2018
HARVARD CONTROL WORKSHOP

AND

REUNION WITH PROF. YU-CHI HO

JULY 7–9, 2018

HARVARD UNIVERSITY
MAXWELL–DWORKIN BUILDING
33 OXFORD ST, CAMBRIDGE, MA 02138, USA

Day 1 Schedule

9:00-9:30	Registration and Light Breakfast
9:30-9:35	Introduction by General Chair, Prof. Chun-Hung Chen
9:35-9:40	Opening Remarks by Prof. Frank J. Doyle III Dean of the John A. Paulson School of Engineering and Applied Sciences Harvard University
9:40-9:45	Remarks by Prof. Yu-Chi Ho
9:45-10:00	Keynote 1: Prof. Leyuan Shi, University of Wisconsin at Madison
10:00-10:15	Keynote 2: Prof. Edwin Chong, Colorado State University
10:15-10:30	Keynote 3: Prof. Qianchuan Zhao, Tsinghua University, China
10:30-10:45	Keynote 4: Prof. Loo Hay Lee, National University of Singapore
10:45-11:00	Coffee/Tea Break
11:00-12:30	Session 1
12:30-1:45	Lunch
1:45-4:00	Session 2
Evening	Reception and Dinner at Prof. Y. C. Ho's House in Lexington, MA.

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Welcome

On behalf of the organizing committee, we would like to welcome you to attend the 2018 Harvard Control Workshop / Reunion with Prof. Ho. It has been several years since our last union at Harvard in 2011. We are sure everyone is very excited to see each other. It is so nice to have the opportunity to come back to the place where we studied for our Ph.D. degrees under the supervision of Prof. Ho many decades ago. Please enjoy this wonderful opportunity.

We would also like to thank our sponsors, including Prof. Qianchuan Zhao and CFINS at Tsinghua University, Prof. Leyuan Shi and her company, LS Optimal, Inc., and Dean Fawwaz Habbal at Harvard University. This event would not have been so enjoyable without their strong support.

Enjoy!

Chun-Hung Chen
George Mason University, USA

Loo Hay Lee
National University of Singapore

Jie Song
Peking University

2018 Harvard Control Workshop

July 7-9, 2018
Harvard University
Maxwell-Dworkin Building
33 Oxford St, Cambridge, MA 02138, USA

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Foreword

Grateful and Honored to be Part of Professor Ho's Extended Academic Family

Lucy Pao
Professor
Electrical, Computer, and Energy Engineering Department
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My first interaction with Professor Yu-Chi (Larry) Ho was in the early 1990s when I was close to finishing my PhD degree at Stanford University. I was engaged to be married and would be moving to the Cambridge/Boston, Massachusetts area after graduation, and I wrote Professor Ho a letter (by snail mail as this was before email became an official means of communication) asking if he had suggestions or leads on any job openings in the systems and controls fields in the Boston area. Even though Professor Ho didn't know me, he was kind enough to respond to my letter. Professor Ho ultimately became a good friend. He always took the time to talk with me early in my career and provided candid and valuable advice and guidance to me. He served as one of my hosts at Harvard when I spent a sabbatical year there during 2001-2002, and his work on ordinal optimization and optimal computing budget allocation influenced the methods my research group was developing at that time in our projects investigating sensor fusion and sensor management algorithms for surveillance and tracking applications. It has been a privilege to know and work with Professor Ho, and I was deeply touched when asked to write a foreword for this Proceedings of the 2018 Harvard Control Workshop and Reunion with Professor Ho.

Professor Ho has contributed significantly to several areas in the broad systems and controls fields. He has made a lasting impact to optimal control, differential games, and discrete event dynamic systems, among many other areas. He has worked on discrete event dynamic systems since the 1970s, and this work has led to numerous contributions in perturbation analysis and ordinal optimization, including the books *Perturbation Analysis of Discrete Event Dynamic Systems*[1] and *Ordinal Optimization – Soft Optimization for Hard Problems*[2].

I am grateful to have become friends with several of Professor Ho's former PhD students, students of former PhD students, collaborators, as well as those whose work has been strongly influenced by Professor Ho. Numerous former students of Professor Ho have become well-respected and distinguished

[1] Y. C. Ho and X. R. Cao, *Perturbation Analysis of Discrete Event Dynamic Systems,* Kluwer Academic Publishers, Boston, 1991.

[2] Y. C. Ho, Q. C. Zhao, and Q. S. Jia, *Ordinal Optimization: Soft Optimization for Hard Problems*, Springer, 2007.

researchers and faculty members and many have themselves mentored a large cohort of graduate students who have continued successfully onto diverse career paths. Professor Ho not only mentored his students in the methods and technical topics of research, he also advised them in how to make presentations and clearly explain their work. Professor Ho's advice has influenced my thinking and approach to my research, and I often reflect on Professor Ho's advice when preparing presentations. He has been an excellent mentor, teacher, and friend to so many of us. I was grateful to have been invited and to have been able to participate in last year's IAS Workshop on Frontiers in Systems and Control in Hong Kong in honor of Professor Ho. I regret that conflicts prevent me from attending this year's workshop, and I wish the many colleagues and friends who are participating this year a wonderful 2018 workshop and reunion with Professor Ho.

The left photo is from the 1998 Japan-USA-Vietnam Symposium in Hanoi, and the right photo is of my family and Professor and Mrs. Ho at a delightful Dim Sum lunch together in Beijing in 2012.

Group photo from the 2017 IAS Workshop on Frontiers in Systems and Control in honor of Professor Ho.

Professional life update

I am a Professor in the Electrical, Computer, and Energy Engineering Department at the University of Colorado Boulder. I have completed sabbaticals at Harvard University (2001-2002, where Professor Ho was one of my hosts), the University of California, Berkeley (2008), the US National Renewable Energy Laboratory (2009), and most recently at the Hanse-Wissenschaftskolleg Institute for Advanced Study in Delmenhorst, Germany (2016-2017) and the ForWind Center for Wind Energy Research at Oldenburg University (2016-2017). I earned B.S., M.S., and Ph.D. degrees in Electrical Engineering from Stanford University.

My research has primarily focused on combined feedforward and feedback control of flexible structures, with applications ranging from atomic force microscopy to disk drives to digital tape drives to megawatt wind turbines and wind farms. I became a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) in 2012 and of the International Federation of Automatic Control (IFAC) in 2013. Selected recent awards include the 2012 IEEE Control Systems Magazine Outstanding Paper Award (with K. Johnson), the 2015 Society for Industrial and Applied Mathematics (SIAM) Journal on Control and Optimization Best Paper Prize (with J. Marden and H. P. Young), the 2017 Control Engineering Practice Award from the American Automatic Control Council, and the Scientific Award 2017 from the European Academy of Wind Energy. Selected recent and current professional society activities include being a Fellow of the Renewable and Sustainable Energy Institute (2009-present), General Chair of the 2013 American Control Conference, member of the IEEE Control Systems Society (CSS) Board of Governors (2011-2013 and 2015), IEEE CSS Fellow Nominations Chair (2016-present), and member of the IFAC Executive Board (2017-2020).

Family update

Photo of my family at my daughter Sarah's college graduation. She received her B.S. degree in Electrical Engineering from Stanford University in June 2018. From left to right are my son Matthew, me, Sarah, and my husband Leo Radzihovsky. Sarah has an internship at Lucasfilm in San Francisco this Summer and will be continuing at Stanford this Autumn to work towards an M.S. degree in Computer Science.

Matthew is a junior, also at Stanford, majoring in Physics with a minor in Math. He plays for the Stanford men's soccer team. A video of their 2018 spring break trip to England can be seen at https://www.facebook.com/StanfordMSoccer/videos/1988877621124009/ .

Contributed Abstracts

EVENT-DRIVEN AND DATA-DRIVEN CONTROL AND OPTIMIZATION IN CYBER-PHYSICAL SYSTEMS

Christos G. Cassandras

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ABSTRACT

Research and, more generally, one's intellectual activities through life seem to be neither linear nor circular. A spiral may be the best geometric shape that describes this process: certain themes are recurring, but there is also a forward-moving component. In this spirit, Discrete Event Systems have enjoyed a renaissance under the title "*Event-Driven* Systems" and Perturbation Analysis has evolved into a perfect fit for *data-driven* control and optimization, a trend which seems to rule the day…

The event-driven paradigm has emerged as an alternative viewpoint, complementary to the time-driven approach, for modeling, sampling, estimation, control, and optimization of dynamic systems that can provide dramatic energy savings in networked settings among other advantages. On the other hand, the ubiquitous availability of data for both off-line and on-line processing opens up new opportunities for data-driven control and optimization methods that combine analytical system models with data. This talk centers on a general framework for event-driven and data-driven optimization that applies to Cyber-Physical Systems (CPS) with applications to cooperative multi-agent systems and to Smart Cities.

The emergence of Discrete Event Dynamic Systems (DEDS) in the 1980s brought to the forefront an alternative viewpoint to the traditional time-driven paradigm in which time is an independent variable and, as it evolves, so does the state of a dynamic system. The event-driven paradigm offers an alternative, complementary look at modelling, control, communication, and optimization. The key idea is that a clock should not be assumed to dictate actions simply because a time step is taken; rather, an action should be triggered by an "event" specified as a well-defined condition on the system state or as a consequence of environmental uncertainties that result in random state transitions. Observing that such an event could actually be defined to be the occurrence of a "clock tick", it follows that this framework may in fact incorporate time-driven methods as well. On the other hand, defining the proper events requires more sophisticated techniques compared to simply reacting to time steps. In the development of DEDS, such events were seen as the natural means to drive the dynamics of a large class of systems including computer networks, manufacturing systems, and supply chains among many. By the early 1990s, however, it became evident that many interesting dynamic systems are in fact "hybrid" in nature, i.e., at least some

of their state transitions are caused by (possibly controllable) events. This has been reinforced by technological advances through which sensing and actuating devices are embedded into systems allowing physical processes to interface with such (inherently event-driven) devices. The term Cyber-Physical System (CPS) has emerged to describe the hybrid structure of systems where some components operate as physical processes modeled through time-driven dynamics, while other components (mostly digital devices empowered by software) operate in event-driven mode. Moreover, many systems of interest are now networked and spatially distributed. In such settings, especially when energy-constrained wireless devices are involved, frequent communication among system components can be inefficient, unnecessary, and sometimes infeasible. Thus, rather than imposing a rigid time-driven communication mechanism, it is reasonable to seek instead to define specific events which dictate when a particular node in a network needs to exchange information with one or more other nodes. When, in addition, the environment is stochastic, significant changes in the operation of a system are the result of random event occurrences, so that, once again, understanding the implications of such events and reacting to them is crucial. In distributed systems, event-driven mechanisms have the advantage of significantly reducing communication among networked components without affecting desired performance objectives. In multi-agent systems where the goal is for networked components to cooperatively maximize (or minimize) a given objective, it has been shown that an event-driven scheme can still achieve the optimization objective while drastically reducing communication (hence, prolong the lifetime of a wireless network), even when delays are present (as long as they are bounded). The use of event-driven optimization methods has the benefit of scaling with the size of the event-space and not the (generally much larger) state space of a system.

The history of Perturbation Analysis (PA) originated with a solution of a long-standing problem in the late 1970s and eventually became part of a broader framework for models, control and optimization of DEDS. The simplest form of PA, *Infinitesimal* Perturbation Analysis (IPA), has grown into a data-driven stochastic gradient estimation method which has evolved beyond DEDS and now provides a framework for control and optimization of Hybrid Systems and, more generally, event-driven methodologies. In recent years, on-line gradient estimation techniques have been shown to boil down to a set of event-driven equations, the "IPA Calculus", where the estimates are (under certain conditions) robust with respect to modeling details and noise, and scalable in the number of observed events.

An area where CPS, event-driven and data-driven methods all come together is that of Smart Cities, an example of Cyber-Physical Systems (CPS) with direct impact to urban settings, where sensor and actuator networks are deployed to monitor the environment and civil infrastructure. Based on data collected, the goals include improvements in traffic control, energy distribution, emergency response, and location-based commerce, to name a few. A direct application of the IPA Calculus framework outlined above is that of adaptive traffic light control. A number of other ongoing Smart City projects include a Smart Parking system which dynamically assigns and reserves an optimal parking space for a user

(driver); a new framework for energy-aware traffic routing in urban networks, specifically targeting Electric Vehicles (EVs); and the "Street Bump" system in the City of Boston which uses regular smartphone capabilities to collect roadway obstacle data and identify and classify them for efficient maintenance and repair. Still to be achieved is the incorporation of the "social'' dimension in CPS through proper incentive mechanisms for inducing Smart City citizens to adopt provably socially optimal policies.

BIOGRAPHICAL SKETCH

Christos G. Cassandras is Distinguished Professor of Engineering at Boston University. He is Head of the Division of Systems Engineering, Professor of Electrical and Computer Engineering, and co-founder of Boston University's Center for Information and Systems Engineering (CISE). He received degrees from Yale University (B.S., 1977), Stanford University (M.S.E.E., 1978), and Harvard University (S.M., 1979; Ph.D., 1982). In 1982-84 he was with ITP Boston, Inc. where he worked on the design of automated manufacturing systems. In 1984-1996 he was a faculty member at the Department of Electrical and Computer Engineering, University of Massachusetts/Amherst. He specializes in the areas of discrete event and hybrid systems, cooperative control, stochastic optimization, and computer simulation, with applications to computer and sensor networks, manufacturing systems, and transportation systems. He has published over 400 refereed papers in these areas, and six books. He has guest-edited several technical journal issues and serves on several journal Editorial Boards. In addition to his academic activities, he has worked extensively with industrial organizations on various systems integration projects and the development of decision-support software. He has most recently collaborated with The MathWorks, Inc. in the development of the discrete event and hybrid system simulator SimEvents.

Dr. Cassandras was Editor-in-Chief of the *IEEE Transactions on Automatic Control* from 1998 through 2009 and has also served as Editor for Technical Notes and Correspondence and Associate Editor. He is currently an Editor of *Automatica*. He was the 2012 President of the IEEE Control Systems Society (CSS). He has also served as Vice President for Publications and on the Board of Governors of the CSS, as well as on several IEEE committees, and has chaired several conferences. He has been a plenary/keynote speaker at numerous international conferences, including the *American Control Conference* in 2001, the *IEEE Conference on Decision and Control* in 2002 and 2016, and the *20th IFAC World Congress* in 2017 and has also been an IEEE Distinguished Lecturer.

He is the recipient of several awards, including the 2011 IEEE Control Systems Technology Award, the Distinguished Member Award of the IEEE Control Systems Society (2006), the 1999 Harold Chestnut Prize (IFAC Best Control Engineering Textbook) for *Discrete Event Systems: Modeling and Performance Analysis*, a 2011 prize and a 2014 prize for the IBM/IEEE Smarter Planet Challenge competition (for a "Smart Parking" system and for the analytical engine of the Street Bump system respectively), the 2014 Engineering Distinguished Scholar Award at Boston University, several honorary

professorships, a 1991 Lilly Fellowship and a 2012 Kern Fellowship. He is a member of Phi Beta Kappa and Tau Beta Pi. He is also a Fellow of the IEEE and a Fellow of the IFAC.

Hong Kong Workshop honoring Y.C. Ho, August 2017

Optimal Computing Budget Allocation (OCBA)

Chun-Hung Chen

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ABSTRACT

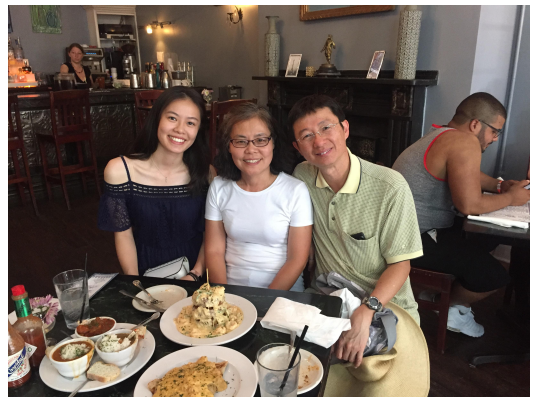
I have been working in enhancing the efficiency of simulation optimization. Our approach aims to maximize the efficiency of finding a good solution, via optimally searching the solution space and sampling the simulation replications. Further, we propose to transform the solution space into a smart space which is smoother and has nice properties. Thus, the search becomes easier and more efficient in the transformed space. A key component of our methodologies is a new technique called Optimal Computing Budget Allocation (OCBA) initially developed when I was a Ph.D. student at Harvard. The ideas of OCBA have been widely investigated and extended by numerous researchers around the world. In simulation optimization, the OCBA algorithm is widely considered as the state-of-the-art algorithm. For example, Prof. Ryzhov's 2017 best publication award from the Informs Simulation Society shows that under some conditions, a class of ranking and selection algorithms "can lead to simulating the systems such that their sampling ratios are asymptotically the same as those of OCBA, which is known to yield near optimal performance."

