsystems. Control of such systems is structured by two or more controllers each receiving an observation stream from a local subsystem and providing an input to the local subsystem. The control objectives mostly refer to the interaction of the subsystems in the global system. Examples of distributed control systems include: the control of autonomous underwater vehicles with the problem of coordination of the activities of the vehicles. The control of road networks with a hierarchical-distributed system for coordination of different control measures. The control of automated guided vehicles on a container terminal for safety and for efficiency. Control of large complex machines with the problem of control of the parallel operations using several actuators and sensors.

Control synthesis of distributed systems will be described for the following control architectures: Distributed control often leading to a game theoretic approach. Distributed control with communication between controllers in which the emphasis is on what, when, and to whom to communicate.

Coordination control with attention for the coordination aspects between subsystems. Hierarchical control of a hierarchically structured system. A research program will be described for control of distributed systems and of hierarchical systems. The lecture is based on the project Control for Coordination of Distributed Systems (C4C; sponsored by the European Commission INFSO-ICT-223844).

Biography: Jan H. van Schuppen is affiliated as senior researcher with the the research institute Centrum Wiskunde & Informatica (CWI) in Amsterdam, The Netherlands and as Full Professor (part time) with the Department of Mathematics of the Delft University of Technology in Delft, The Netherlands. Van Schuppen's research interests include control of distributed/decentralized systems, control of discrete-event systems and of hybrid systems, stochastic control, realization, and system identification. In applied research his current interests include control engineering problems for motorway traffic and control and system theory for biochemical reaction networks. He regularly teaches courses for Ph.D. and master students. He is Co-Editor of the journal Mathematics of Control, Signals, and Systems, was Associate Editor-at-Large of the journal IEEE Transactions Automatic Control, and was Department Editor of the journal Discrete Event Dynamic Systems. Finally, he is currently the coordinator of the C4C Project (CON4COORD, Grant agreement INFSO-ICT-223844) was the coordinator of three other such projects, and was involved in five more such projects all financed by the European Commission.

Title: Semidefinite relaxation for quadratic and quartic optimization with applications to wireless communication
Speaker: Professor Zhi-Quan Luo, University of Minnesota
Time and Location: Bonnet Creek III & VI, Thursday, December 15, 1:30 PM



Abstract: We consider the NP-hard problem of finding a minimum norm vector in n-dimensional real or complex Euclidean space, subject to m concave homogeneous quadratic constraints. We show that the semidefinite programming relaxation for this nonconvex quadratically constrained quadratic program (QP) provides an $O(m^2)$ approximation in the real case, and an $O(m)$ approximation in the complex case. Moreover, we show that these bounds are tight up to a constant factor. When the Hessian of each constraint function is of rank one (namely, outer products of some given so-called {\it steering} vectors) and the phase spread of the entries of these steering vectors are bounded away from $\pi/2$, we establish a certain "constant factor" approximation (depending on the phase spread but independent of m and n) for both the SDP relaxation and a convex QP restriction of the original NP-hard problem. When the homogeneous quadratic constraints are separable and $m=n$, we show that the SDP relaxation is actually tight. All theoretical results will be illustrated through a transmit beamforming application in wireless communication.

Biography: Zhi-Quan (Tom) Luo is a professor in the Department of Electrical and Computer Engineering at the University of Minnesota (Twin Cities) where he holds an endowed ADC Chair in digital technology. He received his B.Sc. degree in Applied Mathematics in 1984 from Peking University, China, and a Ph.D degree in Operations Research from MIT in 1989. From 1989 to 2003, Dr. Luo was with the Department of Electrical and Computer Engineering, McMaster University, Canada, where he later served as the department head and held a senior Canada Research Chair in Information Processing. His research interests lie in the union of optimization algorithms, data communication and signal processing. Dr. Luo is a fellow of IEEE and SIAM. He is a recipient of the IEEE Signal Processing Society's Best Paper Award in 2004 and 2009, and the EURASIP Best Paper Award in 2011. He was awarded the 2010 Farkas Prize from the INFORMS Optimization Society. Dr. Luo currently chairs the IEEE Signal Processing Society's Technical Committee on Signal Processing for Communications and Networking (SPCOM). He has held editorial positions for several international journals including Journal of Optimization Theory and Applications, Mathematics of Computation, IEEE Transactions on Signal Processing, SIAM Journal on Optimization, Management Sciences and Mathematics of Operations.

