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FIRST INTERNATIONAL WORKSHOP ON NONLINEAR DYNAMICS AND SYNCHRONIZATION

INDS '08

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Message from the Chair

In the name of the organization committee I welcome you to the First International Workshop on Nonlinear Dynamics and Synchronization (INDS'08) located at the Alpen-Adria University Klagenfurt in the beautiful small town Klagenfurt. INDS'08 brings together researchers, developers and practitioners from different horizons, with the main aim to establish a platform for discussing the latest advances and applications of nonlinear dynamics and synchronization. INDS'08 is an interdisciplinary workshop and will serve as a forum to present current and future works as well as to exchange research ideas pertaining to various aspects in this exciting and challenging field. With great pleasure I can inform you that we have received a substantial number of high-quality contributions and we thank all authors for their overwhelming response. The best papers were selected through a thorough review process and we have an acceptance rate of approximately 40%. In addition to the contributed papers, INDS'08 also features invited papers as well as poster and demo sessions.

We could win eleven international renowned experts to present exceptionally interesting insights and ideas in nonlinear dynamics and synchronization in keynotes and invited talks. We thank them for their availability and precious time: L.O. Chua, G.R. Chen, J. Kacprzyk, D. Helbing, J. Kurths, W. Mathis, D. Ruan, F. Rulkov, M.C. Mackey, M. Rosenblum and H.B. Hwarng.

We also thank all our reviewers for their efforts to ensure the high standard of this workshop's contributions. Additionally, our thanks are directed to both the local organization committee at the Alpen-Adria University Klagenfurt (especially the staff of the Institute for Smart System Technologies) and to the program and organization chairs for their distinguished work and their efforts to make this first edition of INDS'08 a great success. We do hope that all participants will enjoy two interesting and stimulating workshop days and the stay in our beautiful city Klagenfurt, which is the capital of the federal state of Carinthia in Austria. Carinthia - the southernmost state of Austria, sharing borders with Italy and Slovenia - is situated in a basin of the Alps and has the longest hours of sunshine in the region as well a large number of crystal clear alpine lakes.

We plan to organize this interdisciplinary workshop every year. Thus, this is also an invitation to join and actively participate in INDS'09. We further advertise the possibility to submit either an extended paper version or a fully new paper to one or more of the four INDS'08 post conference publications. The deadlines and guidelines will be posted on our website http://inds08.uni-klu.ac.at in the next days. After undergoing a thorough further review process, selected papers will be published either in one of two books (one with Springer and one with World Scientific Publisher) or in one of two special journal issues (one with "The Open Cybernetics and Systemics Journal" published by Bentham publishing and the second with the "International Journal of Computational Intelligence Systems" published by Atlantis Press).

Kyandoghere Kyamakya
General Chair, INDS'08

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Keynotes

We could win international experts from various fields of non-linear dynamics and synchronization to fascinate us with their exciting keynote speeches and invited talks. The speaker's biographies and a short abstract of their planned talks are presented on the next pages.

Prof. Leon O. Chua, *University of California, Berkeley, USA*

Leon O. Chua received the MSEE from Massachusetts Institute of Technology in 1961, and the Ph.D. from University of Illinois, Urban-Champaign in 1964. After that he was Assistant and Associate Professor at Purdue University until 1970. He became a Professor of Electrical Engineering and Computer Sciences at University of California at Berkeley since 1971.