BIOGRAPHICAL SKETCH

Chun-Hung Chen received his Ph.D. degree from Harvard University in 1994. He is currently a Professor at George Mason University. Dr. Chen was an Assistant Professor at the University of Pennsylvania before joining GMU. He was also a professor at National Taiwan University (Electrical Eng. and Industrial Eng.) from 2011-14. Dr. Chen was awarded with "National Thousand Talents" in 2011. Sponsored by NSF, NIH, DOE, NASA, FAA, Missile Defense Agency, and Air Force in US, he has worked on the development of very efficient methodology for simulation-based decision making and its applications. He has served as a Department Editor for IIE Transactions, Department Editor for Asia-Pacific Journal of Operational Research, Associate Editor for IEEE Transactions on Automation Science and Engineering, Associate Editor for IEEE Transactions on Automatic Control, Area Editor for Journal of Simulation Modeling Practice and Theory, Advisory Editor for International Journal of Simulation and Process Modeling, and Advisory Editor for Journal of Traffic and Transportation Engineering. Dr. Chen is the author of two books, including a best seller: "*Stochastic Simulation Optimization: An Optimal Computing Budget Allocation*". He is an IEEE Fellow.

On the personal side, my wife, Mei-Mei, enjoys her gardening and has grown lots of flowers and vegetables. My daughter, Valerie Chen, just finished her sophomore year at Yale University. She received 2016 ACM Cutler-Bell Prize and appeared at the ACM font page. She also received 2017 NCWIT Collegiate Award. We are proud of her.

With wife and daughter.
Taiwan, January 2018



With wife and daughter.
New Orleans, May 2018

With my co-author of the OCBA book, Prof. Loo Hay Lee. This photo was taken at Loo Hay's Center at National University of Singapore after giving a keynote at a workshop. June 2018.

Modeling, Simulation and Optimization of Complex Systems

Weiwei Chen

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ABSTRACT

My research interest lies in stochastic modeling, simulation and optimization of complex systems, especially in supply chain, logistics, and energy. Based on methodologies used, they can be classified into three main threads.

(1) Supply chain modeling and optimization. Many supply chain problems involve complex operations, often carried out on a large scale. As such, we have developed mathematical models to optimize several logistics and manufacturing systems, and optimization heuristics to solve these models with sufficient speed and accuracy. Examples include intermodal hub location problems, drayage operations optimization, coordinated operations in construction supply chains, and station rebalancing for bike sharing systems.

Recently, I have focused on the interface of finance and operations. In one such work, we developed stochastic queueing and population models to study the combined operational and financial performance of cash conversion systems in corporate entities. The model enables the parent corporation with subsidiaries to study the impact of moral hazard and internal capital market inefficiency on the firm's optimal supply chain designs.

(2) Simulation optimization and randomized global search. Stochastic simulation models are often used to analyze and optimize the design of complex systems, such as healthcare delivery and supply chains. A key topic is how to efficiently choose the best design, subject to computing budget constraints and the random noise inherent in simulation sampling. I have been working with my colleagues in the areas of ranking and selection (when the design space is moderate), and randomized global search (when the design space is large). For the former area, we have extended the optimal computing budget allocation (OCBA) method to several problem settings; and for the latter area, we have developed algorithms based on the nested partitions (NP) framework.

(3) Business analytics in energy and other areas. My industry experience has equipped me with tools and experience for solving real-world business problems, using statistics, data mining, and optimization approaches. One example is a suite of analytical tools developed with my former colleagues at GE, which supports the demand-side management for electric utility companies. Specifically, these tools implement economic demand response (DR) programs as cost-efficient yet effective way for improving utilities' capacity utilization, by financially incenting

customers to curtail or shift their peak electricity demand. The tools have been implemented and deployed in real-world utility systems, generating benefits for the utilities and society.

BIOGRAPHICAL SKETCH

I am currently an Assistant Professor in the Department of Supply Chain Management at Rutgers University. I received the B.S. and M.S. degrees from Tsinghua University, Beijing, China in 2003 and 2006, respectively. Then, I joined Professor Leyuan Shi's group and received my Ph.D. degree from the University of Wisconsin-Madison in 2010. Prior to joining Rutgers in 2014, I was a research scientist in the Management Sciences Lab at General Electric (GE) Global Research Center, NY.

I have been deeply appreciative to the support and guidance that I received from Professor Ho's academic family. My life trajectory changed several times in a meaningful way because of this group. When I was an undergraduate student at Tsinghua, I was one of the audiences when Professor Ho gave a lecture on his academic life. His passion to research and education triggered my thought, for the first time in my life, to get on the academia track. Then, Professor Leyuan Shi brought me to the U.S. to earn the Ph.D. degree under her guidance. The four years at Madison were one of the most fruitful and enjoyable periods of my life. Later, I had the honor to extend my research portfolios by working with Professor Chun-Hung Chen and Professor Loo Hay Lee, as well as other great minds. It has been such an amazing journey so far, thanks to Professor Ho and the group!

On the family side, my wife, Beirong Fu, and I have been married for eleven years. We have an eight-year old son, Kevin Chen. My family loves traveling together, especially to beaches. Kevin is one of the funny guys in school and at home (as you can see from the pictures below). He likes playing piano and board games. The two family pictures below were taken with Professor Leyuan Shi and Professor Chun-Hung Chen, at Professor Shi's 60th birthday party in Xi'an in 2017.

Bounding Approximate Dynamic Programming Schemes

Edwin K. P. Chong

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ABSTRACT

We consider a broad family of control strategies called path-dependent action optimization (PDAO), where every control decision is treated as the solution to an optimization problem with a path-dependent objective function. How well such a scheme works depends on the chosen objective function to be optimized and, in general, it might be difficult to tell, without doing extensive simulation and testing, if a given PDAO design gives good performance or not. We develop a framework to bound the performance of PDAO schemes, based on the theory of submodular functions. We show that every PDAO scheme is a greedy scheme for some optimization problem, and if that optimization problem is equivalent to our problem of interest and is provably submodular, then we can conclude that our PDAO scheme is no worse than something like 63% of optimal. As an important application, we show how to apply our framework to stochastic optimal control problems to bound the performance of approximate dynamic programming (ADP) schemes. Such schemes are based on approximating the expected value-to-go term in Bellman's principle by computationally tractable means, and underlies many modern computational intelligence applications, ranging from self-driving vehicles to the super-human Go-playing program, AlphaGo. Our framework provides the first systematic approach to bounding the performance of general ADP methods in the stochastic setting.

BIOGRAPHICAL SKETCH

Edwin K. P. Chong received the B.E. degree with First Class Honors from the University of Adelaide, South Australia, in 1987; and the M.A. and Ph.D. degrees in 1989 and 1991, respectively, both from Princeton University, where he held an IBM Fellowship. He joined the School of Electrical and Computer Engineering at Purdue University in 1991, where he was named a University Faculty Scholar in 1999. Since August 2001, he has been a Professor of Electrical and Computer Engineering and Professor of Mathematics at Colorado State University. He coauthored the best-selling book, *An Introduction to Optimization* (4th Edition, Wiley-Interscience, 2013).

Prof. Chong received the NSF CAREER Award in 1995 and the ASEE Frederick Emmons Terman Award in 1998. He was a co-recipient of the 2004 Best Paper Award for a paper in the journal Computer Networks. In 2010, he received the IEEE Control Systems Society Distinguished Member Award. He was the founding chairman of the IEEE Control Systems Society Technical Committee on Discrete Event Systems, and served as an IEEE Control Systems Society Distinguished Lecturer. He was a Senior Editor of the IEEE Transactions on Automatic Control.

He was the General Chair for the 2011 Joint 50th IEEE Conference on Decision and Control and European Control Conference. He has served as a member of the IEEE Control Systems Society Board of Governors and as Vice President for Financial Activities until 2014. He served as President in 2017. Currently he serves as Treasurer for the IEEE Educational Activities Board.

Ed and Yat-Yee Chong at Lake Como, May 2018.

The Long and Winding Road

Michael C. Fu

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ABSTRACT

I have been working in the general area of simulation optimization, which has included perturbation analysis and other gradient estimation techniques, stochastic approximation and other gradient-based optimization approaches, global optimization, and Markov decision processes (MDPs). I have been fortunate to be able to work with a diverse group of wonderful research colleagues over the years. One algorithm that was developed with my closest colleague at Maryland, Steve Marcus, and a postdoc and PhD student at the time (both now professors themselves), served as the basis of a technique called Monte Carlo tree search, which was used to train AlphaGo and AlphaZero. For more details, please see
https://www.informs.org/ORMS-Today/Public-Articles/October-Volume-43-Number-5/Google-DeepMind-s-AlphaGo

I've published six books (two research monographs and four edited books):

- *Conditional Monte Carlo: Gradient Estimation and Optimization Applications*,Kluwer Academic Publishers, 1997 (w/ Jian-Qiang Hu).
- *Simulation-based Algorithms for Markov Decision Processes*, Springer-Verlag, 2007 (w/ Hyeong-Soo Chang, Jiaqiao Hu, and Steven I. Marcus; 2nd edition 2013).
- *Perspectives in Operations Research: Papers in Honor of Saul Gass' 80th Birthday*, Springer, 2006 (edited w/ Frank B. Alt and Bruce L. Golden).
- *Advances in Mathematical Finance*, Birkhauser, 2007 (edited w/ Robert A. Jarrow, Ju-Yi Yen, and Robert J. Elliott; Festschrift for Dilip B. Madan's 60th birthday).
- *Encyclopedia of Operations Research and Management Science*, 3rd edition (2 volumes), Springer, 2013 (edited w/ Saul I. Gass).
- *Handbook on Simulation Optimization*, Springer, 2015, editor.

The newest sponsored research project that I just started this year as a co-Pi is entitled, "An Optimization-based Approach to Breaking the Neural Code," and its objective is to be able to take real-time noninvasive neuro-imaging measurements obtained from humans using Electroencephalography (EEG) and Magnetoencephalography (MEG) to estimate brain activity.

BIOGRAPHICAL SKETCH

I was born in Lafayette, Indiana, and I now live in Chevy Chase, Maryland. In between, I've lived in the states of Ohio (multiple places), Illinois, Missouri, Virginia, and Massachusetts (multiple places). Growing up, I moved around a lot, but after receiving my Ph.D. at Harvard in 1989 under Professor Ho, I've worked in the *same* place for going on my 30th year starting this fall (counting my service as Program Director of the Operations Research program at the National Science Foundation from 2010-2012 and 2015).

I currently hold the Smith Chair of Management Science in the Decision, Operations and Information Technologies department of the Robert H. Smith School of Business, University of Maryland, College Park, with a joint appointment in the Institute for Systems Research and an affiliate appointment in the Department of Electrical and Computer Engineering, both in the A. James Clark School of Engineering. I was named a Distinguished Scholar-Teacher by the University in 2004. I am a Fellow of both IEEE and INFORMS.

In terms of family, I'm on my second marriage, and my university health plan currently covers four dependent children (GGBB): the oldest two graduated last May (2017) and after a brief boomerang period are now gainfully employed, the third oldest just finished his junior year at Yale, and the youngest just graduated from high school in June and will be starting college this fall in College Park.

Siyang Gao

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ABSTRACT

My research includes the following three directions:

- Ranking and selection. This is a basic simulation optimization problem for selecting the best simulated system design. Our primary methodology is called Optimal Computing Budget Allocation (OCBA), which was invented by Prof. Chun-Hung Chen, and is an extension of Prof. Yu-Chi Ho's excellent idea of Ordinal Optimization (OO). Thanks to Prof. Chun-Hung Chen and Loo Hay Lee's insightful guidance and kind help, we have conducted some interesting research on several important ranking and selection problems.
- Global optimization. Our methodology falls in the category of metaheuristic algorithms, and solves the optimization problem by iteratively partitioning the solution space into small sub-regions and identifying the promising regions for more portioning. This is a continuation of Prof. Leyuan Shi's nice work of Nested Partitions (NP) search.
- The application of the methods above to real-world problems. The application area is primarily in health care.

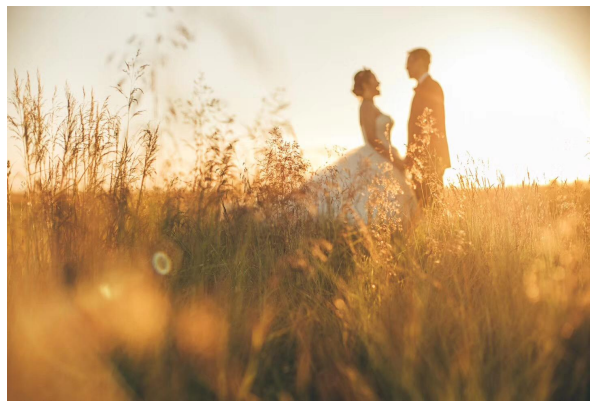
BIOGRAPHICAL SKETCH

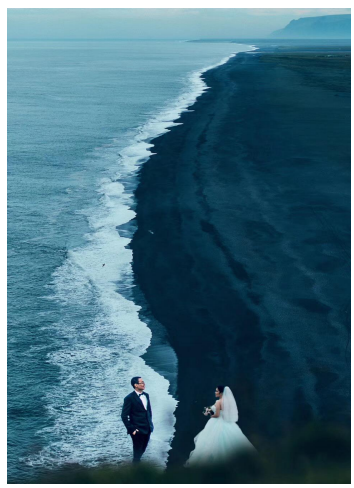
Siyang Gao received the B.S. degree in Mathematics from Peking University, Beijing, China, in 2009, and the Ph.D. degree in Industrial Engineering from University of Wisconsin-Madison, Madison, WI, in 2014 (under the supervision of Prof. Leyuan Shi). Dr. Gao is an Assistant Professor with the Department of Systems Engineering and Engineering Management, City University of Hong Kong. His research is devoted to simulation optimization, large-scale optimization and their applications in healthcare management. His work has appeared in Operations Research, IEEE Transactions on Automatic Control, Automatica, etc. Dr. Gao is a member of the Institute for Operations Research and the Management Sciences (INFORMS) and Institute of Electrical and Electronics Engineers (IEEE).

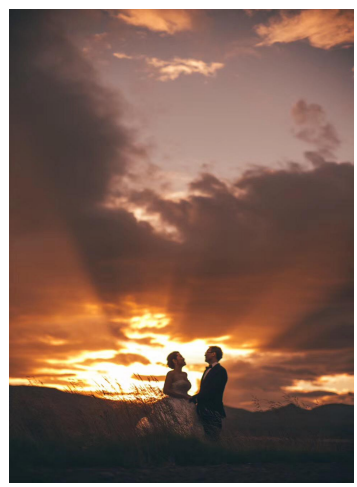
I was doing oral defense of my PhD thesis in 2014.

My honor to meet some respected senior scholars in a workshop in 2017. (From left to right: myself, Prof. Leyuan Shi, Prof. Yu-Chi Ho, Prof. David Yao, Prof. Jie Song)

I got married in 2017. Here are some of my wedding photos.







Information and Prices

Paul Glasserman

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ABSTRACT

I will briefly describe two projects I've been involved in recently, each of which has a connection to some ideas I first learned about in Professor Ho's class on optimal control. The connections are highlighted in bold.

The first project is a paper co-authored with my Columbia colleague Harry Mamaysky, titled "Does Unusual News Forecast Market Stress?" In this paper, we use tools from natural language processing applied to a database of news articles to try to forecast market volatility. The ultimate goal would be to create an early-warning system for a financial crisis.

We measure news sentiment as positive or negative, and we measure the unusualness of news using a measure of relative entropy that compares recent news with older news. We find that unusual negative news forecasts an increase in market volatility.

We conduct this analysis at the level of individual stocks and for the market as a whole. We find that information gets absorbed more quickly at the single-stock level than at the aggregate level.

To make this comparison, we use a vector autoregression to model the evolution of volatility and news sentiment. A vector autoregression is just a **linear dynamical system**, and this is the first connection with Pierce Hall. We study the VAR through its **impulse response functions**, which show the impact of a spike in negative (or positive) news. We find that the responses decay more slowly at the aggregate level than at the single-stock level.

