Stochastic Control and Related Fields Workshop
In Honor of the 75th Birthday of Tyrone Duncan
and 50 Years of His Contributions to Stochastic Control and Related Fields

Sunday, December 11, 2016 / 9:00 am – 6:00 pm
Las Vegas, Nevada

This workshop is held in conjunction with the 55th Conference on Decision and Control.
http://cdc2016.ieeecss.org/workshops.php

Organizers: Bozena Pasik-Duncan (University of Kansas)
Dominique Duncan (University of Southern California)
Sponsor: University of Kansas

Tyrone E. Duncan received the BEE degree from Rensselaer Polytechnic Institute in 1963 and the MS and PhD degrees from Stanford University in 1964 and 1967, respectively. He has held regular positions at the University of Michigan (1967-1971), the State University of New York, Stony Brook (1971-1974), and the University of Kansas (1974-present) where he is Professor of Mathematics and Courtesy Professor of Electrical Engineering and Computer Science. He has held visiting positions at the University of California, Berkeley (1969-1970), the University of Bonn, Germany (1978-1979), and Harvard University (1979-1980) and shorter visiting positions at numerous other institutions throughout the world. He has done research in stochastic analysis, stochastic control and filtering, information theory, differential geometry, stochastic adaptive control, stochastic systems and related topics. He is a member of AMS, IEEE, MAA, and SIAM, an IEEE Fellow, an IFAC Fellow and a SIAM Fellow.

This workshop presents a wide variety of stochastic problems that use stochastic control to analyze and solve them. The importance of stochastic control to solve physical problems arises from the basic fact that most physical models have a stochastic component, for example, by the appearance of noise that describes perturbations or unmodeled dynamics of physical systems. Workshop participants are introduced to an important collection of stochastic control topics that have a wide range of applicability. The talks include foundational questions of the probabilistic models of systems, impulse control of capital models and ergodic or long range average time impulse problems, optimal transport problems on directed graphs, the control of power systems and communication networks by pricing, symmetries and conservation laws for ensemble systems, mean field games and nonlinear filtering, the use of information in estimation and stochastic control, the relation between information and topology, the control of the Schroedinger equation, asymptotic properties of nonlinear models, and trading of pairs of stocks.

The workshop should be of interest to researchers who wish to increase or broaden their knowledge of the possible approaches and applications of stochastic control. The talks will be given by important contributors to stochastic systems and control. Younger researchers are especially encouraged to participate to learn about the challenges and opportunities in very active field of research. All CDC 2016 participants with their interests in stochastic systems and control are welcome to join in this special celebration.
Bozenna Pasik-Duncan received her Ph.D. and Habilitation doctorate degrees from the Mathematics Department of the Warsaw School of Economics in 1978 and 1986, respectively. She was a staff member of the Mathematics Department of Warsaw School of Economics from 1970 until 1984. In 1984 she moved to the University of Kansas, where she is currently a Professor of Mathematics, a Courtesy Professor of Electrical Engineering and Computer Science and a Courtesy Professor of Aerospace Engineering. Dr. Pasik-Duncan’s current research interests are primarily in stochastic adaptive control, computational aspects of stochastic control, and stochastic analysis with its applications to mathematics of finance, medicine, and telecommunications. Her other current interests include mathematics education at K-12 schools, control engineering education, and mathematics education for women in science and engineering. She has received numerous awards in recognition of her teaching and service. Dr. Pasik-Duncan has been actively involved in the IEEE Control Systems Society (CSS) in a number of capacities. She is a Fellow of IEEE; was awarded the IEEE Third Millennium Medal and the IEEE Control Systems Society Distinguished Member Award; and is a Fellow of IFAC.