Dr. Chua is known internationally as a pioneer in 3 major research areas, namely, neural networks, chaos and nonlinear circuits. His word in these areas has been recognized internationally through numerous major awards, including 11 honorary doctorates from major universities in Europe and Japan, and 7 USA patents. He was elected Fellow of IEEE in 1974, a foreign member of the European Academy of Sciences (Academia Europea) in 1997, and a foreign member of the Hungarian Academy of Sciences in 2007. He was honored with many major IEEE prizes, including the IEEE Browder J. Thompson Memorial Prize Award in 1972, the IEEE W. R. G. Baker Prize Award in 1978, the Frederick Emmons Award in 1974, twice winner of the IEEE M.E. Van Valkenburg Award (1995 and 1998). He is also a Recipient of the top 15 most cited authors Award in 2002 from all fields of engineering published during the 10-year period from the Current Contents (ISI) database, the IEEE Neural Networks Pioneer Award in 2000, the IEEE Gustav Kirchhoff Award in 2005, and the IEEE Vitold Belevitch Award in 2007. Throughout his career, Dr. Chua has authored around 500 papers and 8 books. He is widely recognized as the father of nonlinear circuit theory and cellular neural networks (CNN). Dr. Chua also invented a five-element electronic circuit for generating chaotic signals. Known internationally as the Chua Circuit, it is used by many researchers to design secure communication systems based on chaos and has become a standard paradigm for teaching chaos in textbooks on nonlinear dynamics.

Keynote: A nonlinear dynamics perspective of Wolfram's new kind of science

Wolfram's monumental best seller entitled "A new kind of science" was based almost entirely on brute-force computer simulations. In sharp contrast, this 2-hour lecture presents a rigorous *analytical* theory based on *attractors* from a nonlinear dynamics perspective.

New results and concepts to be presented include the partitioning (via Felix Klein's Vierergruppe) of all 256 local Boolean rules studied empirically by Wolfram into 88 global equivalence classes, one of which contains 4 topologically-conjugate rules capable of universal computation, and endowed with a 1/f spectrum. Another major result is the rigorous characterization of the time-asymptotic dynamics (attractors) of 112 local rules via an explicit generalized *Bernoulli shift formula*.

Even more surprising, we have discovered the attractors of 170 local rules are blessed with the remarkable property of *time-reversality*. For such rules, the *past* evolution in time can be recovered from the *future* evolutions of a corresponding "twin" rule. Only 86 local rules exhibit an "arrow of time".

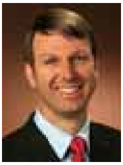
One of our most fascinating discoveries is a new phenomenon, dubbed an *"isle of Eden,"* having no counter part in hyperbolic differential equations, which has neither a past, nor a future!

In addition to providing a mathematical foundation for brainlike dynamics, the discoveries cited above provide a simple dynamical mechanism for mimicking many exotic phenomena from brain science, relativity, quantum physics, cosmology, etc.

Prof. Guanrong Ron Chen, ***City University of Hong Kong, Hong Kong***
Guanrong Chen received the M.Sc. Degree in Computer Science from the Sun Yat-sen, China and the Ph.D. Degree in Applied Mathematics from Texas A&M University, USA. He is an IEEE Fellow (1996) and currently is a Chair Professor and the Founding Director of the *Centre for Chaos and Complex Networks* at the City University of Hong Kong.
Prof. Chen served and is serving as Chief Editor, Deputy Chief Editor, Advisory Editor and Associate Editor for several international journals including the IEEE Circuits and Systems Magazine, IEEE Transactions on Circuits and Systems (I and II), IEEE Transactions on Automatic Control and the International Journal of Bifurcation and Chaos. He received the 1998 Harden-Simons Prize for the Outstanding Journal Paper Award from the American Society of Engineering Education, the 2001 M. Barry Carlton Best Annual Transactions Paper Award from the IEEE Aerospace and Electronic Systems Society, the 2002 Best Paper Award from the Institute of Information Theory and Automation, Academy of Science of the Czech Republic and the 2005 IEEE Guillemin-Cauer Best Transaction Annual Paper Award from the Circuits and Systems Society. He is an honorary professor at different ranks in more than twenty universities in Argentina, Australia, China and USA.