The second project is partly inspired by these findings but is theoretical rather than empirical. With Harry Mamaysky and a PhD student, Yiwen Shen, we are developing a model of information-driven cycles in prices and volatility. The model has features in common with **LQG systems**. The "state" is the next dividend (Gaussian) to be paid by a stock and a measure of the fraction of the variance of the dividend known to informed investors. The state has linear dynamics. In each period, investors choose optimal portfolios by minimizing a quadratic objective; they can also choose to become informed, at a cost. Matching supply and demand determines a price, and the price turns out to be a noisy linear signal of the state, so uninformed investors use the price to make inferences about the state, in a simple form of **filtering.**

Most of this is standard in a large body of research going back to a static model of Grossman and Stiglitz in 1980. Our model extends the classical framework first by introducing dynamics but even more importantly by introducing **feedback.**

As more investors become informed, we allow positive feedback that makes more information available. The system has two stable regimes, one with low volatility and high prices, and another with high volatility and low prices. The system occasionally transitions from one regime to another, and the transition describes the onset (or end) of a crisis.

BIOGRAPHICAL SKETCH

My wife, Elaine, is working on a book on the history of attitudes toward cancer. Our son Aaron just finished his third year as a doctoral student in Chinese history at Columbia, and our younger son Ethan is living in Cambridge, working at MacLean Hospital, and deciding what he wants to do next. Besides my day job at Columbia, I have worked part-time since 2011 for the Office of Financial Research in the U.S. Treasury Department, though the office has had a rocky time since the change in administration.

Probably 1987

How Do We Perceive The Visual Scene?

Weibo Gong

University of Massachusetts, Amherst

ABSTRACT

One of Professor Ho's wise advice to students is to think about real world problems. How do human and many animals perceive the visual environment is such a real challenge. In this short piece I try to describe my recent work on a signal representation for cognitive computation.

Signal representations suitable for easy extraction of invariants are crucial for many tasks of general intelligence. Our visual system has evolved for this purpose. However, the pixel intensity based representations that underlie many successful image processing algorithms are seemingly inconsistent with our vision functions. For example, our eyes make rapid involuntary movements but our visual perceptions of the environment are stable. In fact, we see many objects in our visual scene simultaneously, and when focusing we see some very clearly. Our two eyes receive different sets of light signals, but we don't see double. Even in just one eye, we have millions of non-collocated photo receptors, and yet they work together to provide a seamless perception of the visual scene. How do they collaborate at the algorithmic level? Our hypothesis is that all these signal sensors sample the same set of signal values that characterize the visual scene, thereby helping each other in the spirit of the law of large numbers, where repeated observations of a fixed set of statistical parameters help to improve estimation accuracy.

In our proposed signal representation model, visual (spatial) signals are converted to time signals (by a linear dynamic system) in order to propagate and convey information to subsequent memory and analogical mechanisms. Such time signals, representing small visual regions, should be able to collaborate with those of neighboring regions in order to represent the larger scene. The basic algorithmic unit is modeled by a partial differential equation with second order time dynamics. The algorithm aims to exhibit the following necessary features of natural cognitive computation:

- Biological plausibility;
- Accuracy and robustness;
- High fidelity information conversion;
- High information throughput using slow processing units;
- Foundations for high-capacity/fast-access memories, concept abstraction, and analogical thinking.

We believe that visual signal processing is similar to the human mind's capacity to abstract concepts. This is believable since Nature repeats successful mechanisms. Human and animal minds are constantly searching for relations among event sequences, observed or internal. In fact all objects, concepts and their interactions are defined by the relations among their constituents. Relations are much more stable and useful than the raw signal pieces. The ability to

remember repeated relations is critical in the game of survival. Thus, important questions include: How does the mind generate invariant relations; How can they be coded into a high-capacity, fast-access memory; and, What are the enabling algorithms for these processes? We develop the signal representation models and their related algorithms based on the visual signal representation discussed above.

Finally, we emphasize that the ideas discussed above are conceived in continuous time via continuous dynamical systems. We do so to connect with the motivating biology of the brain. In implementing these proposed abstraction processes via a digital computer, quite a few steps can be bypassed. For example, memory addressing is straightforward in digital computing. Also, signal matching is accomplished easily with an inner product rather than resonating circuits. Our proposed signal converter does not need to mimic a partial differential equation since its output is related to the phase computed by an FFT algorithm. A vector with components ranked by the spatial frequencies and taking the values of the phases would be effective in many cases. In fact, the efficiency of modern digital computing combined with the right concept abstraction algorithms should be a concern in terms of social impact.
In the rare event that someone is intrigued by the above discussions please feel free to contact me at gong@ecs.umass.edu.

Next Generation Software-Defined-Storage System

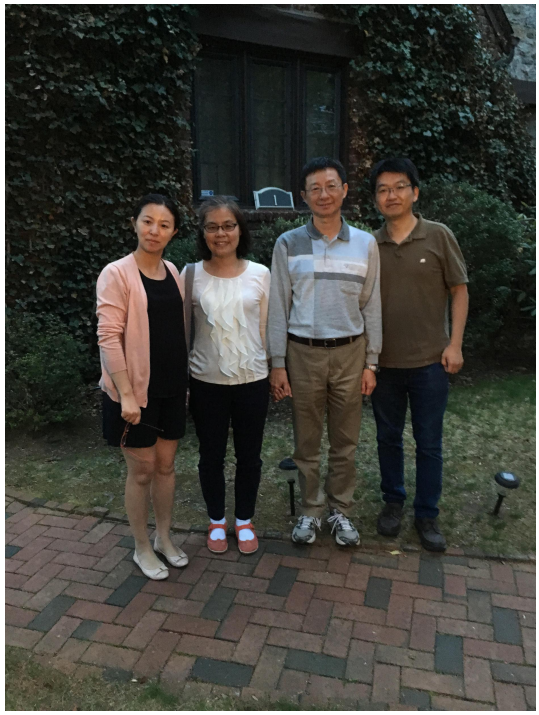
Donghai He

Software Engineer/Research in a startup
New York, NY, USA

BIOGRAPHICAL SKETCH

I received my Ph.D. degree from George Mason University. My thesis advisor is Prof. Chun-Hung Chen. I had been working on designing and developing a key discrete-event airport/airspace simulation tool sponsored by FAA for five years. The purpose of this tool is to help improve aircraft operations in airports and airspace by simulation optimization. I also worked on multiple research projects for federal government agencies, such as NASA and MDA. In 2013, I joined the core R&D team in a well-funded technology startup company backed by multiple venture capital firms to develop a cutting-edge next generation software-defined-storage computer cloud system. The fundamental idea is to rebuild the infrastructure of current computer storage system so that the new system can fully optimally utilize the underlying hardware with maximized flexibility. The new system can provide maximized performance with significantly reduced hardware cost and footprint in modern data centers. We have stabilized the system and reached among the top performers in the cloud storage industry after five-year extremely challenging work. In addition to advanced software technologies, we have broadly researched in related fields, such as dynamic optimal resource allocation and system control, real-time anomaly detection by machine learning, and workload tracking and prediction with neural network kalman filter. After work, I enjoy playing with my children, reading, fishing, and sometimes watching sci-fi movies. My wife and I have two daughters, a 7-years old and a 6 month-old.

Trip to Yosemite National Park,2017.



(Left) Professor Chen and family visited my home in NY, 2018. (Right) My family 2018.

My research and personal life since graduation from Harvard

Jian-Qiang Hu

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ABSTRACT

I did my Ph.D. thesis on Perturbation Analysis (PA), mainly on two topics: 1) proving the strong consistency of Infinitesimal Perturbation Analysis (IPA), and 2) trying to extend the applicability of IPA to problems where it fails in its original form (or sample path performances are discontinuous). I have continued working on issues related to sensitivity analysis and optimization of discrete-event stochastic systems during the last three decades. I feel very lucky and fortunate as a member of Professor Ho's academic family and have opportunities to collaborate with many members of this family (Michael Fu, Paul Glasserman, Steve Strickland, Weibo Gong, Mei Deng, Yorai Wardi, Michael Zazanis, Leyuan Shi, Pirooz Vakili, Christos Cassandras, Xiren Cao, Les Servi, Chun-Hung Chen, Loo Hay Lee). I am still working closely with some of them today. Many of my early works on PA were joint works with Michael. In addition to extending the applicability of various PA methods and addressing some theoretical issues, I also worked together with him on many application problems, such as option pricing, quality control, and inventory optimization.

Over the years, I have also tried to branch out into some other areas. I started working on the problem of flow control for flexible manufacturing systems and queueing network approximation in early 1990s. The problem of flow control is mainly a stochastic control problem and was a rather new direction for me. My work on queueing network approximation was mainly based on the technique of MacLaurin series that Weibo and I jointly developed when we initially tried to using PA to calculate high derivatives for the G/G/1 queue. During 2000-2001, I worked full-time at Sycamore Networks Inc., an optical equipment company, where I started working on the design of optical networks. My work in this area continued until a few years ago when Huawei (the largest Chinese network equipment company) asked me to help them to solve some of their optical network design problems.

Since coming back to China, I have started working on several new research directions, which include:

1. Supply chain management. During 2007-2012, I did some extensive consultant works with Jointown Pharmaceutical Inc., one of the largest pharmaceutical distribution companies in China. One of the largest projects I got involved was to help them to update their ERP system and to revamp their procurement organization structure. This led my interests in many issues related supply chain management.
2. Financial engineering. Being in Shanghai, the financial center of China, I

have many opportunities to work with various financial institutions, including Shanghai Stock

Exchange, Shanghai Futures Exchange, Shanghai Gold Exchange, and many big banks and hedging funds. One interesting problem we have studied recently is the impact of trading restrictions and margin requirements on stock index futures.

3. Healthcare. Because Jointown is a pharmaceutical distribution company, it is where I was first introduced to some problems related to healthcare (but mainly focusing on supply chain related issues, e.g., how to make supply chain operations in hospitals more efficient). Recently I have been working with one of the largest hospitals in Shanghai on several interesting problems, including bed management and medical imaging processing (angiocardiography). For example, we have formulated the bed management problem as a multi-person stochastic game based on which we can study admission behavior of doctors and its implication, and we have also used real admission data to validate some of the results obtained based on our game model.
4. Application of simulation to airline scheduling problems. Previously most airline scheduling problems have been formulated as integer (or mixed) linear programming problems. We are working with China Eastern Airlines to help them to explore the possibility of applying simulation models in conjunction with some of the recently developed optimization techniques (e.g., AI based), which some researchers have been referring as "smart" simulation. This is mainly an application problem, and but it provides a good opportunity for us to apply our simulation models and techniques.

In summary, to addition to problems related to discrete-event stochastic systems, simulation, and stochastic optimization, my recent research efforts have been focused on financial engineering and healthcare problems.

In my research, I have been following one of the advices given by Professor Ho: trying to find interesting research problems in solving real-world problems. It has benefited me tremendously.

BIOGRAPHICAL SKETCH

I received my B.S. degree in applied mathematics from Fudan University (China) and my M.S. and Ph.D. degrees in applied mathematics from Harvard University in 1987 and 1990, respectively. After my graduation from Harvard, I joined the Department of Manufacturing Engineering (later the Department of Mechanical Engineering and the Division of Systems Engineering) at Boston University. In 2008, I came back to Shanghai, China and joined my alma mater, Fudan University, where I am currently with the Department of Management Science. My current research interests include discrete-event stochastic systems, simulation, and stochastic optimization, with applications towards supply chain management, financial engineering, and healthcare.

Finally, here is an update on my personal life. I had a very severe heart attack five years ago and went through a quintuple bypass surgery. This kind of experience could of course change one's perspective on life. Luckily, I have

fully recovered from that operation and I am doing well. My daughter Helen graduated from college last year and is working for a tech company in Bay Area now. My older son Kevin is currently a junior majoring in applied math, and my younger son Alex is a 7th grader. My wife Lei works in one of the largest hospitals in Shanghai, and she loves traveling and foods, so do I (but I have to watch my diet more carefully since my bypass operation).

Lei and I were traveling in France during the summer of 2017

Decisions in 4PL: The Internet-Plus" Logistics Supply Chain Management

Dr.Min Huang, Prof.

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ABSTRACT

With the development of information and communication technology as well as the rise of sharing economy, "Internet-Plus" mode is becoming the new operation mode of many traditional and start-up enterprises. The Forth Party Logistics(4PL), emerging with the concept of sharing economy and "Internet-Plus", as a new mode of logistic and supply chain integration, brings lots of fresh opportunities for enterprises. However, new decision problems arise along with the opportunities, and also challenge the researchers and entrepreneurs. In our study, various decision problems for 4PL are identified in the three decision levels: (a) Strategic level decisions including network design problems and risk management problems; (b) Tactical level decisions including Customer Routing Problem (CRP) and Collaborative Vehicle Routing Problem (CVRP); and (c) Operational level decisions including reverse auctions based suppliers selection and matching of suppliers and customers. Moreover, new methodologies are provided to address these challenges.

On the s*trategic level*, for the network design problems in 4PL, the location-logistics and resilience network design concepts are proposed which extend the tradition SC network design from the selection of locations to the integrated selection of locations and logistics as well as from considering the interruption of location to considering the interruption of logistics. The mathematical models are presented, the effective algorithms are proposed and some discussions are given which give some insights to the entrepreneurs. For the risk management problems in 4PL, contracts design for the outsourcing logistics quality risk is studied from 4PL perspective; various contracts are analyzed and their pros and cons are discussed; we found that the cooperative bargaining contract is the most effective to 4PL and social welfare. The extension of contracts for discrete efficiency distribution scenarios is analyzed. Also, contracts design for the outsourcing logistics time risk is also studied from 4PL perspective.

On the *tactical level*, a novel CRP in 4PL is proposed. The time and cost concern of customers are considered and the behaviors of customers are integrated in the analysis of service level. The prospective theory integrated mathematical models are presented, the effective algorithms are proposed and the discussions are given which obtained some insights to the entrepreneurs. For the CVRP in 4PL, the collaborative logistics of heterogeneous depots are studied， which proposes both routing planning and cost-saving sharing mechanisms with some insights for CVRP.

On the *operational level*, for the reverse auctions based suppliers selection in 4PL, the bounded rationality behavior of suppliers and buyer such as different thinking levels, consequences of anticipated regrets, risk aversion and loss aversion are considered. The first- and second-price sealed-bid reverse auctions situations are discussed and the managerial insights are obtained. For the matching of suppliers and customers in 4PL, a systematic model of multilateral automated negotiation is studied, which generate effective matching with individually stable advantages.

In general, the work of our group covers a range of topics in the general area of manufacturing and services systems, including the decisions (planning, scheduling, and inventory control)and data analysis of manufacturing systems; the decisions (supplier selection, contracting to multi-stage coordination, SC network design, SC risk management, CRP, CVRP, etc) in logistics supply chain systems; the decisions(routing, resource management, and Quality of Service management and control) in communication network systems. Our group verse in advanced techniques in operations research and computation, including stochastic modeling, discrete-event simulation, statistical analysis and inference, game theory, dynamic programming, optimization and algorithms, and others. Also, our research is close interaction and integration with information systems and software engineering. Our group's problems and projects are supported by NSFC , foundation of MoE of China, foundation of Liaoning province of China, as well as well grounded in real-world sources, mostly from the industrial base. In the research, our group pursues the goal of application-oriented yet never shying away from sophisticated methodologies, and well balanced between solving problems and generating insights.

We would like to take this opportunity to thanks to the advisement, helps and supports of Prof. David Yao from Columbia University, Prof. Shu-Cherng Fang from North Carolina State University, Prof. Xiuli Chao from University of Michigan (Ann Arbor), Prof. Keith W. Hipel from University of Waterloo ， Prof. V. Jorge Leon from Texas A&M University, Prof. Loo Hay Lee from National University of Singapore, and my friends including all of you. And it is really Prof Ho to whom we should express our gratitude because it is him who brings us together. Wish everyone enjoy the reunion.

BIOGRAPHICAL SKETCH

Dr. Min Huang is a professor in the College of Information Science and Engineering at Northeastern University in China, backbone professor of State Key Laboratory of Synthetical Automation for Process Industries and was a senior visiting scholar in the Department of Industrial and Operations Engineering at University of Michigan (Ann Arbor) in 2011.

Dr. Huang has been recognized as the Distinguished Young Scholars by the National Science Foundation of China, Changjiang Scholarship Chair Professor of MOE in China, Special allowances experts of the State Council of China, New Century Excellent Talents in University of MOE in China, the backbone professor of 2 Foundation for Innovative Research Groups of National Science Foundation of China(Information and Management Department of National Science Foundation of China), Henry Fok Education Foundation funded award for young college teachers (for Research), One Hundred level Talent Program (Liaoning province).