Dominique Duncan majored in mathematics and Polish Literature at the University of Chicago and minored in Computational Neuroscience. She received a Ph.D. in Electrical Engineering from Yale University in 2013. After graduation, she was a professor of Mathematics at Sichuan University in Chengdu, China for a summer program. She then took a postdoc position in Neurology at the Stanford University School of Medicine followed by a postdoc position in Mathematics at UC Davis. She began her current postdoc position at the USC Stevens Neuroimaging and Informatics Institute in August of 2015. Her projects involve an epilepsy bioinformatics study for antiepileptogenic therapy following traumatic brain injury, a study on the effects of high intensity exercise on the brain, and the development of an online game to crowd source quality control in MRI segmentation. She has served in many leadership positions including an elected member of the Yale Graduate and Professional Student Senate for 6 years, an elected member of the Stanford University postdoctoral association, the chair of the UC Davis postdoctoral scholars association, and the USC postdoctoral association communications chair, a member of the education committees in CSS, AACC, and IFAC, and a member of the WIE outreach committee. She has been a frequent speaker at CSS & AACC HS Workshops on the Beauty of Controls.
Invited Speakers:

John Baillieul
Distinguished Professor, Arespace and Mechanical Engineering
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Topological Aspects of Information Acquisition
Notions of entropy with mathematical similarities to the well-known Shannon entropy but developed in very different ways by Kolmogorov and co-workers have led to important connections between information and topology. Recently, topological methods in data analytics emerging from both mathematics and computer science have raised the possibility of even deeper connections being made between topology and information. I shall survey some of the latest results on these connections and show how they point to new approaches to exploring data sets and guiding robotic exploration.

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." Baillieul's current research is aimed at understanding decision making and novel ways to communicate in mixed teams of humans and intelligent automata. He is also interested in the deploying control systems whose operation shows selected characteristics of animal behaviors in challenging environments. Baillieul served as fortieth President of the IEEE Control Systems Society, and he is a Fellow of the IEEE, a Fellow of SIAM, and a Fellow of IFAC.

John S. Baras
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Non-commutative Probability Models in Multi-Agent Inference and Decision Making
First we review various notions and concepts of non-commutative probability from the areas of quantum mechanics, multi-observer statistics, information theory, nonlinear control systems, inference in the Internet, multi-agent control systems, collective human cognition and decision making from psychology and behavioral sciences. We then take a step backwards and investigate how the various probability models in these areas were constructed from observational data; i.e. we investigate how a “Kolmogorov-like” construction of probability models could be carried out when multiple observers (not necessarily exchanging all their data and models) are involved. We develop an axiomatic method for such a construction that reveals some of the foundations of such models. These include; existence of incompatible events, notions of information sharing, directed information, probabilities on constrained event algebras, representations of constrained event algebras. We next describe various logics linked to constrained event algebras, and in particular independence-friendly logic (IF Logic). We describe the
connections of the latter to multi-agent game theory. We close with our long-term research plans to unify the various notions of non-commutative probability

John Baras received his diploma in Electrical and Mechanical Engineering from the National Technical University of Athens, Greece, 1970; M.S., Ph.D. in Applied Mathematics from Harvard University 1971, 1973. Since 1973, faculty member in the Electrical and Computer Engineering Department, and in the Applied Mathematics, Statistics and Scientific Computation Program, at the University of Maryland College Park. Since 2000, faculty member in the Fischell Department of Bioengineering. Since 2014, faculty member in the Mechanical Engineering Department. Founding Director of the Institute for Systems Research (ISR), 1985 to 1991. Since 1991, Founding Director of the Maryland Center for Hybrid Networks (HYNET). Since 2013, Guest Professor at the Royal Institute of Technology (KTH), Sweden. IEEE Life Fellow, SIAM Fellow, AAAS Fellow, NAI Fellow, and a Foreign Member of the Royal Swedish Academy of Engineering Sciences (IVA). Received the 1980 George Axelby Prize from the IEEE Control Systems Society, the 2006 Leonard Abraham Prize from the IEEE Communications Society, the 2014 Tage Erlander Guest Professorship from the Swedish Research Council, and a three year (2014-2017) Senior Hans Fischer Fellowship from the Institute for Advanced Study of the Technical University of Munich, Germany. Professor Baras' research interests include systems and control, optimization, communication networks, signal processing and understanding, robotics, computing systems and networks, network security and trust, and model-based systems engineering.