Keynote: On the Synchronizability of Complex Dynamical Networks
Some concerned issued on synchronization and synchronizability of complex networks are addressed, regarding synchronized regions, synchronization conditions and the relationships between the topology and the synchronizability. The presentation will first be motivated by showing two simple examples of regular symmetrical graphs, which have identical structural parameters (average distance, degree distribution and node betweenness centrality) but have very different synchronizabilities. These simple examples demonstrate the intrinsic complexity of the network synchronizability problem. I will then show that for a complex network with identical node dynamics in any topology, two key factors influencing the network synchronizability are the structure of the network inner-linking matrix and the eigenvalues of the network outer-linking matrix. Some more examples will then be provided to show that an addition of new edges to a network can either increase or decrease the network synchronizability, depending on the underlying network topology and where the edges are added. Therefore, to search for some conditions under which the network synchronizability may be increased through adding edges, research found that graph theory is very helpful. It will be demonstrated that for networks with disconnected complementary graphs, adding edges never decreases their synchronizabilities. This implies that better understanding and careful manipulation of the complementary graphs are important and useful for enhancing the network synchronizability. Moreover, it will be shown that an unbounded synchronized region is always easier to analyze than a bounded synchronized region for any complex network. Consequently, to effectively enhance the network synchronizability for the case where the synchronous state is an equilibrium point of the network, a new design method will be presented for determining a rank-1 inner-linking matrix, which means only one state variable is used for coupling therefore very cost-effective, such that the resulting network has an unbounded synchronized region. Throughout this presentation, both theoretical analysis and computer simulations will be presented with comparisons, revealing the essence of graph theory for studying complex network synchronization.

Prof. Chen has been nominated lately for the ”2008 National Natural Science Award of China”. As the date of final interview conincides with the workshop, he will not be able to attend and give his interesting talk. We wish Professor Chen all the best for the competition and strongly hope that he is going to win the award.



Prof. Dirk Helbing, ***Swiss Federal Institute of Technology Zürich (ETH Zürich)***
Since June 1st 2007, Dirk Helbing (born on January 19, 1965) is Professor of Sociology, in particular of Modeling and Simulation at ETH Zurich. Before, he worked as Managing Director of the Institute for Transport & Economics at Dresden University of Technology, where he was appointed full professor in 2000. Having studied Physics and Mathematics in Göttingen, his master thesis dealt with the nonlinear modeling and multi-agent simulation of observed self-organization phenomena in pedestrian crowds. Two years later, he finished his Ph.D. at Stuttgart University on modeling social interaction processes by means of game-theoretical approaches, stochastic methods and complex systems theory, which was awarded two research prizes.

After having completed his habilitation on traffic dynamics and optimization in 1996, he received a Heisenberg scholarship. Both theses were printed by international publishers. Apart from this, Helbing has (co-)organized several international conferences and (co-)edited proceedings or special issues on material flows in networks and cooperative dynamics in socio-economic and traffic systems. He has given 250 talks and published more than 200 papers, including several contributions to journals like Nature, Science or PNAS, which were discussed by the public media (newspapers, radio and TV) more than 200 times. He collaborates closely with international scientists. For example, he worked at the Weizmann Institute in Israel, at Xerox PARC in Silicon Valley, at INRETS in Paris and the Collegium Budapest - Institute for Advanced Study in Hungary, where he is now a member of the external faculty.

Keynote: From emergent crowd behavior to self-organized traffic light control
Crowds and traffic flows have been successfully modeled as driven many-particle systems. Due to the non-linear interactions and delayed adaptions in these systems, one finds a rich spectrum of self-organization phenomena. This includes, for example, various forms of traffic jams, noise-induced breakdowns, freezing-by-heating and slower-is-faster effects, self-organized oscillations, and spontaneous synchronization phenomena. We also discuss instabilities in the motion of dense crowds and the occurrence of turbulence-like phenomena that have been discovered by high-performance video analysis techniques.
Non-linear interactions do not automatically lead to a system optimum. The system may be rather trapped in a local optimum or behave in an unstable way. Therefore, one interesting question is how to modify many-particle interactions in order to avoid this. Future traffic assistance systems will, for example, be able to increase the stability and capacity of traffic flows. Moreover, self-organized traffic light and production scheduling based on decentralized control approaches will allow for better adaptation to variations in capacities and demands. This will lead to a higher quality and performance of traffic and production systems in the future.

Prof. Jürgen Kurths, ***Potsdam University, Germany***

Keynote: Synchronization in Oscillatory Networks

The formation of collective behaviour in large ensembles or networks of coupled oscillatory elements is one of the most fundamental aspects of dynamical systems theory. Applications range from physics and chemistry via neuroscience to engineering and social sciences. Here some basic properties, potentials but also open problems will be discussed.