Her research is supported by more than 30 projects funded by NSFC (including National Science Foundation for Distinguished Young Scholars of China, Major International Joint Research Project of NSFC, etc), the National High-Tech Program (863 planning) of China and foundation of MOE of China as PI. Her research is also supported by more than 20 projects funded by NSFC (including Foundation for Innovative Research Groups of National Science Foundation of China, Key Program of NSFC, etc), the National High-Tech Program (863 planning) of China and foundation of MOE of China as Co-investigator.

She has authored more than 200 refereed publications in international and domestic academic journals and conferences (90 among them are cited by SCI). 2 books are published and 1 book is translated from English to Chinese. The 9 national invention patents and 11 software copyrights have been authorized.

She has been showered with 8 prizes and awards honored by the state and MOE of China (7 for research and 1 for teaching). She holds several scientific and technological achievements of MOE of China

She currently serves as the Vice President of Uncertainty Council of Operations Research Society of China; the Board Member of ICEB China Chapter, Society of Management Science and Engineering of China, Intelligent Computing Council and Behavioral Operations Management Council of Operations Research Society of China; the Academic Committee Member of Logistics and Systems Engineering Council of Systems Engineering Society of China; the Member of INFORMS and POMS; the Associate Editor of Asia Pacific Journal of Operational Research; the Editorial Board Member of Asian Journal of Management Science and Applications, Journal of Systems Engineering, Control and Decision, and Operations Research and Management Sciences and the Organizing Committee Member of many international conferences. She organized 4 International Academic Workshop as the conference chairman. She was invited for delivering plenary speeches in many international conferences.

She was invited as visiting professor of The University of Michigan, Texas A&M University, North Carolina State University, Chiba Institute of Technology, National University of Singapore, the University of Hong Kong, the City University of Hong Kong,the Hong Kong Polytechnic University.

Her research interests cover the management of logistics and supply chain systems, the modeling, analytics and optimization for manufacturing and service systems, the theory and application of planning and scheduling, risk management, behavioral operations management, data analysis and machine learning, computational intelligent, etc.

Visiting at University of Michigan (Ann Arbor) in 2011

June 20, 2018

Dear Professor Ho and Auntie Sophia,

Time really flies. The year of 2001 is just like yesterday. Together with the birth of the Center for Intelligent and Networked Systems (CFINS) at Tsinghua University, there was also the turning point of my life, being part of the Ho academic family. I cannot tell you how excited I was when Professor Ho told me in his office in the main building of Tsinghua that I was admitted to be his first PhD student in Tsinghua. It was the first year of the new millennium. And there was me starting my new life.

The past 17 years is just like one day. And I am still living it. Many things have happened, even after your visit in Tsinghua in the last year. Let me share a few exciting news with you.

Zhiqing, my son, is now about to finish his first grade in the primary school. He plays center back in the soccer team of his class, "the most important position in that battlefield" (I am quoting from his own words). I was never good at sports when I was a teenager. Watching Zhiqing playing soccer enlightened me that education is more about encouraging one to surpass himself or herself. Growing with my son also make me understand how much patience and wisdom you had when you supervised me during my PhD.

Yan, my wife, is about to receive her driver license, which is a great accomplishment. Speaking four languages does not help much in driving. ☺ But the desire to see more of the world does. ☺ I never thought that I need to drive. But my visit to Lexington in 2006 totally changed my mind. The colorful leaves in the new England fall is priceless. I can still see that when I close my eyes now. Yes, it is that passion and desire to see more and to learn more that drive us forward, and keep us young. Professor Ho and Auntie Sophia, you are always young in my heart.

I am doing well in my academic career. Thank for the help from Professor Xiaohong Guan and Qianchuan Zhao. I am now a member of the Technical Committee on Control Theory, Chinese Association of Automation. I also continue to serve as an associate editor for IEEE Transactions on Automatic Control, the flagship journal in our field. My main research work is on optimization for cyber physical energy systems with applications to smart buildings and smart grids. CFINS has received two National Key Research and Development projects. And soon I will also nail down another million-dollar project with leading industry in this field. Therefore, CFINS is financially healthy. We will have a new junior faculty joining CFINS this fall. As the associate director, I promise you that CFINS will not only survive but also grow.

Also, I have supervised a number of PhD students by myself now. I just received the Mentor Award from Tsinghua University, the selection of which is by students' voting. Actually, I was doing nothing more for the students than what you did for me.

Thank you, for guiding my life.

Best regards,
(Samuel) Qing-Shan Jia
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Associate Professor and Associate Director
Center for Intelligent and Networked Systems (CFINS), Department of Automation
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Vice Dean, Tsinghua Global Innovation eXchange (GIX) Institute
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Simulation in Online Decision

Guangxin JIANG

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ABSTRACT

The first time I touched Professor Ho is through his blog, when I was a graduate student. Those articles in the blog helped me pursue my Ph.D degree, and let me decide to be an academic researcher. I am very glad to join in this fantastic academic family and meet other members. I currently work in School of Management, Shanghai University. My research is about simulation analytics, simulation methodology, simulation optimization, with their applications in financial engineering and operation management. In this workshop, I would like to introduce my recent work on simulation analytics. Simulation has been used as a tool of design to evaluate, to compare and to optimize the performance of different system designs. It is rarely used in real-time decision due to the timeliness. However, with the fast growth of computing capability and with more and more data analytics tools available, we propose an offline-learning-online-application (OLOA) framework that treats simulation as a data generator, applies data mining tools to build predictive models, and then uses the predictive models for real-time decision.

BIOGRAPHICAL SKETCH

Dr. Guangxin JIANG is a lecturer in the Department of Management Science and Engineering, School of Management, Shanghai University. He received his PhD and B.Sc in Applied Mathematics from Tongji University in 2015 and 2010, respectively. He was a joint PhD student in the Robert H. Smith Business School, University of Maryland, College Park, from 2013 to 2014. Prior to joining Shanghai University, he was Postdoctoral Fellow in the Department of Economics and Finance, City University of Hong Kong.

Past Career and Biographical Sketch
Prepared for Proceedings of Y. C. Ho Workshop on July 7, 2018

Marcia Kastner

mkastner@comcast.net

Past Career

My Ph.D. from Harvard allowed me to pursue many different kinds of work in academia, industry, and government. Because of my husband's job (see Biographical Sketch below), I was constrained to jobs only in the Boston area, which, fortunately, provided many interesting opportunities. The following is a list of those jobs, in chronological order:

- Assistant Professor of Manufacturing Engineering at Boston University, teaching probability, statistics, and operations research in the College of Engineering (This was before other Ho students became professors at BU.)
- Systems engineer at Bolt, Beranek, and Newman (in the same group as Peter Luh, Sheldon Baron, and R. Muralidharan), working on a game theory model of peak-load electricity pricing
- Operations research analyst at ALPHATECH, an MIT spinoff, working on queuing algorithms and team theory models for computer architectures and manufacturing facility layouts
- Systems engineer at MIT Lincoln Laboratory, working on algorithms for air traffic control automation
- Trainer and software engineer at I-Kinetics, another MIT spinoff, developing and teaching professional training courses in middleware
- Technical manager of client-side software quality assurance at Akamai Technologies (Michael Yang and Ed Lau were at Akamai at the same time.)
- Consultant for MIT's OpenCourseWare program, which provides free online access to MIT course materials
- Assessment Lead for Mathematics Test Development at the Massachusetts Department of Elementary and Secondary Education, overseeing the development of the MCAS (Massachusetts Comprehensive Assessment System) standardized math tests required by federal and state law for all public school students in grades 3-8 and 10

Biographical Sketch

I have a B.S. in mathematics from the University of Chicago (I'm originally from Chicago), where I met my husband, Marc Kastner. We've been married more than 50 years and have two daughters, Sonia and Julia. Everyone in the family has a connection to Harvard. Before Marc became professor of physics, then department head of the Physics Department, and then dean of the School of Science at MIT, he was a post-doctoral fellow at Harvard in what was then called the Division of Applied Sciences (where I was simultaneously a graduate student). Sonia was an undergraduate at Harvard, and Julia has an MBA from Harvard Business School. Sonia lives and works in San Francisco. Julia lives and works in Philadelphia and is getting married this summer.

I retired in 2008, and Marc retired from MIT in 2015. After he retired, Marc was offered a job to start a new organization called the Science Philanthropy Alliance and to become its president. The mission of the Alliance is to advise wealthy philanthropists and foundations on how to support basic science research. He was told that he could stay in Boston to start the organization, but several people advised him to start it in Silicon Valley because "that's where the money is." So in March 2015, we moved to Silicon Valley in the San Francisco Bay area to try it out. We very quickly decided to move here permanently, since our daughter Sonia lives in San Francisco, we have many friends in the Bay area, there's no snow (!), and Marc's work was going well. So we sold our house in Newton, MA, and bought a house in Los Altos Hills, CA, where we now reside.

After I retired I wrote a book on math testing, based on my experience at my last job. Since then I've been busy overseeing renovations on our new house, taking adult education courses, attending exercise classes, and getting involved with art museums.

In August 2014 we went to Amsterdam for vacation and were able to visit Frits Schoute (Ho student and my officemate at Harvard) and his wife Marietje at their home in a town outside Amsterdam. Here is a photo of Frits and me at his house:

Michael Larson (1996)

Seagrass Advisors / Northwest Quant Services / Jockalytics
larsonmichael@gmail.com

Life post-DAS has taken me from Cambridge to Chicago to Seattle to Minneapolis and back to Seattle again, where I live with my wife Kirstin (Harvard '93), son Anders (age 13), daughter Sonja (age 11), and dog Ruby (age 4). Kirstin is an attorney representing clients on intellectual property, trademark and copyright matters. The kids are active in sports and all kinds of teen and pre-teen activities. As a family, whenever possible we enjoy escaping to the mountains to hike or ski, and to the ocean to explore tide pools and mess around.

Professionally, I've been fortunate over the years to have had the opportunity to work with some extraordinary people on a range of challenging mathematical problems in both the financial and retail industries.

In 2000, as the dot-com bubble was bursting, I shocked friends and family by making the seemingly irrational decision to head west to a company notorious for its inability to generate a profit. I joined Amazon as a founding member of its strategic planning & optimization team, a data science swat team responsible for constructing many of the mathematical models that drive Amazon's operational processes. Armed with my DEDS toolkit, I had the opportunity to lead early efforts to quantify the relationships between Amazon's strategic business objectives and underlying supply chain economics through application of stochastic optimization techniques and associated performance analytics. It was an all-out battle to reduce fulfillment costs, while improving product availability, customer conversion and shipping performance. And I had a blast along the way. Side note, for those who have read Brad Stone's *The Everything Store: Jeff Bezos and the Age of Amazon*, these DEDS-inspired algorithms were the same ones credited with being Amazon's "secret weapon" during its initial drive to profitability.

A few years later, an impulsive sketch that I had concocted for a new, highly-scalable, real-time price management solution (competitor reconnaissance and algorithmic response) somehow managed to make its way into Bezos' hands without my knowledge. Next thing you know, I found myself with a new boss and was off to the races again - this time tasked with convincing the global retail organization that they should trust the website's prices to a math guy from operations. With the help of a great team, the system became a reality (and even managed to trigger a bit of an earthquake in the retail world the day we "flipped the switch"). At any rate, I'm happy to report that Amazon still uses this tool to manage all of its pricing decisions.

I absolutely loved the time I spent at Amazon: unbelievably fun and exciting – and admittedly a bit exhausting as well. After leaving Amazon, I worked for a couple of large hedge funds before deciding to strike out on my own. Fast forward and the result is three companies that I currently run (either independently or together with some of my Amazon friends):

1. Seagrass Advisors – Investment company specializing in algorithmic trading strategies tailored to the needs of individual investors.
2. Jockalytics – Sports gaming analytics and technology platform. Our initial product (a fantasy sports marketplace) is scheduled to launch later this

summer in time for the NFL season.

3. Northwest Quant Services – Data science and analytics consulting firm dedicated to helping clients leverage their data assets in order to achieve meaningful operational improvements and performance optimization.

Between these three ventures and countless adventures around the house, there rarely is a dull day anymore.

My professional journey since leaving Cambridge has been directly influenced by a passion for stochastic optimization and the associated thrill of constantly chasing and tackling the next unsolved problem. To that end, I am especially grateful to Professor Ho and all of my DEDS friends for everything I learned 20+ years ago in Pierce Hall. I'm really looking forward to having a chance to catch up with everyone in July!

Contact info:
Jonathan Lee

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ABSTRACT

After graduating from the group in 2002, I joined the U.S. DOT, Volpe Center. During my first few years at Volpe, I supported research projects across several transportation modes. I then turned my focus to air traffic control and management research, supporting FAA and NASA. Currently, I am the manager of a small division which focuses on aircraft wake turbulence and weather research. Our work on aircraft wakes have enabled reduced separation between aircraft during arrival and departure. The reduced separation has resulted in significant operational efficiency gain at many major airports in the U.S. and millions of dollars in fuel savings per month to the air carriers.

BIOGRAPHY

Jonathan T. Lee joined the Volpe National Transportation Systems Center, in 2002, as an operations research analyst. He has been the chief of the Aircraft Wake and Weather Division since 2012. Prior to that, Lee was a project leader in air traffic control concepts and systems, working on projects sponsored by the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA). His area of research includes air traffic management (ATM) concepts and systems research and development; human-system integration; National Airspace System (NAS) modeling, simulation and optimization; and performance evaluation and assessment of the NAS. Some of the projects he has been involved in include the FAA mid-term NextGen En Route Workstation Project, FAA Tailored Arrivals Project, FAA Staffed NextGen Tower Project, the NASA NextGen ATM-Airportal Project, NASA Virtual Airspace Modeling and Simulation Project, and the NASA Detroit Deicing Decision Support Tool Project. He holds a patent on modeling deicing process on airport surface.

Lee holds a Ph.D. and A.M. in applied mathematics from Harvard University and a B.S. in mathematics from Rensselaer Polytechnic Institute. His graduate work focused on modeling, simulation, and optimization of complex systems.

PERSONAL MESSAGE

I have caused many a gray hair to Professor Ho while I was studying at Harvard. If it's not for Professor Ho, I probably wouldn't have graduated. Despite the difficulties, Professor has always been a trusted advocate and advisor to me, in my academic, professional, and personal life. Professor, thank you for everything that you have done for me!

Digital Twin for Smart System

Loo Hay Lee

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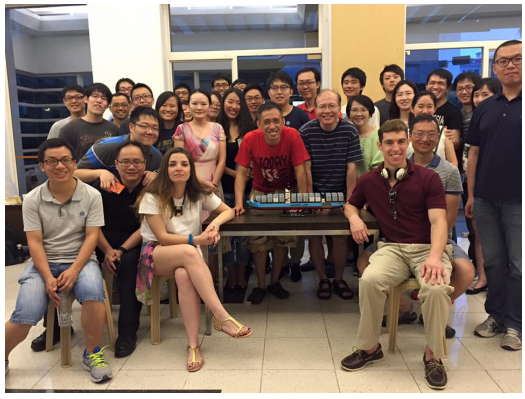
ABSTRACT

My research has been focuses on simulation optimization and logistics and supply chain systems. These years, working with my research team, we have built a framework of simulation optimization (O2DES), which consists of event scheduling modules, and various simulation optimization tools such as stochastics optimization algorithm and OCBA algorithm. We have successfully used this framework to develop various models for different industries to solve their planning, operation and design issues.

Last year, Singapore government has come out with Industry Transformation Map (ITM) for various industry sectors. One of the main theme of the ITM is on digitization. We have been engaged by various government agencies such as Economic Development Board (EDB), Maritime Port Authority (MPA) to help companies in preparing themselves in this ITM roadmap, in particular, we are asked to develop digital twins systems (simulation models) for the smart warehouse systems and smart port system. We plan to use O2DES to develop these systems.

To work on these problems, we have set up two research centers: Center of Excellence for Modeling and Simulation for Next Generation Port (C4NGP) and Center for Next Generation Logistics (C4NGL), and have secured research funding around 21 million Singapore dollar (about 15 million USD). We aim to hire 40 full time staff to work for these two centers to develop the digital twin systems.



BIOGRAPHICAL SKETCH

I am currently an Associate Professor in the Department of Industrial Engineering and Management, and the program director for Master of Science in Supply Chain Management, the director for C4NGL and co-director for C4NGP.