Alain Bensoussan
Ashbel Smith Professor
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Capital Accumulation and Real Options
We study here the situation of a firm that exploits an external resource, and decides its investments at appropriate times, in the spirit of real options. However, we are interested in a sequence of projects, and not just a single one. Each project represents a substantial investment, with fixed cost and variable costs measuring the scale of the project. At the same time, the firm is growing and thus accumulates capital, which puts it each time in a more favorable position to exploit the external resource. The problem is to define the sequence of optimal stopping times to invest. We follow the methodology of impulse control, in which the value function is the solution of a Quasi Variational Inequality (QVI). We obtain new types of QVI, which we can solve in some particular cases.

Alain Bensoussan is Ashbel Smith Professor and the Director of ICDRiA (International Center for Decision and Risk Analysis) at the University of Texas at Dallas. He is also Chair Professor of Risk and Decision Analysis at the City University Hong Kong. He is Professor Emeritus at the University Paris Dauphine. Professor Bensoussan served as President of National Institute for Research in Computer Science and Control (INRIA) from 1984 to 1996; President of the French Space Agency (CNES) from 1996 to 2003; and Chairman of the European Space Agency (ESA) Council from 1999 to 2002. He
was World Class University Distinguished Professor at Ajou University, from 2010 to 2013. He is a member of the French Academy of Sciences, French Academy of Technology, Academia Europae, and International Academy of Astronautics. His distinctions include AMS Fellow, IEEE Fellow, SIAM Fellow, Von Humboldt award, and the NASA public service medal. Professor Bensoussan is a decorated Officer of Legion d’Honneur, Commandeur Ordre National du Merite and Officer Bundes Verdienst Kreuz.

He has an extensive research background in stochastic control, risk analysis and inventory control. He has published 13 books and more than 400 papers and proceedings. He develops a comprehensive approach to Risk Analysis, to apprehend technical and socio-economic risks simultaneously. He has experience in aerospace and information technology industries. His main current interests concern the energy sector, real options, revenue management and mean field control.

Peter Caines
James McGill Professor and Macdonald Chair
Department of Electrical and Computer Engineering
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Nonlinear Filtering and Mean Field Games
In the standard linear quadratic Gaussian (LQG) and the non-linear Mean Field Game (MFG) models, possibly with a major agent, the agents are coupled by the empirical mean of the states of the population of agents that appears in both their dynamics and their cost functions. MFG theory shows that, under reasonable assumptions: (i) in the infinite population limit, a best response control strategy exists for each agent which depends only upon the individual agent’s observations of its own state (together with the state of the major agent state, if present) and on the state distribution of the generic agent, namely the system’s mean field, and which achieves a Nash equilibrium, and (ii) when applied in the finite population game, this control strategy achieves an epsilon-Nash equilibrium. In this talk MFG systems are considered where each agent has only noisy observations of its individual state, or alternatively, complete observations of its individual state and noisy observations of the major agent’s state. The LQG cases of these problems have already been analyzed in (Huang, Malhame, Caines, 2006; Kizilkale, Caines, 2014, 2016; Firoozi, Caines, 2015). For both of the alternatives mentioned, we analyze the situation where the dynamics and the cost functions are nonlinear and show (Sen, Caines, 2015, 2016) that the application of non-linear filtering theory and the Separation Principle yield a Nash equilibrium in the asymptotically infinite population limit and give the corresponding epsilon-Nash equilibria in the finite population cases. Work with Nevroz Sen.