Title: Monitoring of Large-scale Nonlinear Systems by Approximation-based Methods: Theory and Industrial Perspectives
Speaker: Professor Thomas Parisini, Imperial College London & University of Trieste
Time and Location: Bonnet Creek IX & XII, Thursday, December 15, 1:30 PM

Abstract: We live in a "distributed world" made by countless "nodes", being them cities, computers, people, etc., connected by a dense web of transportation, communication, or social ties. The term "network", describing such a collection of nodes and links, nowadays has become of common use thanks to our extensive reliance on "connections of interdependent systems" for our everyday life, for building complex technical systems, infrastructures and so on. In an increasingly "smarter" planet, it is expected that systems are safe, reliable, available 24/7, and possibly at low-cost maintenance. In this connection, monitoring and fault diagnosis are of customary importance to ensure high levels of safety, performance, reliability, dependability, and availability. In fact, faults and malfunctions can result, just referring to industrial plants, in off-specification production, increased operating costs, chance of line shutdown, danger for humans, detrimental environmental impact, and so on. Faults and malfunctions should be detected promptly and their source and severity should be diagnosed so that corrective actions can be possibly taken.

This lecture deals with a on-line approximation-based distributed fault diagnosis approach for large-scale nonlinear systems, by exploiting a "divide et impera" approach in which the overall diagnosis problem is decomposed into smaller subproblems, simpler enough to be solved within the existing computation and communication architectures. The distributed detection, isolation and identification task is broken down and assigned to a network of "Local Diagnostic Units", each having a "different/local view" on the system: they are allowed to communicate with each other and also to cooperate on the diagnosis of system components that may be shared thus yielding a global diagnosis decision. In the lecture, issues and perspectives will be addressed as well in a paradigmatic industrial context of safety-critical process control systems.

Biography: Thomas Parisini received the "Laurea" degree (Cum Laude and printing honours) in Electronic Engineering from the University of Genoa in 1988 and the Ph.D. degree in Electronic Engineering and Computer Science in 1993. He was with Politecnico di Milano and since 2001 he is professor and Danieli Endowed Chair of Automation Engineering with University of Trieste. Since 2009, Thomas Parisini is Deputy Rector of University of Trieste and since 2010 he holds the Chair of Industrial Control at the Imperial College London. He authored or co-authored more than 200 research papers in archival journals, book chapters, and international conference proceedings. His research interests include neural-network approximations for optimal control problems, fault diagnosis for nonlinear and distributed systems and nonlinear model predictive control systems. Among several awards, he is a co-recipient of the 2004 Outstanding Paper Award of the IEEE Trans. on Neural Networks and a recipient of the 2007 IEEE Distinguished Member Award. He is involved as Project Leader in several projects funded by the European Union, by the Italian Ministry for Research, and he is currently leading consultancy projects with some major process control companies (ABB, Danieli, Duferco, Electrolux, among others). Thomas Parisini is the Editor-in-Chief of the IEEE Transactions on Control Systems Technology. He was the Chair of the Conference Editorial Board and a Distinguished Lecturer of the IEEE Control Systems Society. Moreover, he was an elected member of the Board of Governors of the IEEE Control Systems Society and of the European Union Control Association (EUCA) as well as a member of the board of evaluators of the 7th Framework ICT Research Program of the European Union. Thomas Parisini is currently serving as an Associate Editor of Int. J. of Control and served in several editorial boards of international journal including the IEEE Trans. on Automatic Control, Automatica, and the IEEE Trans. on Neural Networks. He was involved in the committees of several international conferences. In particular, he was the Program Chair of the 2008 IEEE Conference on Decision and Control and he is General Co-Chair of the 2013 IEEE Conference on Decision and Control. Thomas Parisini is a Fellow of the IEEE.