I am married with two kids. My elder daughter Hannah (17 years old) is currently studying architecture in Singapore Polytechnic, and my son Jeremy (15 years old) is currently in secondary school. Each year, we have a family trip and December last year (2017), we went to Iceland, and have manage to view the northern light, and I even brought my two kids for snorkeling at Silfra (the underwater gap between Europe and America Continents).

I have been active in serving as a volunteer police officer with a rank of Sargent(2). This is one of the best achievement that I have – to overcome my physical weakness to be qualified as a police officer.

Besides this, I also pick up sports such as cycling and running, riding motorbike, and start to learn to play guitar. Even though I am about to enter into 50th. I am still enjoying all the activities that I am involved and continued to learn new things. In summary, I felt that life is full of excitement. This is what I have learned from Professor Ho, “never too late to learn”.

2018 Harvard Control Workshop

Les Servi ‘81

Personal update

Wife: Part-time Radiologist

Son: A VP banker structuring loans, getting married 2019.
Daughter: Phd. Mech Engineering (MIT) working for small research company

Me:

Latest hobby: Learning to play pool

MITRE:

Running Decision Analytics group at MITRE

Cyber Analytics project

Heath Analytics project

Papers

First

Highest cited

Favorite

Coolest

Most unappreciated

Most complicated

Simplest

Ties to oldest previous work

First paper:

A class of center-free resource allocation algorithm. with Ho and Suri. 1981. 73 citations.
Idea: Can coordinate resources allocation in a completely decentralized manner

Highest cited paper:

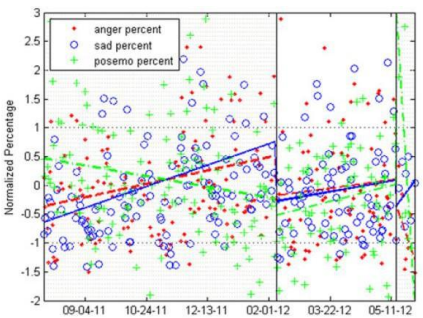
M/M/1 queues with working vacations. with Finn. 2002. 408 citations.
Idea: Inventing a new class of problems more important than contributing to an older class of problems

Favorite paper:

Nested square roots of 2. 2003. 32 citations.
Idea: Not all formulae for pi are known.

Coolest paper (and patent):

Analyzing social media data having discontinuous underlying dynamics. 2013. 6 citation
Idea: Dynamics of moods can be modeled



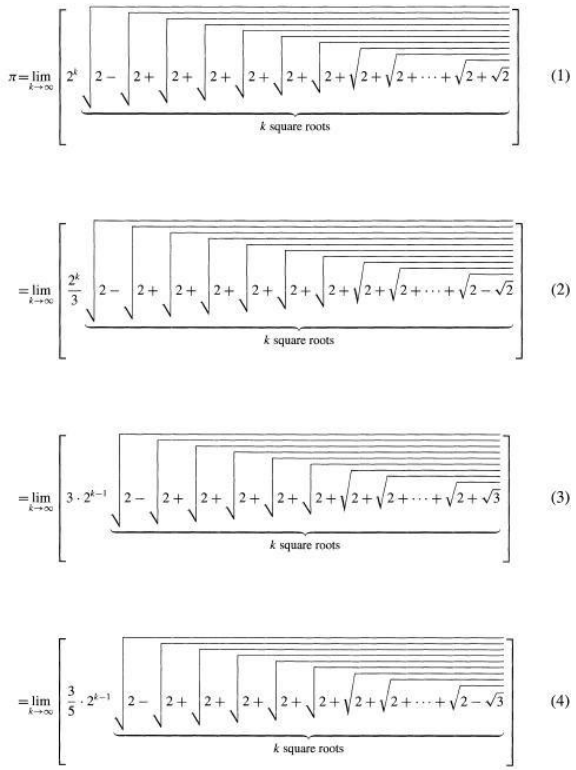


Fig. 2. Mood shift analysis of the Twitter messages showing a breakpc
2/6/2012 and 5/14/2012.

Most unappreciated papers :

see above and
A two-point Markov chain boundary-value problem. with Daley. 1993. 16 citations.
Idea: One can infer queue lengths from transactional data by solving a simple boundary value problem.

Most complicated proof:

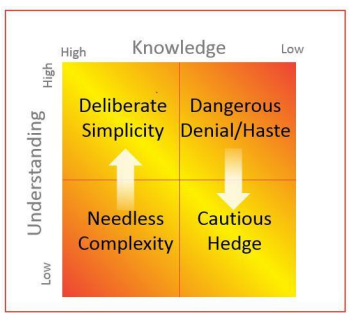
Oscillating random walk models for GI/G/1 vacation systems with Bernoulli Schedules. with Keilson. 1986 citations252.
Idea: Waiting time of some queueing systems is the independent summation of two easilyunderstood components.

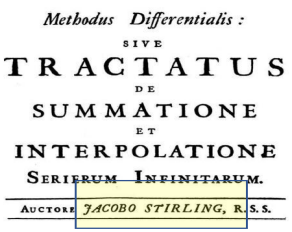
Simplest paper: A Modeling Model 2017 citations 0.

Idea: There are broad categories of good and bad models

Ties to oldest previous work*:*
The Distributional Form of Little's Law and the Fuhrmann-Cooper Decomposition. 1988. citations 73. With Keilson.

Idea: Little Law L W can be generalized to distributions.




Methodus Differentialis :
SIVE
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ET
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SERIERUM INFINITARUM.
AUCTORE JACOBO STIRLING, R.S.S.

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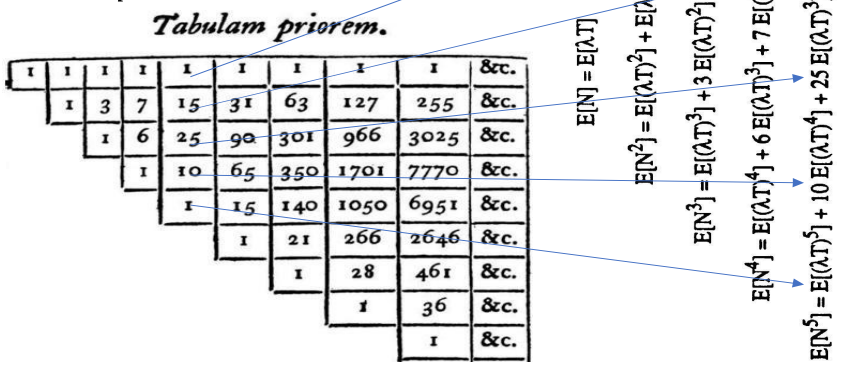

Distributed Decision Making in Networked Systems

Na Li

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ABSTRACT

Recent radical evolution in distributed sensing, computation, communication, and actuation has fostered the emergence of cyber-physical network systems. Examples cut across a broad spectrum of engineering and societal fields such as power grids, swarm robotics, air/ground transportation systems, green buildings, and other societal networks. Regardless of the specific application, one central goal is to shape the network collective behavior through the design of admissible local decision-making algorithms. This is nontrivial especially due to the challenges placed by the local connectivity, imperfect communication, time-varying uncertainty, and the complex intertwined physics and human interactions. I have been worked on formally advancing the systematic design in distributed coordination in network systems. My group investigates the fundamental performance limit placed by the various challenges, design fast, efficient, and scalable algorithms to achieve (or approximate) these performance limits, and test and implement the algorithms on real-world applications, in particular energy networks. The long-term goal is to integrate mathematical, engineering, and economic approaches to develop distributed coordination rules to ensure high-performance and high-confidence operation of various networked systems, which will ultimately improve the sustainability of our society.

BIOGRAPHICAL SKETCH

Na Li is currently the Thomas D. Cabot Associate Professor of Electrical Engineering and Applied Mathematics at Harvard University where she joined as an assistant professor in 2014. She received her B.S. degree in Mathematics in Zhejiang University in 2007 and PhD degree in Control and Dynamical systems from California Institute of Technology in 2013. She was a postdoctoral associate of the Laboratory for Information and Decision Systems at Massachusetts Institute of Technology 2013-2014. Her research lies in distributed optimization and control of cyber-physical networked systems. She received NSF career award (2016) and AFSOR Young Investigator Award (2017), the Best Student Paper Award finalist in the 2011 IEEE Conference on Decision and Control. She received NSF career award (2016) and AFSOR Young Investigator Award (2017), Harvard Climate Change Solution Award (2018), and the Best Student Paper Award finalist in the 2011 CDC. She has served on IEEE CSS Conference Editorial Board (CEB) since 2016, was a guest editor of one special issue of f IET Generation Transmission & Distribution, and has been in the Program Committees of several conferences and workshops.

On the personal side, Na Li and her husband, Pengcheng Luo, live in Cambridge with their 4-year-old daughter, Sheryl Luo, and 1-year-old son, Kevin Luo.

With family on Christmas Eve of 2017.

With family on June 2018

Automated Driving and Smart System Development – Insight from a Tool Supplier

Xiaocang Lin, Ph.D.

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2 Jackson Road, Sherborn, MA 01770

ABSTRACT

We have seen a significant breakthrough in recent years in automated driving system and other smart system development. MathWorks is a premier software supplier that provides scientific computing and industrial development software to various players in this domain. We are exploring from a tool supplier's angle that how these tools have and will continue to help driving this monumental engineering advance.

BIOGRAPHICAL SKETCH

Dr. Xiaocang Lin graduated from Harvard University with a Ph.D. in Engineering Science in 2000. He has worked in MathWorks since 2001. He is currently a director of software development in charge of multiple development areas in embedded code generation and model verification and validation areas.

Dr. Lin lives in Sherborn MA with his wife and two daughters. In his spare time, he enjoys traveling, hiking, gardening, and reading.

Optimization in Logistics

Zhen Lu (镇璐)

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http://my.shu.edu.cn/Index.aspx?TID=272

ABSTRACT

Give an update or summary of your research or work. If you are not working or have retired, you can talk about what you did before or what you have enjoyed doing recently, or anything you would like to share with this group.

I mainly used some methodologies such as operations research, simulation techniques to perform some studies on the operations management in logistic service and manufacturing companies.
(1) Port operations: I proposed a series of mixed-integer programming models as well as some solution methods for the berth allocation, quay crane assignment, yard storage area allocation problems in container terminals.
(2) Maritime logistics: I proposed some decision models and policies for deciding the optimal refueling ports, port visiting sequence, waste disposal ports for maritime ships so as to reduce the operation cost.
(3) Supply chain optimization: I mainly focused on optimizing the facility location, scale decision, as well as the transportations among the facilities.

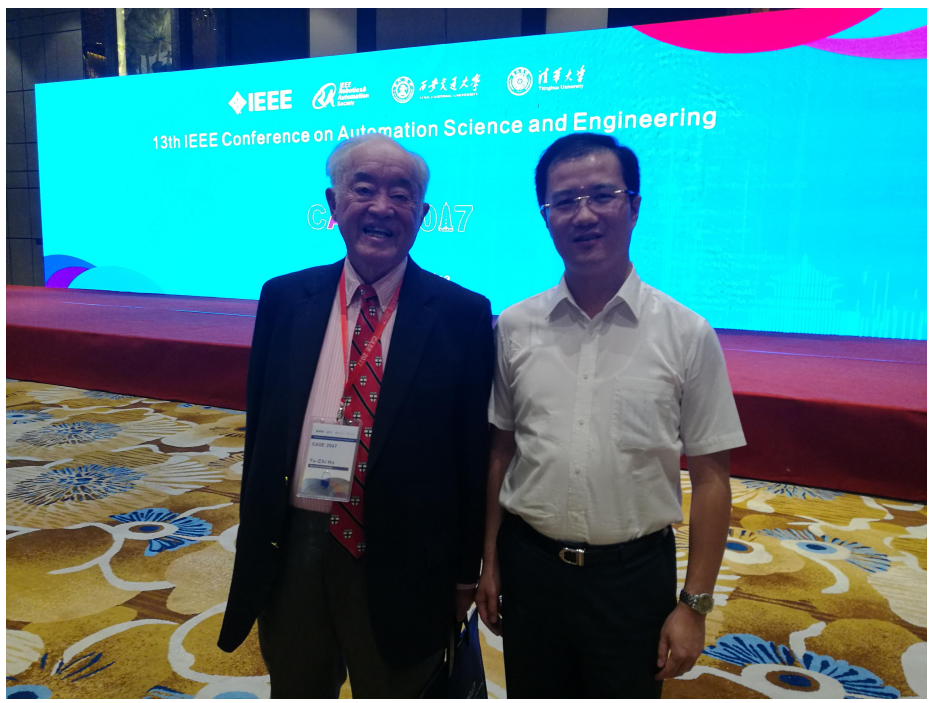
BIOGRAPHICAL SKETCH

Give an update of yourself. You are also welcome to give an update about your family, such as your kids or so.

I am now a Professor and a Vice Dean in School of Management, Shanghai University, Shanghai, China. I obtained the B.E. and Ph.D. degrees from Shanghai Jiao Tong University in 2003 and 2008, respectively. Then I worked as a Post-Doctoral Research Fellow in National University of Singapore from 2008 to 2010; Prof. Lee Loo Hay is my supervisor during my working at NUS. Since 2011, I have been working at the Department of Management Science and Engineering, School of Management, Shanghai University. My research interests include port operations, maritime logistics, supply chain management, and knowledge management. He has published more than 50 papers on some reputable journals such as *Transportation Science*, *Transportation Research Part B*, *Naval Research Logistics* and *European Journal of Operational Research*. He serves as an Associate Editor of *IMA Journal of Management Mathematics*, *Asia-Pacific Journal of Operational Research*, *Journal of Industrial and Production Engineering*, etc.

I have one boy, 6 years old. In this September, he will enter a primary school, where my wife is working as a Chinese teacher.

Having dinner with Prof. Lee Loo Hay and Dr. Bao Jie, who introduced me to Prof. Lee



Meeting Prof. Ho for the first time at Xi An.

Fundamental and Complete Resolution of Mixed-Binary Linear Programming Problems

Peter B. Luh, Mikhail Bragin and Bing Yan

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ABSTRACT

Mixed-Binary Linear Programming (MBLP) problems involve binary and continuous decision variables with linear constraints and objective functions, and are prevalent in applications, e.g., power system unit commitment and economic dispatch. Since derivatives of an objective function with respect to binary decision variables do not exist, there is no necessary optimality condition. As a result, partial enumeration of binary variables is generally needed, and the complexity to obtain an optimal solution increases exponentially as the problem size increases, limiting the sizes of problems or quality of solutions. In this talk, a fundamental and complete resolution of such problems for near-optimal solutions with quantifiable quality in a computationally efficient way is presented, using unit commitment and economic dispatch of power systems as the problem context. The novelties include (1) a decomposition framework to exploit the exponential reduction of complexity upon decomposition; (2) an innovative and systematic way to tighten subproblem formulations offline, noting that if the convex hull of a subproblem can be directly delineated by its constraints, then the subproblem can be solved by using linear programming methods without much complexity; and (3) the novel "Surrogate Absolute Value Lagrangian Relaxation" (SAVLR) method that overcomes all major difficulties of traditional Lagrangian relaxation for very effective coordination of subproblem solutions while providing lower bounds to quantify solution quality. Numerical testing demonstrates superior performance of the approach, and points a brand new way to formulate and solve practical MBLP problems.

BIOGRAPHICAL SKETCH

Peter B. Luh received his B.S. from National Taiwan University, M.S. from M.I.T., and Ph.D. from Harvard University. He has been with the University of Connecticut since 1980, and currently is a Board of Trustees Distinguished Professor and the SNET Professor of Communications & Information Technologies. He is also a member of the Chair Professors Group, Center for Intelligent and Networked Systems (CFINS) in the Department of Automation, Tsinghua University, Beijing, China; and a member of the Short-Term Thousand-Talent Program, the State Key Laboratory of Synthetical Automation for Process Industry, Northeastern University, Shenyang, China. Professor Luh is a Life Fellow of IEEE, and the Chair of IEEE TAB Periodicals Committee for the 2018-19 term, overseeing 200 IEEE journals and magazines from cradle to grave. He was the VP of Publications of IEEE Robotics and Automation Society (RAS, 2008-2011), the founding Editor-in-Chief of the IEEE Transactions on Automation Science and Engineering (2003-2007), and the Editor-in-Chief of IEEE

Transactions on Robotics and Automation (1999-2003). He was also the Founding Chair of the Steering Committee of the IEEE Conference on Automation Science and Engineering (2006-2011). His research interests include smart grid, intelligent manufacturing, and energy-smart and safe buildings. He received RAS 2013 Pioneer Award and 2017 George Saridis Leadership Award.