Peter Caines received the BA in mathematics from Oxford University in 1967 and the PhD in systems and control theory in 1970 from Imperial College, University of London, under the supervision of David Q. Mayne, FRS. After periods as a postdoctoral researcher and faculty member at UMIST, Stanford, UC Berkeley, Toronto and Harvard, he joined McGill University, Montreal, in 1980, where he is James McGill Professor and Macdonald Chair in the Department of Electrical and Computer Engineering. In 2000 the adaptive control paper he coauthored with G. C. Goodwin and P. J. Ramadge (IEEE Transactions on Automatic Control, 1980) was recognized by the IEEE Control Systems Society as one of the 25 seminal control theory papers of the 20th century. He is a Life Fellow of the IEEE, and a Fellow of SIAM, the Institute of Mathematics and its Applications (UK) and the Canadian Institute for Advanced Research and is a member of Professional Engineers Ontario. He was elected to the Royal Society of Canada in 2003. In 2009 he received the IEEE Control Systems Society Bode Lecture Prize and in 2012 a Queen Elizabeth II Diamond Jubilee Medal. Peter Caines is the author of Linear Stochastic Systems, John
Wiley, 1988, and his research interests include stochastic, mean field, decentralized and hybrid systems theory together with their applications to natural and artificial systems.

**P.S. Krishnaprasad**
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**Optimality, Geometry and Cycles**
Optimal control problems that admit explicit integrability occupy a special place of interest in deterministic and stochastic systems. As in the case for integrability questions in mechanics, here too symmetries and conservation laws have a defining role. In this talk we discuss models and results pertaining to such questions in isolated systems and ensembles of interacting systems. With proper interpretation, one sees interesting examples in thermodynamic cycles falling into this category. The tools used to pursue these problems arose first in the study of Hamiltonian systems with symmetries. Some of this work is in collaboration with Eric Justh and Yunlong Huang.

P. S. Krishnaprasad received the Ph.D. degree from Harvard University in 1977. He taught in the Systems Engineering Department at Case Western Reserve University from 1977 to 1980. Since August 1980, he has been with the University of Maryland, currently a Professor of Electrical & Computer Engineering, with a joint appointment at the Institute for Systems Research. His interests lie in the areas of geometric control theory, filtering and signal processing, robotics, acoustics, and biologically-inspired approaches to control, sensing and computation. His current work includes the study of natural and artificial collectives, control in statistical physics, and the efficiency of engines across scales that perform useful work in cycles. He is a Fellow of the IEEE. He delivered the Munich Mathematical Colloquium Lecture in fall 2006, the Hendrik W. Bode Lecture of the IEEE Control Systems Society in 2007, and the Baetjer Colloquium Lecture at Princeton University in 2012.

**P.R. Kumar**
Professor and College of Engineering Chair in Computer Engineering
Texas A&M University
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**Optimal Operation of a Decentralized Stochastic System: End-to-End Control of an Unreliable Multi-Hop Network**
We examine a problem of contemporary interest involving the optimal operation of a distributed stochastic dynamic system, end-to-end scheduling of a communication network. We address the problem of how to optimally schedule multiple flows with hard end-to-end deadlines over a network of unreliable links with average power constraints so as to maximize their throughput. We exhibit an exactly optimal policy for this distributed system that employs easily determined prices to distributedly schedule link transmissions throughput the entire network. (Joint work with Rahul Singh.)
P. R. Kumar obtained his B. Tech. degree in Electrical Engineering (Electronics) from I.I.T. Madras in 1973, and the M.S. and D.Sc. degrees in Systems Science and Mathematics from Washington University, St. Louis, in 1975 and 1977, respectively. From 1977-84 he was a faculty member in the Department of Mathematics at the University of Maryland Baltimore County. From 1985-2011 he was a faculty member in the Department of Electrical and Computer Engineering and the Coordinated Science Laboratory at the University of Illinois. Currently he is at Texas A&M University, where he is a University Distinguished Professor and holds the College of Engineering Chair in Computer Engineering.

Kumar has worked on problems in game theory, adaptive control, stochastic systems, simulated annealing, neural networks, machine learning, queueing networks, manufacturing systems, scheduling, wafer fabrication plants and information theory. His research is currently focused on energy systems, wireless networks, secure networking, automated transportation, and cyberphysical systems.