Recent research has revealed a rich and complicated network topology in the cortical connectivity of mammalian brains. A challenging task is to understand the implications of such network structures on the functional organization of the brain activities. This is studied here basing on dynamical complex networks. We investigate synchronization dynamics on the cortico-cortical network of the cat by modelling each node (cortical area) of the network with a sub-network of interacting excitable neurons. We find that the network displays clustered synchronization behaviour and the dynamical clusters coincide with the topological community structures observed in the anatomical network. Our results provide insights into the relationship between the global organization and the functional specialization of the brain cortex.

This approach of a network of networks seems to be of general importance, especially for spreading of diseases or opinion formation in human societies or socio-economic dynamics.

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Prof. Da Ruan, *Belgian Nuclear Research Centre, Belgium*

Da Ruan (PhD in Math, Ghent U, Belgium 1990) is a scientific staff member at the Belgian Nuclear Research Centre (SCK•CEN). He was a Post-Doctoral Researcher from 1991-93 and since 1994 has been a senior researcher and FLINS Project Leader at SCK•CEN. He is the principal investigator for the research project on intelligent control for nuclear reactors, cost-estimation for large nuclear projects under uncertainty, and computerized decision making systems for society and policy support at SCK•CEN. He was a guest research scientist at the OECD Halden Reactor Project (HRP), Norway from April 2001 to September 2002 as a principal investigator for the research project on computational intelligent systems for feedwater flow measurements at HRP. His major research interests lie in the areas of mathematical modelling, computational intelligence methods, uncertainty analysis and information/sensor fusion, decision support systems to information management, cost/benefit analysis, and safety and security related fields.

Dr. Ruan currently serves as Scientific advisor at the National Institute for Nuclear Research of Mexico for the project "*Adaptive fuzzy control and its applications in nuclear systems*" (Mexico), Regional editor for Europe of *Int. J. of Intelligent Automation and Soft Computing* (TSI Press, Albuquerque, NM), co-editor-in-chief of *Int. J. of Nuclear Knowledge Management* (Interscience Publishers, Geneva), editor-in-chief of *Int. J. of Computational Intelligence Systems* (Atlantis Press, Paris), Editor of the book series of *Intelligent Information Systems* and the proceedings series of *Computer Engineering and Information Science*, Part time Professor at the Dept. of Applied Math. and CS in Ghent University and Adjunct Professor in the Faculty of Information Technology at University of Technology, Sydney, Australia.

Keynote: The role of computational intelligence in complex decision systems

In recent years there has been a growing interest in the need for designing intelligent systems to address complex engineering problems. One of the most challenging issues for the intelligent system is to effectively handle real-world uncertainties that cannot be eliminated. These uncertainties include sensor imprecision, instrumentation and process noise and disturbances, unpredictable environmental factors, to name a few. These uncertainties result in a lack of the full and precise knowledge of the system including its state, dynamics, and interaction with the environment. Computational intelligent techniques including fuzzy logic, neural networks, and genetic algorithms etc., as complimentary to the existing traditional techniques, have shown great potential to solve these demanding, real-world problems that exist in uncertain and unpredictable environments. These technologies have formed the foundation for intelligent systems. An overview on computational intelligence in control and decision making for complex systems will be given over the last four decades. Some real-world cases on power plant operation, information-driven safeguards, cost estimation under uncertainty for a large engineering project, and decision support for long-term options of energy policy will be illustrated for the potential use of computational intelligence related techniques in complex systems. Essential steps on implementing computational intelligence related techniques in industry will be presented via R&D, demonstration, and commercialization. Challenges and future research directions will be concluded in this talk.

Prof. Janusz Kacprzyk, ***Polish Academy of Sciences, Poland*** Janusz Kacprzyk is Professor of Computer Science at the Systems Research Institute, Polish Academy of Sciences, and Honorary Professor at the Department of Mathematics, Yli Normal University, Shanxi, China. He has been a visiting professor at many universities in the USA, England, Italy, UK and Mexico. He is an Academician (Member) of the Polish Academy of Sciences and Foreign Member of the Spanish Royal Academy of Economic and Financial Sciences.