The Theory of Personalized-X: analysis and operation of data-poor dynamics rich systems

Giulia Pedrielli,

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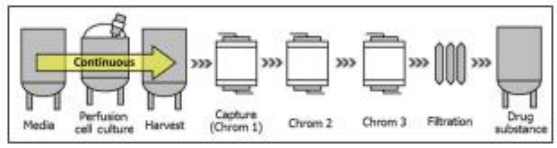
web: https://cidse.engineering.asu.edu/directory/pedrielli-giulia/

ABSTRACT

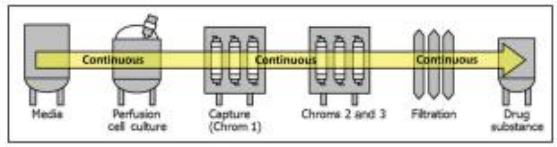
Recent Technologies are enabling "on-demand" complex (Personalized) systems. Design and oper- ate them robustly is a substantial problem since the time for planning-design-scheduling-operation is dramatically reduced. Personalized systems can adapt to different scenarios/users, examples are personalized-robotics (e.g., self-driven cars, shoe manufacturing), personalized-marketing (e.g., advertisement), personalized-homes (e.g., Google home, Amazon echo), personalized-medicine (e.g., gene therapy, car-T). Despite the technology enabled potential, these systems are far from being robust and scalable. Two main classes of personalized-X arise in the scope of this proposal:
(1) data rich with simple dynamics, (2) data poor with complex dynamics. This proposal looks into the second class of systems, focusing on personalized medicine, and it proves that techniques for simulation and optimization need to fundamentally advance in aspects of modeling, analysis and control in order to become amenable to personalized-X. Specifically, models should be adopted seamlessly for planning, scheduling and control due to the fact that personalized-X are created and controlled in a very short horizon. My research faces these challenges with the following objec- tives: (1) advancing simulation formalisms to embed control and proving the relationship with tra- ditional simulation languages; (2) derive structural properties for complex systems based upon the languages in (1) by using and extending results from graph theory thus bringing together formal methods and operations research; (3) shift the optimization paradigm from best approximation, to best optimization with the wrong model, thus extending the fields of simulation-optimization. Concurrent simulation-analysis-and optimization leads to the education objective of this proposal: training students to understand the inherent implications of optimization into simulation model- ing and how techniques in formal methods and operations research need to grow hand to hand to achieve optimization of complex systems.

1 Background and Motivation

We look into the future Bio-manufacturing, within the Bio-pharmaceutical industry, as a type of Personalized - X system. The pharmaceutical industry has recently witnessed major breakthroughs at manufacturing level, with the introduction of disposable and single use equipment, as well as at medical level, with the recent discoveries on cell therapy. We argue that the



(a) Continuous upstream process with perfusion, with batch downstream.



(b) Continuous Integrated fully continuous.

Figure 1: Continuous manufacturing scenarios (source: [1])

bio-manufacturing systems of the future are Personalized-X and new techniques should support the design scheduling and operation of these systems at the same time. We focus on the contribution that operations research can give in the advancement of bio-manufacturing in the attempt to solve the design and operation challenges of *disposable and single use systems*, within the scenario of personalized cancer care.**Single use and disposable systems** Bio-manufacturing in undergoing the revolution of continuous and single use processes. Traditional tools for sequential design and operation of bio-systems have little to contribute in scenarios of *continuous manufacturing* (CM), *single-use*, and *disposable technologies*. Continuous manufacturing implementation in the down-stream process is still a challenge due to the unpredictability of biological processes as opposed to chemical reactions in petrochemical applications. Four scenarios are depicted for possible evolutions of continuous manufacturing in [1]. Challenges remain in understanding the advantage of hybrid (e.g., Fig. 1(a)) and fully continuous architectures (Fig. 1(b)). However, [1] does not consider the impact of disposable or single-use technologies. This aspect has been recently discussed in [2] that highlights how "*with the introduction of single-use systems, continuous processing offers an attractive alternative to batch processing in terms of facility footprint and space-time yield*". This is due to the fact that single use technologies allow for smaller batches, smaller preparations (buffers), reduced cleaning, thus remarkably shortening the production lead time. However, several operational challenges unfold from the opportunity to produce simultaneously mutliple products. *While continuous manufacturing scenarios have been investigated, the impact of single-use technology in the several hybrid solutions appear to be a substantially unanswered problem. This impacts the study and generation of dynamic and adaptive manufacturing architectures for the productions of the future.*

CAR T Therapy CAR T-cell therapy is a type of cancer immunotherapy that works with your immune system by using the patient T cells (or fighter cells). Since most CAR T cell therapies use a person own cells to create cancer-fighting cells, each therapy is personalized. In sum, CAR T cells are generated by removing T cells from a patient's blood and engineering the cells to express the chimeric antigen receptor, which reprograms the T cells to target tumor cells. While science progresses at fast pace, the manufacturing of clinical-grade CAR-T cells as performed under cur- rent good manufacturing procedure (cGMP) represents, at the current moment, the most critical bottleneck for the wide implementation of this promising therapeutic modality.

While the methods proposed in my research do not intend to replace small scale testing, we argue the *simulation and analysis of synthetic data* can help in driving discovery of manufacturing solutions as a preliminary analysis to lab-based testing. Also, the same methods can enhance analysis and operations of technological solutions adopted. In other words, *advancing modeling and optimization to address challenges of personalized production can boost the path to discovery of novel manufacturing solutions for this family of therapies that are witnessing increasing demand from the research and academic field as well as from the general public*.

2 Foundation and Theory for Personalized-X

Through my research, I am developing the required theory and methods to assess and allow the efficient design and operations of Personalized-X Systems, with a particular focus in Bio-Pharmaceutical disposable and single use techs for personalized medicine as described in section 1. As demonstrated in [3, 4], there is a fundamental need to bring together simulation modeling and analysis.

This approach allows to enhance efficiency of both approaches leading to novel results and methods for analysis methodology.

The goal of this research is to advance simulation based optimization in order to enable effective modeling, analysis and operations of personalized-X systems by means of (1) a novel simulation language, (2) an analytical framework to derive properties of instances of models developed according to (1), and (3) an optimization architecture able to handle and effectively use models that are mismatched with respect to the real system to make quick decisions. In order to develop these three components, we need to understand which modeling aspects need to be integrated in simulation, which tools need to be developed in order to characterize and simplify those augmented, *bright* simulators, and how these and the related properties can be use effectively to enhance operations of real systems, through action and information feedback.

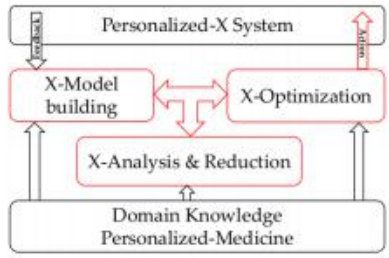


Figure 2: Research Main Components Interaction.

3 Biographical Sketch

Giulia Pedrielli is currently Assistant Professor for the School of Computing Informatics System Design Systems Engineering in Arizona State University. She was Postdoctoral student at National University of Singaporeunder the mentoring of Professor Lee Loo Hay. She develops her research in stochastic methods for performance evaluation and simulation based optimization of complex systems. She is focusing on real time control problems and how to extend simulation based algorithms in this context. Her applications range from manufacturing to logistics and health care.

Figure 3: Fun activities during the semester.

Highlights: I have graduated my first 3 master students this semester, and I am developing a game to introduce DES in high-school. I went to George Mason to give an invited seminar and explored DC with Professor Chen!

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[4] Christos G Cassandras and Stephane Lafortune. *Introduction to discrete eventsystems*. Springer Science & Business Media, 2009.

An Evolving Career Journey of Working with Systems

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INTRODUCTION

I was Yu-Chi "Larry" Ho's eighth student, as measured by when I completed my Ph.D. requirements. At this point, I am more or less retired except for speaking about and marketing a book I wrote with my daughter, Jennifer Poage, called, *Flair: Design Your Daily Work, Products, and Services to Energize Customers, Colleagues, and Audiences*. So, my talk is a look back at my career path and major lessons learned along the way.

ABSTRACT

My Ph.D. course work was in optimal control theory and my thesis in pattern recognition. This gave me a firm background in systems and uncertainty. I gradually evolved from working on technology systems to taking a broad systems view of all the success factors for technology to not only result from successful research and development, but also what leads to successful adoption, implementation, and use. Successful technical applications involve: (1) the technology itself; (2) human issues of users and stakeholders, and (3) business issues of the technology's viability to provide value. This includes examining such topics as the technology, users, stakeholders and decision-makers, producibility, business practices and culture affecting its use, and external influences such as economic, political, and environment issues.

This career journey led to a range of research and applications:

- Develop methods to assess technical risks to successfully design a system.
- Design Project Portfolio Management processes to manage a set of multiple research projects.
- Methods to conduct benefit assessments that address all stakeholders.
- Develop performance measures for the technology to manage its development.
- Develop methods to integrate technology design and Human Factor analysis so that the technology and users perform their integrated work seamlessly.

I not only developed techniques to perform these studies and applied them, but I was able to teach short courses, publish papers, and speak to groups and conferences. What excites me is concepts and how to make them useful.

Most of my work over the past twenty-five years was on future concepts for Air Traffic Control. I worked on projects sponsored by the FAA and NASA, and I

worked on teams from the Volpe Center (US Department of Transportation), Georgia Tech University, San Jose State University, BAE Systems, Saab Sensis, and Engility. The variety of the work was a major factor in holding my interest throughout my career.

Fourteen years ago, at age 60, I took retirement from the federal government and began to work as an independent consultant. A few years ago, Congress passed sequestration that heavily cut funds for government research. Thereafter, FAA and NASA limited their research to Air Traffic Control improvements that could be implemented in 2 or 3 years and stopped longer term research. The firms I subcontracted with went out of business or changed their direction. My work had dried up, but the timing was okay since I was now 70.

Lucky for me, I had become interested in how to excite my audiences about my work so they were more likely to adopt my results. I had been exposed to storytelling in business and realized I could structure my work to tell a story of how it worked and how it provided benefits. This skill became a great asset in marketing my consulting work. I also realized I could "sell" my skills and results by creating experiences of using my output.

My daughter, Jennifer Poage, worked in fashion design, and she needs to put excitement into her designs every day. We decided to write a book about how to design your work output and the presentation of your work to excite audience's heads and hearts. After 1½ years of research and writing, *Flair: Design Your Daily Work, Products, and Services to Energize Customers, Colleagues, and Audience* was published by Maven House Press in March 2016.

I refer to my career as working in soft systems. I say that one cannot be as precise as in technical systems, but one can, and should, develop and use structured processes.

BIOGRAPHICAL SKETCH

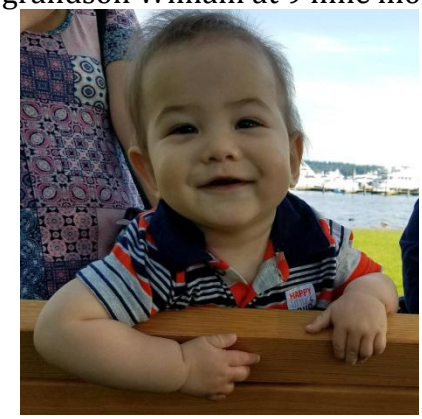
Throughout my career, I followed lessons I learned from Larry: develop a deep understanding of a problem and its solution; begin with understanding and solving a real-world problem and then generalize the approach you developed to other problems; and do both a good technical job and a good job communicating your work (without both of these, you work will not likely have an impact). My understanding of these lessons continued to grow the longer I worked. Another piece of advice from Larry that I now realized I followed is to fall in love with, and marry, an exceptional spouse (thank you Joanne).

My residence and home office is in Lexington, Mass. I have only owned one house as did Larry, and I had one long-term employer (as did Larry) but I also worked on my own for a dozen years.

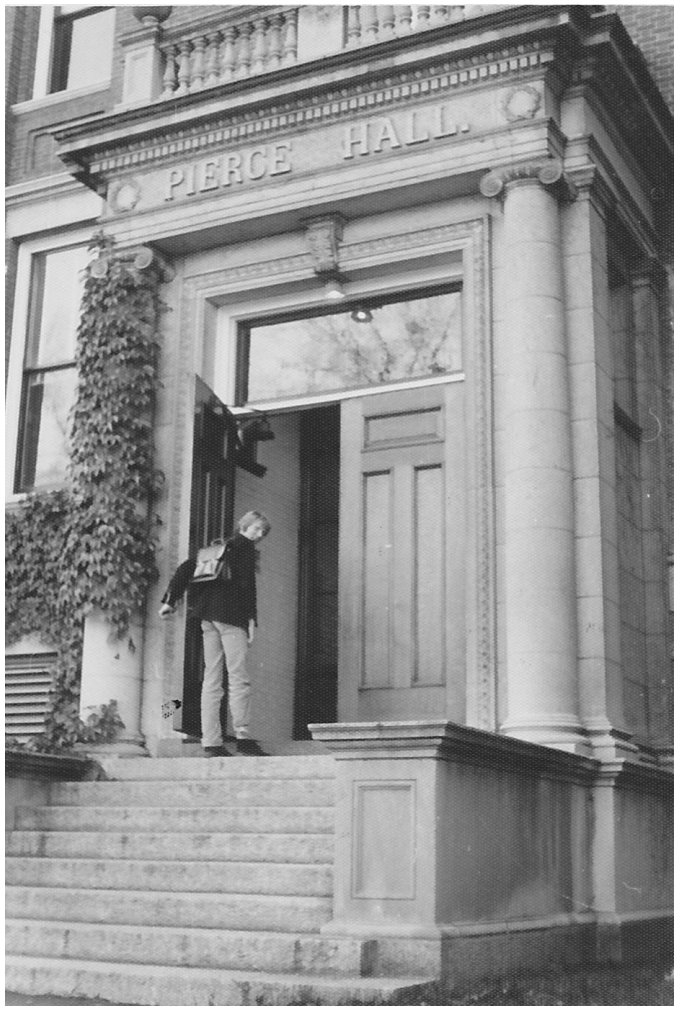
My spouse, Joanne, is retired from a career as a reference librarian. Most recently she was Head of Reference at the Bedford Free Library here in the Boston area. My daughter graduated in art history from Drew University, obtained a fashion design degree from Parsons School of Design, worked designing sportswear for

Reebok, studied for a Masters in Fashion Design Management at the London College of Fashion, and is now pursuing a Ph.D. from the same school researching how to bring together the fashion industry, the medical field, new technology, and persons with disabilities to collaboratively design clothing for persons with disabilities. My son Jeff is currently the Assistant Manager at the Lids Locker Room store in the nearby Burlington Mall. He previously worked at the Reebok corporate store at their headquarters and was part of management at a New Balance store. My youngest son, Jonathon, completed a B.S. in physics at University of Chicago and a Ph.D. in physics at Tufts University. After working for a while at Volpe Center in Kendall Square, he and his spouse, Nhu-Y Le, moved to the Seattle area where Y (which is pronounced as a long e) is an immigration attorney with Microsoft. They had our first grandchild last September, and Jon is taking time currently to be with William.

My grandson William at 9 nine months:



I keep up varied interests by belonging to Boston CHI (Computer-Human Interface), Harvard Alumni Entrepreneurs, Harvardwood, the Harvard Business School Association of Boston, and the Crimson Consulting Collaborative. This next year, I will conduct a workshop in how to be creative at the First Parish Unitarian Universalist Church of Lexington. I continue to write and have even taken up writing poetry.



1974 Frits Schoute arriving at Pierce Hall

Glad I made switch in 1st year to Larry Ho

Resulted in thesis

1977

Decentralized Control in Computer Communication

Eldest daughter of Frits and Marietje witnessed writing of thesis at Peabody Terrace

and the whole Internet (r)evolution

she is now 42 years and at Cambridge University (UK)

United States Patent [19]

Schoute

[11] **4,398,289**

[45] **Aug. 9, 1983**

[54] **METHOD FOR THE TRANSMISSION OF DATA PACKETS**

[75] Inventor: **Frederik C. Schoute**, Hilversum, Netherlands

[73] Assignee: **U.S. Philips Corporation**, New York, N.Y.