Kumar is a member of the National Academy of Engineering of the USA, and a Fellow of the World Academy of Sciences. He was awarded an honorary doctorate by the Swiss Federal Institute of Technology (Eidgenossische Technische Hochschule) in Zurich. He received the Outstanding Contribution Award of ACM SIGMOBILE, the IEEE Field Award for Control Systems, the Donald P. Eckman Award of the American Automatic Control Council, and the Fred W. Ellersick Prize of the IEEE Communications Society. He is an ACM Fellow and a Fellow of IEEE. He was a Guest Chair Professor and Leader of the Guest Chair Professor Group on Wireless Communication and Networking at Tsinghua University, Beijing, China. He is an Honorary Professor at IIT Hyderabad. He was awarded the Distinguished Alumnus Award from IIT Madras, the Alumni Achievement Award from Washington University in St. Louis, and the Daniel C. Drucker Eminent Faculty Award from the College of Engineering at the University of Illinois.

William M. McEneaney
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Dynamic Programming for Stationarity and a Diffusion Representation for the Schrödinger Equation

It has recently been shown that one may apply dynamic programming to obtain stationary values of payoff functionals, yielding an association of the Hamilton-Jacobi equation to the stationary-value function. This is extended to complex-valued and diffusion problems. A control representation for the solution of the Schrödinger equation is obtained, utilizing complex-valued diffusion processes. The Maslov dequantization is employed, where the domain is complex-valued in the space variable. The notion of stationarity is utilized to relate the Hamilton-Jacobi form of the dequantized Schrödinger equation to its stochastic control representation. Through the use of stationarity, convexity of the payoff is not required, and there is no restriction on the problem duration.
William M. McEneaney received his B.S. and M.S. in Mathematics from Rensselaer Polytechnic Institute in 1982 and 1983, respectively. He worked at PAR Technology and Jet Propulsion Laboratory, developing theory and algorithms for estimation and guidance applications. Dr. McEneaney attended Brown University from 1989 through 1993, obtaining his M.S. and Ph.D. in Applied Mathematics. His thesis research, conducted under Prof. W.H. Fleming, was on nonlinear risk-sensitive stochastic control. Dr. McEneaney has since held positions at Carnegie Mellon University and North Carolina State University, prior to his current appointment in the Mechanical and Aerospace Engineering Department of University of California, San Diego. His recent interests have been in Stationary Action, Max-Plus Algebraic Methods for Hamilton-Jacobi-Bellman Partial Differential Equations, Risk-Sensitive and Robust Control and Estimation, and Partially-Observed Stochastic Games.

Sanjoy K. Mitter received his Ph.D. degree from the Imperial College of Science and Technology in 1965. He taught at Case Western Reserve University from 1965 to 1969. He joined MIT in 1969 where he has been a Professor of Electrical Engineering since 1973. He was the Director of the MIT Laboratory for Information and Decision Systems from 1981 to 1999. He has also been a Professor of Mathematics at the Scuola Normale, Pisa, Italy from 1986 to 1996. He has held visiting positions at Imperial College, London; University of Groningen, Holland; INRIA, France; Tata Institute of Fundamental Research, India and ETH, Zürich, Switzerland; and several American universities. Professor Mitter is the recipient of the IEEE Eric E. Sumner Award for 2015. Also in 2015, Professor Mitter was elected a Foreign Fellow of the Indian National Academy of Engineering. He was the Ulam Scholar at Los Alamos National Laboratories in April 2012 and the John von Neumann Visiting Professor in Mathematics at the Technical University of Munich, Germany from May-June 2012. He was awarded the AACC Richard E. Bellman Control Heritage Award for 2007. He was the McKay Professor at the University of California, Berkeley in March 2000, and held the Russell–Severance-Springer Chair in Fall 2003. He is a Fellow of the IEEE and IFAC. He is the winner of the 2000 IEEE Control Systems Award. He was elected a Foreign Member of Istituto Veneto di Scienze, Lettere ed Arti in 2003. In 1988, he was elected to the National Academy of Engineering. His current research interests are Communication and Control in a Networked Environment, the relationship of Statistical and Quantum Physics to Information Theory and Control and Autonomy and Adaptiveness for Integrative Organization.
Lukasz Stettner
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Ergodic Impulse Control Problems
The purpose of this talk is show recent results concerning long run average and long run risk sensitive impulse control of Feller Markov process. Impulse control consists of a sequence of stopping times and shifts of Markov process at these times to certain point, which we choose, in a compact set. The main problem is to show the existence of solutions to suitable Bellman equations and to study stopping problems with unbounded running cost. Such solutions are first shown in the case when solutions to additive or multiplicative Poisson equations are bounded from below. Later on this property is relaxed using special approximation procedure. Applications of the results to risk neutral and risk sensitive portfolio optimization are also shown. The results are based on joint papers with J. Palczewski (Leeds) and M. Pitera (Cracow).

Lukasz Stettner received his M.S. from University of Lublin in 1978, Ph.D. in 1981 and habilitation in 1991 in mathematics from Institute of Mathematics Polish Academy of Sciences (IMPAN) in Warsaw, Poland. Since 1978, he works in the IMPAN, since 2000 as scientific director of the Institute and since 2001 as full professor. Since 2003, he was chairman of the Mathematical Center for Science and Technology at IMPAN. Professor Stettner supervised 14 Ph.D. thesis. Editor of Applicationes Mathematicae and IMPAN Lecture Notes. Since 2013 vice chair of IFIP TC7 (System Modelling and Optimization). Since 2005 Representative of PTM to ICIAM. In 2013-2016 member of the Central Commission for Degrees and Titles in Poland. His research interests are: stochastic control, mathematics of finance and insurance, stochastic analysis.

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Tryphon Georgiou
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Chancellor’s Professor of Mechanical and Aerospace Engineering
University of California, Irvine

Robust Transport Over Networks
We consider transportation over a strongly connected, directed graph. The scheduling amounts to selecting transition probabilities for a discrete-time Markov evolution that is designed to be consistent with initial and final marginal constraints on mass transport. We address the situation where initially the mass is concentrated on certain nodes and needs to be transported in a certain time period to another set of
nodes, possibly disjoint from the first. The random evolution is selected to be closest to a prior measure on paths in the relative entropy sense—such a construction is known as a Schroedinger bridge between the two given marginals. It may be viewed as an atypical stochastic control problem where the control consists in suitably modifying the prior transition mechanism. The prior can be chosen to incorporate constraints and costs for traversing specific edges of the graph, but it can also be selected to allocate equal probability to all paths of equal length connecting any two nodes (i.e., a uniform distribution on paths). This latter choice for prior transitions relies on the so-called Ruelle-Bowen random walker and gives rise to scheduling that tends to utilize all paths as uniformly as the topology allows. Thus, this Ruelle-Bowen law (MRB) taken as prior, leads to a transportation plan that tends to lessen congestion and ensures a level of robustness. We also show that the paradigm of Schroedinger bridges as a mechanism for scheduling transport on networks can be adapted to graphs that are not strongly connected, as well as to weighted graphs. (Work with Yongxin Chen, Tryphon Georgiou, and Michele Pavon)

Allen Tannenbaum is presently Distinguished Professor of Computer Science and Applied Mathematics & Statistics at the State University of New York at Stony Brook. He is also Visiting Investigator of Medical Physics at Memorial Sloan Kettering Cancer Center in New York City. He has held a number of other positions in the United States, Israel, and Canada including the Bunn Professorship of Electrical and Computer Engineering and Interim Chair, and Senior Scientist at the Comprehensive Cancer Center at the University of Alabama, Birmingham. He received his Ph.D. with thesis advisor Heisuke Hironaka at the Harvard University in 1976. Tannenbaum has done research in numerous areas including robust control, computer vision, and biomedical imaging, having almost 500 publications. He pioneered the field of robust control with the solution of the gain margin and phase margin problems using techniques from Nevanlinna–Pick interpolation theory, which was the first H-infinity type control problem solved. Tannenbaum used techniques from elliptic curves to show that the reachability does not imply pole assignability for systems defined over polynomial rings in two or more variables over an arbitrary field. He pioneered the use of partial differential equations in computer vision and biomedical imaging co-inventing with Guillermo Sapiro an affine-invariant heat equation for image enhancement. Tannenbaum further formulated a new approach to optimal mass transport (Monge-Kantorovich) theory in joint work with Steven Haker and Sigurd Angenent. In recent work, he has developed techniques using graph curvature ideas for analyzing the robustness of complex networks.