[21] Appl. No.: **235,171**

[22] Filed: **Feb. 17, 1981**

[30] **Foreign Application Priority Data**

Feb. 15, 1980 [NL] Netherlands 8000941

[51] **Int. Cl.**[3] **H04J 3/02**

[52] **U.S. Cl.** **370/93**; 370/95; 370/94

[58] **Field of Search** 370/17, 19, 60, 89, 370/90, 91, 95, 96, 94, 92, 93

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,251,880 2/1981 Baugh et al. 370/94

Primary Examiner—Douglas W. Olms

Attorney, Agent, or Firm—James J. Cannon, Jr.

[57] **ABSTRACT**

Method for the transmission of data packets from a plurality of substations to a main station via a channel which they have in common, the main station transmitting a synchronizing signal which on reception in the substations indicates the beginning of a period which has been subdivided into a sequence of time slots of mutually equal lengths, those substations which have a data packet ready for transmission to the main station transmitting this packet to the main station in a time slot which was randomly selected from the said sequence of time slots, and the main station classifying the time slots as successful or mutilated depending on whether an unmutilated or a mutilated packet is received, in the main station the number of time slots of a next following period or frame being adapted on the basis of the detection of the number of successful and mutilated time slots and taking the conditional probabilities of the occurence of successful and mutilated time slots, given the number of substations transmitting in a time slot, into consideration.

2 Claims, 2 Drawing Figures

3D Printing and Optimization

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ABSTRACT

Give an update or summary of your research or work. If you are not working or have retired, you can talk about what you did before or what you have enjoyed doing recently, or anything you would like to share with this group.

According to the shape of the raw material, the 3D printing can be divided into four kinds: lamination, filament, powder and liquid. The filament based Fused Deposition Modeling (FDM) is the most common in recent years. Nevertheless, due to the high accuracy, the technology using ultra-violet (UV) light to cure the liquid resin play an important role in dental and aerospace areas. My work focuses on the photopolymerization process based on the Digital Light Processing (DLP) technology.

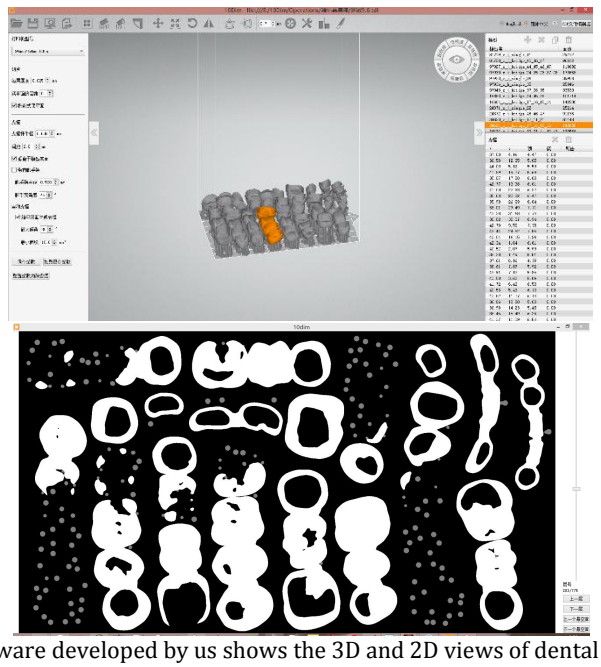

Fig. 1 The software developed by us shows the 3D and 2D views of dental crowns and bridges

Fig. 2. The mechanism, the 3D printer and the printed models

After slicing the digital 3D models into thin layers (Fig. 1), we get many high resolution bitmap images. The images are sent to a Digital Micro-mirror Device (DMD) and projected onto the surface of liquid resin. The DMD is an array of up to several millions of micro-mirrors which can be switched on and off independently, and each mirror corresponds to a pixel of the image (Fig. 2). The DLP printer uses an inexpensive high performance Light-Emitting Diodes (LED) as its light source. Exposure of the UV light cures the resin to form a layer. After one layer is completed, the build platform moves up to build the next layer. The process repeats until the whole models are built. This process is used to cure polymer only. In very recent years, it is extended to cure the slurry mixed up by polymer and ceramic power. After curing, we obtain a "green part". After we sinter the green part in an oven with high temperatures, we obtain dense and precise ceramic objects. This is a new and fast developing method for processing the ceramics. In Fig. 2, we show the mechanism and the 3D printer developed by us that can build ceramics.

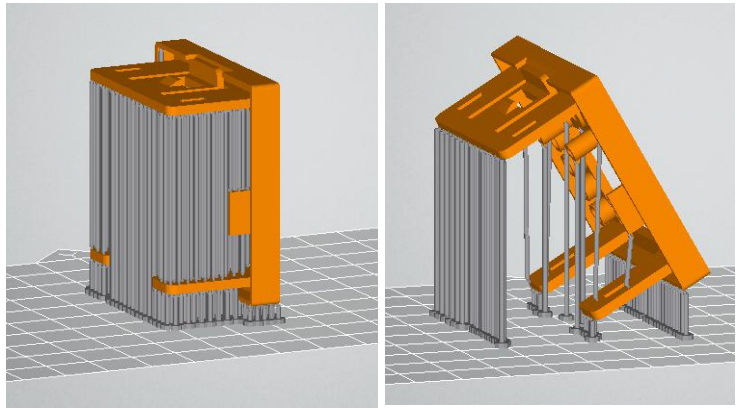

Fig. 3 Different orientation leads to different supports

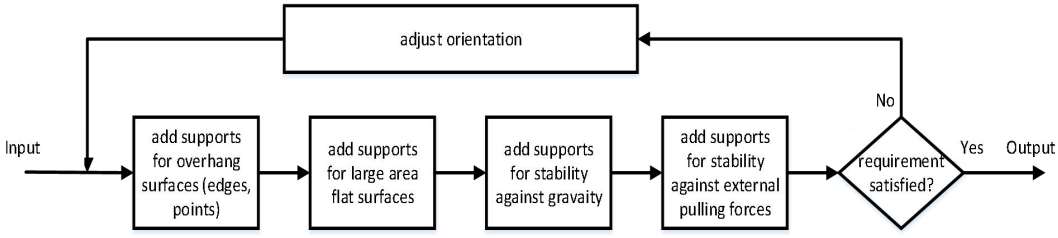

Fig. 4 A two level optimization problem, upper level for orientation and lower level for automatic support generation

The automatic support generation methods are indispensable for the DLP and the FDM 3D printing (Fig. 3). However, the automation level of these methods is not high and people need to set the orientation and adjust the supports manually. We model the automatic support generating problem as a two level parametric optimization problem. At the upper level we optimize the orientation. The objectives include the deformation, the model building time, the material quantity for the supports, and the surface quality. At the lower level, we check the conditions for various types of supports given an orientation, including supports for the overhang surfaces (overhang edges, overhang points), for the large flat surfaces, for the stability against the gravitational and external pulling forces when printing, and we generate supports with suitable shapes and density. We need to use the computer graphics and the image processing technologies to process the meshes, and batch evaluations of different orientations are necessary. These cause heavy computational burdens. Based on the Graphics Processing Unit (GPU), we employ the Genetic Algorithm (GA) and the Ordinal Optimization (OO) method to solve the problem, making good use of both the software and hardware technologies. The research can solve the automatic support generation problem systematically, can reduce or even eliminate human interventions, can reduce the failure possibility, and can raise the printing quality.

BIOGRAPHICAL SKETCH

Give an update of yourself. You are also welcome to give an update about your family, such as your kids or so.

Zhen Shen received his B. E. and Ph. D. in 2004 and 2009 respectively, both from Dept. of Automation, Tsinghua University. Now he is an associate professor at the State Key Laboratory for Intelligent Control and Management for Complex Systems, Chinese Academy of Sciences. His research interests are intelligent manufacturing and complex systems. He has authored about 30 referred journal and conference papers, and has applied about 20 patents with 9 authorized, with 1 PCT. He is a recipient of the 2005 “Outstanding Achievement Award” from United Technology Research Center (UTRC).

I am Prof. Ho’s truly last student with the number 53. I got married in the year 2014. My wife, Xuan Lu, received her B. E. from Dept. of Precision Instruments and Mechanical Engineering in 2007, and her M.E. from Institute of Electrical Engineering, Chinese Academy of Sciences in 2010. Now she is a senior engineer at China Nuclear Power Engineering Co., Ltd. We have a son named Yipan Shen born at Nov. 19, 2016.

Wedding photo

A retro style photo when my son is one full year old

Smart Factory: Manufacturing Execution Optimization

Leyuan Shi

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ABSTRACT

Many manufacturing firms use aggregated data to provide scheduling/decision solutions for handling their daily operations. Given the nature of shop floor operating in real-time, these average-based scheduling systems cannot be fully executed since unexpected events will almost always occur such as rush orders, design changes, machine breakdowns, defective parts, and delivery delays etc. Currently, shop-floor responds to unexpected events via manually scheduling or by Excel, which leads to poor predictability and visibility of performance, slow response to uncertainties and market changes, and low efficiency of their production and supply chain systems. In this talk, Manufacturing Execution Optimization (MEO) technologies developed by Dr. Shi and her team will be presented. MEO will enable the production system to be smart. By establishing top floor to shop floor communication in real time, manufacturing firms will be able to significantly improve their production and supply chain efficiency while achieving a faster response to changes and disturbances in the most time-optimal manner. MEO is developed based on Nested Partitions (NP) optimization framework.

BIOGRAPHICAL SKETCH

Professor in the Department of Industrial and Systems Engineering at University of Wisconsin-Madison and also the founding chair of the Department of Industrial Engineering and Management at Peking University of China. She received her Ph.D. in Applied Mathematics from Harvard University in 1992. Her research interests include simulation modeling and large-scale optimization with applications to operational planning and scheduling and digital supply chain management. She has developed a novel optimization framework, the Nested Partitions Method that has been applied to many large-scale and complex systems optimization problems. Her research work has been funded by NSF, NSFC, NIH, AFSOR, ONR, State of Wisconsin, and many private industrial companies and funding agencies with a total funding of more than 15 million dollars. Shi has published 3 books and more than 130 papers. She is currently serving as Editor for *IEEE Trans on Automation Science and Engineering* and had served on the editorial board for *Manufacturing & Service Operations Management* and *INFORMS Journal on Computing.* She was General Chair, co-Chair, and program committee for many national and international conferences. She is also one of the inventors for a set of digital tools including Manufacturing Execution Optimization (MEO), Maintenance Repair & Overhaul Optimization (MRO2), and Dynamic Manufacturing Critical-Path Time (DMCT). She is an IEEE Fellow.

Took my mother for a tour to celebrate hers 90th birthday!

A Systematic Optimization of Academic and Life Development

Jie Song

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The web link ：http://www2.coe.pku.edu.cn/faculty/songjie/

ABSTRACT

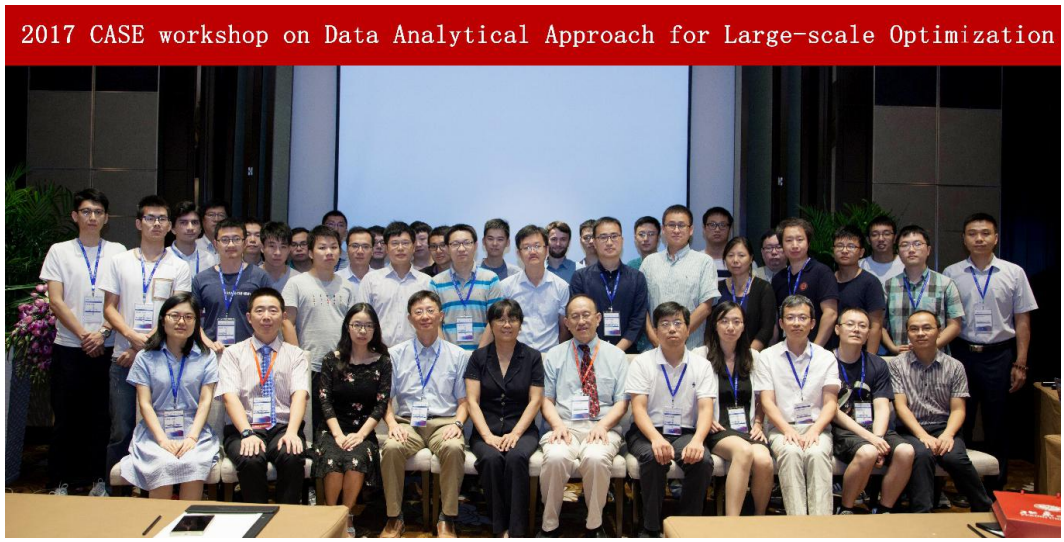
In service systems, as the development of Internet, both the demand behavior and system supply side become highly complex because of the information interaction, along with tremendous requirements in the functionality and quality of services, this arising the challenges both in the strategic and operational decision makings. My research goal is to develop novel methods/tools from an industrial engineering's perspective by sufficiently understand the dynamic nature of the complex service engineering system in an information-rich environment, and appropriately integrating online learning knowledge to make real-time decision with purpose to improve the efficiency and effectiveness of service engineering systems. My research has focused on the development of multi-fidelity stochastic models to support decision making under uncertainty, both on strategic and operational level in complex systems. Specifically, I have been conducting theoretic research on stochastic modeling and algorithm design with application domains in healthcare, energy management and public service delivery.

BIOGRAPHICAL SKETCH

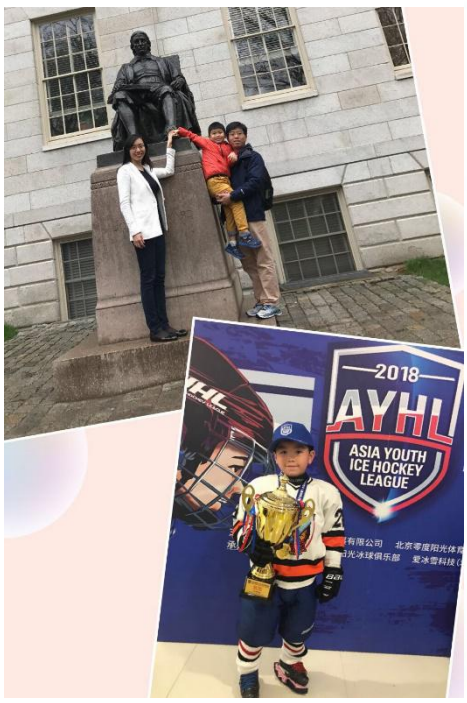
I am currently an associate professor with Department of Industrial and Management Engineering at Peking University, Beijing, China. I received the B.S. degree in applied mathematics from Peking University, China in 2004, and the Ph.D. degree in industrial engineering from Tsinghua University in 2010. During 2007 to 2008, I have been a research fellow in Georgia Institute of Technology. I joined Professor Leyuan Shi's group as post doctor in University of Wisconsin Madison since 2010. Luckily, I begin my academic career as assistant professor in 2012 in Peking University.

My career development has been deeply supported from Professor Ho's academic family. I have been working closely with Prof. Leyuan Shi, who always encourage me not only to do good research, but also trying to solve real problem. The research we have conducted in Peking University made significant impact in China, to support government's decision making. Because of this, I have been honored the Changjiang Youth Scholar Award by Ministry of Education in China. I had also been very lucky to get all kinds of support from Prof.Ho's academic family, like Professor Chun-Hung Chen , Professor Xiaohong Guan, as well as other great minds. I am the winner of the Best Paper Award of 2014 IEEE CASE, in which conference Prof. Peter Luh is the funding chair. My publications have appeared in many leading journals including Discrete Event Dynamic Systems: Theory and Applications, IEEE Automation Science and Engineering etc. I am currently is the Associate Editor of IEEE Automation Science and Engineering, Flexible Services and Manufacturing Journal, Asian Pacific Journal of Operations Research.

On the family side, my husband, Chao Lu who is a professor in Tsinghua University. We have an seven-year old son James Lu, who like playing Ice Hockey, and full of happiness.



Pictures in Xi'an in 2017 with Prof.Ho's academic family and friends



Pictures with my family

Pictures with Prof. Ho's academic family

Production, Logistics and Energy Analytics and Optimization in Steel Industry

Lixin Tang
Northeastern University

Abstract: This paper discusses some interesting topics on the production, logistics and energy analytics and optimization in the steel industry, including: 1) production scheduling in steel-making and hot/cold rolling operations; 2) logistics scheduling in storage/stowage, shuffling, transportation and (un)loading operations; 3) energy optimization including energy allocation and coordinated planning and scheduling of production and energy; 4) data based analytics including dynamic analytics of BOF steelmaking process based on multi-stage modeling; temperature prediction of blast furnace; temperature prediction of molten iron in transportation process; energy analytics for estimation, prediction of generation and consumption, diagnosis and benchmarking; temperature prediction of reheat furnace based on mechanism and data; strip quality analytics of continuous annealing based on multi-objective ensemble learning; process monitoring and diagnosis of continuous annealing based on mechanism and data.