His work has won several awards including IEEE Fellow in 2008, O. Hugo Schuck Award of the American Automatic Control Council in 2007 (shared with S. Dambreville and Y. Rathi), and the George Taylor Award for Distinguished Research from the University of Minnesota in 1997. He has given numerous plenary talks at major conferences including the Society for Industrial and Applied Mathematics (SIAM) Conference on Control in 1998, IEEE Conference on Decision and Control of the IEEE Control Systems Society in 2000, and the International Symposium on the Mathematical Theory of Networks and Systems (MTNS) in 2012. He is also well-known as one of the authors of the textbook Feedback Control Theory (with John Doyle and Bruce Francis), which is currently a standard introduction to robust control at the graduate level.
Tryphon T. Georgiou received his Diploma in Mechanical and Electrical Engineering from the National Technical University of Athens, 1979, and the Ph.D. degree from the University of Florida in 1983. He is Professor Emeritus at the University of Minnesota where he served on the faculty for almost 30 years and, as of July 2016, he is Chancellor’s Professor of Mechanical and Aerospace Engineering at the University of California, Irvine. He is a recipient of the George S. Axelby Outstanding Paper award of the IEEE Control Systems Society for the years 1992, 1999, and 2003, a Fellow of the IEEE and IFAC, and a Foreign Member of the Royal Swedish Academy of Engineering Sciences (IVA).

Pravin Varaiya
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Dileep Kalathil
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Reaching a Rational Expectations Equilibrium Among a Group of Agents
Each agent \( i = 1, \ldots, N \) seeks to estimate the expected value of a random variable \( X \). Agent \( i \)'s estimate at time \( t \) is denoted \( X_i(t) \). This estimate is based on \( i \)'s initial private observation \( z_i \) and messages \( m_j(\tau) \), \( 1 \leq \tau \leq t - 1 \) broadcast by agent \( j \) to the entire group. Thus \( X_i(t) = \mathbb{E}(X | z_i, m_j(\tau), j \leq N, \tau \leq t - 1) \). A random variable \( X^* \) is a rational expectations equilibrium (REE) if \( X_i(t) \to X^* \) a.s. for all \( i \). The existence and uniqueness of a REE depends on the structure of the broadcast messages. Borkar-Varaiya studied the situation wherein \( m_i(\tau) = X_i(\tau) \) and when all agents have the same prior. Teneketzis-Varaiya examined the same setting but permitted different priors. In this discussion we consider other signal structures. (Work with Dileep Kalathil.)

Pravin Varaiya is a Professor of the Graduate School in the Department of Electrical Engineering and Computer Sciences at the University of California, Berkeley and a Visiting Professor at the Institute for Advanced Study at the Hong Kong University of Science and Technology. His current research is devoted to electric energy systems and transportation networks. From 1975 to 1992 he was also Professor of Economics at Berkeley. From 1994 to 1997 he was Director of the California PATH program, a multi-university research program dedicated to the solution of California’s transportation problems. Varaiya has held a Guggenheim Fellowship and a Miller Research Professorship. He received Honorary Doctorates from L’Institut National Polytechnique de Toulouse and L’Institut National Polytechnique de Grenoble, and the Field Medal and Bode Lecture Prize of the IEEE Control Systems Society. He is a Fellow of IEEE, a member of the National Academy
of Engineering, and a Fellow of the American Academy of Arts and Sciences. He is on the editorial board of "Discrete Event Dynamical Systems" and "Transportation Research---C". He has co-authored three books and over 300 technical papers.