Biography

Lixin Tang is the Vice President of Northeastern University, a Cheung Kong Scholars Chair Professor, the Director of the Institute of Industrial & Systems Engineering, and the Head of the Operation Analytics and Optimization Centre for Smart Industry at Northeastern University of China. He is the leader of an Innovative Research Group of NSFC and the Programme of Introducing Talents of Discipline to Universities (111 Plan). He is also a member of the 7th discipline Review Group of the State Council for Control Science & Engineering, a member of discipline Review Group of Management Science Department of NSFC. He serves as the chair of Operations Analytics and Optimization on Smart Industry Group of ORSC. He is the winner of National "May 1" Labor Medal.

His research interests cover industrial big data science, data analytics and machine learning, reinforcement learning and dynamic optimization, computational intelligent optimization, plant-wide production and logistics planning, production and logistics batching and scheduling and engineering applications in manufacturing (steel, petroleum-chemical, nonferrous), energy, resources industry and logistics systems.

He has published 109 papers in international journals such as *OR*, *M&SOM*, *INFORMS Journal on Computing*, *IISE Transactions*, *NRL*, *IEEE Transactions on Evolutionary Computation*. He was selected into the list of 2014, 2015, 2016 and 2017 Most Cited Chinese Researchers by Elsevier. The paper published on flagship journal *IIE Transactions* (now renamed as *IISE Transactions*) won the Best Applications Paper Award of 2015-2016.

He serves as invited Cluster Chair of INFORMS International 2018. He was invited to co-chair a track the 9th IFAC Conference on Manufacturing Modelling, Management and Control. He also serves as an Associate Editor of *IISE Transactions*, *IEEE Transactions on Evolutionary Computation*, *IEEE Transactions on Cybernetics*, *IEEE Transactions on Automation Science and Engineering*, *Journal of Scheduling*, *International Journal of Production Research*, *Journal of the Operational Research Society*, in Editorial Board of *Annals of Operations Research*, and an Area Editor of the *Asia-Pacific Journal of Operational Research*.

Title: What I have been up to

Pirooz Vakili

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Department of Mechanical Engineering
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Phone: 617-353-2839

ABSTRACT

I have worked in two main areas in the relatively recent past: (i) Developing algorithms for efficient Monte Carlo simulation, and (ii) Developing optimization algorithms for computational protein docking. The ideas for the first part have close affinity with general notions of Perturbation Analysis and what I learnt from Professor Ho and his students, and, in the second part, coincidentally, I have benefited from some of the work that was developed at the other end of the hall at Harvard by Professor Brockett and his students.

In the first part, with my students, we have introduced the idea of Data Base Monte Carlo (DBMC) for efficient stochastic simulation. The core idea of the approach is a borrowed notion from Perturbation Analysis: Trajectories of a stochastic system driven by the same stochastic input ω but at different parameter values are correlated and carry information about each other. Given this fact, we asked if one can obtain information from simulation of a stochastic model for a database of stochastic inputs (ω's) and at a set of parameter values $\theta(1)$, …, $\theta(k)$, and use this information to obtain information at other unexamined θ's. We have considered the adaption of various Variance Reduction methods, such as Control Variate, Stratification, and Importance Sampling to this setting. More recently we are looking at possible application of the method for reducing the variance of the gradient of a cost function in the context of stochastic optimization.

In computational protein docking the problem is to obtain the three-dimensional coordinates of a docked complex given the coordinates of the individual components proteins/molecules. This problem is formulated as an energy/score minimization problem. However, the energy functions generally have a very large number of local minima which make the optimization specially challenging. Most state-of-the-art algorithms use a multi-stage optimization approach that, among others, includes a local optimization component that is applied many times in the course of the overall docking algorithm. We have employed a manifold optimization approach to this problem with some success. In a recent work with a PhD student who is defending his thesis on July 6, we have argued that it is beneficial to introduce a different Riemannian metric on the manifold of rotations, an idea that led us to examine the work of Frank Park, a contemporary of mine at Harvard and a fellow basketball player at Quadrangle Recreational Athletic Center, with Roger Brockett.

Very recently, with two colleagues, computational and experimental material scientists, I have started examining if ideas of sequential decision making, design of experiments, and machine learning can be beneficial to speeding up the process of new material and process development.

BIOGRAPHICAL SKETCH

I live with my wife Chantal in the same house I lived in when I was a student of Professor Ho, at almost a stone throw from Pierce Hall. I often pass by the office I shared with Paul Glasserman, Weibo Gong, Jian Qiang Hu, and Michael Fu at different times. I teach at Boston University and am a member of the Division of Systems Engineering and Department of Mechanical Engineering, and a colleague of Christos Cassandras, another of Professor Ho's student.

My son, Tomas, is a 41-year-old Jazz musician based in Brooklyn New York and he, as part of a trio, will be performing at the legendary Village Vanguard Jazz club in Manhattan New York, July 17-22. Parent will be attending!

A c/μ-Rule for Scheduling of Group-Server Queues

Li Xia

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ABSTRACT

In this presentation, we will introduce our recent finding of the so-called c/μ-rule for the scheduling of group-server queues. This rule can be viewed as a sister version of the famous cμ-rule for polling queues. We study a dynamic server scheduling problem in a queueing system with multi-class severs, where servers are heterogeneous and can be classified into K groups. Servers in the same group are homogeneous. Service times are exponentially distributed and customer arrival is a Poisson process. Servers in groups can be dynamically turned on or off to save costs. Our goal is to find the optimal server scheduling policy to minimize the long-run average cost, which consists of customer holding cost and server operating cost. The challenge of this problem is the curse of dimensionality, since the state space is infinite.

We study this problem from the viewpoint of sensitivity-based optimization. Some structural properties of the optimal policy are characterized, such as the monotonicity and convexity. Under a reasonable condition of scale economies for servers, we further prove that the optimal policy obeys a c/μ-rule, where c is the operating cost rate and μ is the service rate for a server. That is, the servers with smaller c/μ should be turned on with higher priority. Specifically, we should turn on the most possible number of servers in groups whose c/μ is smaller than G(n), where G(n) is a computable index called perturbation realization factor. With the monotone property of G(n), we further prove that the optimal policy has a threshold structure when the c/μ-rule is applicable. This rule is very simple and easy to implement in practice, while the optimality is still reserved. Based on these results, an efficient search algorithm is further developed to find the optimal policy or optimal thresholds.

BIOGRAPHICAL SKETCH

Dr. Li Xia is an associate professor with the Center for Intelligent and Networked Systems (CFINS), Department of Automation, Tsinghua University. He got his Bachelor and PhD degree from the Department of Automation, Tsinghua University, in 2002 and 2007, respectively. After graduation, he worked at IBM Research China as a Research Staff Member and at the King Abdullah University of Science and Technology (KAUST) Saudi Arabia as a Postdoctoral Research Fellow. He returned to Tsinghua University as a faculty in 2011. He was a visiting scholar at Stanford University, the Hong Kong University of Science and Technology, etc. He serves/served as an Associate Editor and Program Committee Member of a number of international journals and conferences. His research interests include

the methodology research in stochastic learning and optimization, Markov decision processes, queueing theory, reinforcement learning, and the application research in building energy, energy Internet, industrial Internet, etc. He is an IEEE senior member.

Li Xia got his PhD degree under the supervision of Prof. Xi-Ren Cao and he is the third generation of Prof. Ho's academic family.

Some Extensions of Optimal Computing Budget Allocation

Xiao, Hui

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ABSTRACT

My research focuses on simulation optimization, especially the optimal computing budget allocation (OCBA), i.e., determining the best simulation budget allocation rule based on a pre-specified objective. Up to now, there major problems that I have worked are as follows.

1. Rank based allocation rule. Most of the existing research work in ranking and selection focused on selecting the single best or best subsets from a finite number of alternatives. However, litter research has been devoted to analyzing how the simulation budget allocation rule can be improved if the ranking information is needed. In this area, we have derived the simulation budget allocation rules for ranking all alternatives completely, and ranking designs with consideration of stochastic constraints. These simulation allocation rules are applied to population-based evolutionary algorithms to improve the search efficiency of these algorithm in stochastic environment.

2. Simulation budget allocation rule with response surface. Previous research in ranking and selection assume that there is no relationship among different alternatives. These procedures are generally very efficient when the number of alternatives is relatively small. However, the efficiency of simulation drops significantly in the case of a large number of alternatives. In this research, we propose to improve the efficiency of simulation further by incorporating the simulation output from across the domain into quadratic functions. We assume that the domain of interest can be divided into adjacent partitions and the mean of the underlying function is approximately quadratic in each partition. The objective is to determine how to allocate the simulation replications among each partition and how the simulation replications should be distributed within each partition so that we can maximize the probability of correctly finding the best design point within a limited simulation budget. This approach has also been extended to subset selection and constrained ranking and selection problems when the performance of all alternatives can be modeled by certain regression functions.

3. Simulation budget allocation for sequential sampling problems. This research develops an efficient ranking and selection procedure for selecting the best

system under the constraint of sequential sampling. The proposed procedure extends the optimal computing budget allocation (OCBA) approach to systems whose mean performances are a function of a certain variable such as location or time. We characterize this as a prediction problem and imbed a regression model into the OCBA procedure. Under the sequential sampling constraints, we determine the optimal simulation budget allocation among all systems concurrently with the optimal simulation run length and optimal number of simulation groups for each system.

4. Robust ranking and selection. This research considers the scenario when the input distribution are not given. We approximate the input distribution by discrete scenarios and determine the efficient simulation budget allocation among different designs and different scenarios.

BIOGRAPHICAL SKETCH

I received bachelor of Engineering and PhD degrees from Department of Industrial and Systems Engineering, National University of Singapore in 2009 and 2013 respectively. Currently, I am working in Department of Management Science, School of Statistics, Southwestern University of Finance and Economics, Chengdu, Sichuan, China.

Chengdu is a good city for travel, where you can taste spicy Sichuan food and hotpot. There are many places of interest in Chengdu such as Mount Qingcheng, Dujiangyan Irrigation System, Sichuan Giant Panda Sanctuaries and Wuhou Shrine.

This is the photo we taken in Xi'an last year during the CASE 2017 conference. Eight of the people in the photo are Prof. Lee Loo Hay's students, and are working in China, Singapore and United Stated in the academic area.

Enhancing the efficiency for simulation optimization and complex decision making

Si Zhang

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Webpage: http://my.shu.edu.cn/Index.aspx?TID=1960

ABSTRACT

My research mainly focuses on the development of simulation optimization methods with both good searching mechanism and high computing efficiency. For the problem with finite candidate solutions, we consider studying the optimal computing budget allocation methods on improving its computing efficiency. For large-scale problem, we solve it from two perspectives. The first one is developing the optimal computing budget allocation for some specific searching algorithms to improve its computing efficiency and the quality of final selected solutions to solve complex optimization problems. The other one is developing a multi-fidelity optimization framework to exploit the benefits of the high accuracy of high-fidelity model and the low computing cost of low-fidelity model to efficiently find the optimal solution for large-scale optimization problems.

BIOGRAPHICAL SKETCH

Si Zhang, an associate professor in the School of Management, Shanghai University, Shanghai, China since 2016. She received her BEng from the Department of Industrial Engineering at Nanjing University in 2008, and her Ph.D. under the supervision of Prof. Loo Hay Lee from Department of Industrial and Systems Engineering of the National University of Singapore in 2013. After her Ph.D. graduation, she has worked as a post-doctoral under the supervision of Prof. Chun-Hung Chen at George Mason University from 2013 to 2016. Her research focuses on simulation optimization, especially the design and implementation of computing budget allocation algorithms for large-scale simulation optimization problems.

This photo was taken when I first saw Prof. Ho, and attended the research family gathering. There were so many wonderful and touching moments happened on that gathering. I'm very lucky to have great supervisors and be one member of this warm family! All the best for Prof. Ho and our big family!

Title: **Insect Intelligent Building (I^2B)**

Qianchuan Zhao

Professor of Dept Automation
Director of Center for Intelligent and Networked Systems
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ABSTRACT

Internet of Things (IoT) is a promising technique solution to gather a lot of real-time information about building operation and relevant to building management. This provides a huge opportunity for improving building operation performance and reducing energy and maintenance cost. In this talk, we will introduce a new paradigm called Insect Intelligent Building (I^2B) based on IoT to see how building facilities or space units could be regarded as insects with low level intelligence yet could work together by only local communication to demonstrate smart behavior of improving building performances under various uncertain environments. Several interesting sample problems will be used to show the power of this simple idea. Similar to many applications in other areas, our I^2B is inspired by so called swarm intelligence, but more suitable for the building control and management context. In certain sense, the method is also inspired by Prof. Ho's basic of ordinal optimization, we leverage the power of randomness in exploring good enough solutions to complex problems.

BIOGRAPHICAL SKETCH

Qianchuan Zhao received the B.E. degree in automatic control in July 1992, the B.S. degree in applied mathematics in July 1992, and MS and Ph.D. degrees in control theory and its applications in July 1996, all from Tsinghua University, Beijing, China. He is currently a Professor and Director of the Center for Intelligent and Networked Systems (CFINS) http://cfins.au.tsinghua.edu.cn, Department of Automation, Tsinghua University. He was a Visiting Scholar at Carnegie Mellon University (worked with Prof. Bruce Krogh), Pittsburgh, PA, and Harvard University, Cambridge, MA, in 2000 and 2002, respectively. He was a Visiting Professor at Cornell University, Ithaca, NY, in 2006. His current research focuses on the modeling, control and optimization of complex networked systems. He has published more than 80 research papers in peer-reviewed journals and conferences. He is a recipient of the 4th HO PAN QING YI best paper award in DEDS field in the year 2000, the 9th Guan Zhao-Zhi Award best paper award in the year 2003 and the 2005 UTRC Outstanding Achievement Award, 2009 national natural science second award of China and 2013 national natural science second award by Ministry of education in China. Dr. Zhao is an associate editor for the Journal of Optimization Theory and Applications, IEEE Transactions on Control of Network Systems, the IEEE Transactions on Automation Science and Engineering, an associate editor for the joint conference CDC-ECC'05 and International Program Committee member for WODES'04. He is a senior member of IEEE.

Working with Streaming Data in Simulation and Nonconvex Optimization

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ABSTRACT

It has become increasingly important to work with streaming data in various applications that require real-time decision making. Recently, Enlu works on two research areas that involve streaming data. First, she looks into quantification of input model uncertainty for stochastic simulation, for which online methods are almost non-existing. She proposes a computationally efficient online method to assimilate streaming input data to update the input uncertainty quantification in real time. Second, she studies some widely-used algorithms in machine learning from a theoretical viewpoint, in order to understand algorithm behaviors and potentially improve them. For example, she studies the asynchronous momentum stochastic gradient descent method which is popular for distributed nonconvex optimization, and gained important insights into the role of momentum and its trade-off with asynchrony.

BIOGRAPHICAL SKETCH

Enlu Zhou received the B.S. degree with highest honors in electrical engineering from Zhejiang University, China, in 2004, and the Ph.D. degree in electrical engineering from the University of Maryland, College Park, in 2009. Her Ph.D. advisors are Dr. Steven I. Marcus and Dr. Michael C. Fu. From 2009-2013 she was an assistant professor in the Industrial & Enterprise Systems Engineering Department at the University of Illinois Urbana-Champaign. She joined as an assistant professor in the School of Industrial and Systems Engineering at Georgia Tech in 2013, and was promoted to associate professor with tenure in 2016. She is a recipient of the Best Theoretical Paper award at the Winter Simulation Conference in 2009, AFOSR Young Investigator award in 2012, and NSF CAREER award in 2015. She has served or is currently serving as an associate editor for Journal of Simulation, IEEE Transactions on Automatic Control, and Operations Research.

Enlu and her husband recently had a new addition to their family: their daughter Andrea Qiu. She was born on March 6, 2018. Her Chinese name is Anxin Qiu (仇安欣), which means “in pursuit of inner peace and happiness”. Andrea has brought so much joy to the family!

Enlu enjoys travelling very much (this is part of the reason she wanted to be a professor!) The picture below was taken on July 12, 2017, in Cordes-sur-Ciel (meaning “city in the sky”), a beautiful old village in France. She made this excursion while she was attending the IFAC World Congress in Toulouse, France.