Dileep Kalathil is a Post-Doctoral Fellow in the Department of Electrical Engineering and Computer Sciences at the University of California, Berkeley. He received his PhD from the University of Southern California. His research deals with decentralized learning in multi-agent systems, simulation based learning and optimization of controlled Markov processes, and the integration of renewable resources into the electricity grid.

Gang George Yin
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Nonlinear Stochastic Models
In this talk, we consider some nonlinear stochastic models. They are arising for instance, from SIR epidemic formulations and consideration of safeguarding bio-diversity using protection zones etc. Both non-degenerate and degenerate cases will be considered. We study certain asymptotic properties such as existence of invariant distributions and convergence to the invariant distributions in total variation norm. Related control problems will also be mentioned.

George Yin received the B.S. degree in Mathematics from the University of Delaware in 1983, M.S. degree in Electrical Engineering, and Ph.D. in Applied Mathematics from Brown University in 1987. He joined Wayne State University in 1987, and became a professor in 1996. His research interests include stochastic systems and applications. He served as a member of the program committee for many IEEE Conference on Control and Decision; he also severed on the IFAC Technical Committee on Modeling, Identification and Signal Processing, and many conference program committees; he was Co-Chair of SIAM Conference on Control & Its Application, 2011, and Co-Chair of two AMS-IMS-SIAM Summer Research Conferences; he also chaired a number SIAM prize selection committees. He was Chair of SIAM Activity Group on Control and Systems Theory, and served on the Board of Directors of American Automatic Control Council. He is an associate editor of SIAM Journal on Control and Optimization, and on the editorial board of a number of other journals. He was an Associate Editor of Automatica (2005-2011) and IEEE Transactions on Automatic Control (1994-1998). He is a Fellow of IEEE, Fellow of IFAC, and a Fellow of SIAM.
Pairs-Trading Under Geometric Brownian Motions
This talk is about an optimal strategy for simultaneously trading a pair of stocks. The idea of pairs-trading is to monitor their price movements and compare their relative strength over time. A pairs trade is triggered by their prices divergence (e.g., one stock moves up a significant amount relative to the other), and consists of a pair of positions to short the strong stock and to long the weak one. Such a strategy bets on the reversal of their price strengths. From the viewpoint of technical tractability, typical pairs trading models usually assume a difference of the stock prices satisfies a mean reversion equation. In this paper, we consider the optimal pairs-trading problem by allowing the stock prices to follow general geometric Brownian motions. The objective is to trade the pairs over time to maximize an overall return with a fixed commission cost for each transaction. The optimal policy is characterized by threshold curves obtained by solving the associated HJB equations (quasi-variational inequalities). Moreover, a numerical example is included to demonstrate the dependence of our trading rules on various parameters and to illustrate how to implement the results in practice.

Qing Zhang is a Professor of Mathematics at University of Georgia. He received his B.Sc. from Nankai University in 1983 and M.Sc. and Ph.D. from Brown University in 1985 and 1988, respectively. His research interests include stochastic system and control, filtering, and applications in manufacturing and finance. He has published more than 130 journal papers and four monographs on two-time scale Markovian systems and application in manufacturing. He received a Creative Research Medal from The University of Georgia for outstanding accomplishment in research and creativity in 2000 and a M. G. Michael Award from Franklin College of Arts and Sciences at University of Georgia for new initiatives in scholarship and excellence in research in 2009. He co-edited five books and was an associate editor of IEEE Transactions on Automatic control, Automatica, and SIAM Journal on Control and Optimization. He is currently a corresponding editor of SIAM Journal on Control and Optimization. He also served on a number of international conference organizing committees including Co-Chair of AMS-SIAM Summer Seminar in Manufacturing in 1996, Co-Chair of AMS-IMS-SIAM Summer Research Conference in Mathematics of Finance in 2003, and Co-Chair of the Organizing Committee for the SIAM Conference on Control and Applications in 2017.