His research interests include intelligent systems, soft computing, fuzzy logic, decision making, decision analysis and decision support, database querying, information retrieval, data analysis, data mining, etc.

He is president of the IFSA (International Fuzzy Systems Association) and president of the Polish Society for Operational and Systems Research. He is fellow of IEEE and IFSA. He received the 2005 IEEE CIS Fuzzy Pioneer Award for pioneering works on multistage fuzzy control, notable fuzzy dynamic programming and the Sixth Kaufmann Prize and Gold Medal for pioneering works on the use of fuzzy logic in economy and management.

His publication record is: 5 books, 30 volumes, 300 papers. He is Editor in chief of 3 Springer's book series and a co-editor of one Springer book series, is on the editorial boards of approx. 30 journals and a member of the IPC at more than 200 conferences.

Keynote: Towards a more efficient complex problem solving using human centric type computing paradigms

We start with a brief account of complex decision making problems, and advocate the use of modern approaches to real world decision making emphasizing the concept of a decision making process that involves more factors and aspects like: the use of explicit and tacit knowledge, intuition, emotions, individual habitual domains, non-trivial rationality, different paradigms, etc. We stress the need for computer based decision support systems that should exhibit some "intelligence" which is meant in an individual and collective perspective, and give an overview of main types of decision support systems.

We present some new so-called computing paradigms that try to attain a synergy, and bridge the gap between the human user and computer systems that is mainly caused by the fact that natural language is the only fully natural means of communication and articulation for a human being but it "strange" to the computer. We advocate the so-called: human centric computing, human centered computing, human computing, etc. that can help bridge this gap.

We also point some relations of the proposed approach to the analysis and explanation of decision making and decision processes, both of a decision analytic and game type, with elements of approaches to decision making based on neuroeconomics.

Then, we present Zadeh's paradigm of computing with words (and perceptions) as a tool that may help bring computing closer to the human being by an explicit use of (quasi)natural language in many phases of computing, problem solving, etc.

We indicate relations between the computing with words and human centric computing paradigms, and indicate - first - that the former can be viewed as an attempt at providing proper tools to implement the latter, and that both can play a crucial role in intelligent decision support systems.

We show some implementations of using linguistic data summaries in a business context and show that they can be viewed as extremely human consistent data mining tools, notably for novice users.

Prof. Dr.-Ing. Wolfgang Mathis, ***Leibnitz University of Hannover, Germany***
Wolfgang Mathis was born in Celle (Germany) on May 13, 1950. He received the Dipl.-Phys. degree in 1980 and the Dr.-Ing. degree, (Ph.D.) in electrical engineering in 1984 (TU Braunschweig) and was granted with the Habilitation Degree. He became a full professor at the Universities of Wuppertal (1990) and Magdeburg (1996). In 2000 he became a full professor at the Leibniz University Hannover and holds the chair of Theoretical Electrical Engineering (TET). His research interests include theory of nonlinear circuits and dynamical systems (incl. noise), RF CMOS circuit analysis and design, parallel computation, nanoelectronics, quantum computing, analysis and numerics of electromagnetic fields. He is chair of the IEEE Circuits and Systems Society German chapter since 2001 and became an IEEE senior member since 1998, received the IEEE Fellow award in 1999 and became He is a member of IEEE, VDE/ITG, DPG (German Physical Society). Furthermore he is member of the Nordrhein-Westfälische Academy of Science since 2001 and received the VDE/ITG Award.

Keynote: Oscillatory Circuits and Synchronization in RF Circuit Design

Prof. Michael C. Mackey, ***McGill University, Montreal, Quebec, Canada***
Prof. Mackey has an undergraduate degree in Mathematics and made his doctorate in Physiology and Biophysics in Washington. Currently he is a Joseph Morley Drake professor of Physiology and the director of the Centre for Nonlinear Dynamics in Physiology and Medicine at McGill University in Montreal, Canada. Before going to McGill University in 1971, Prof. Mackey did research at the National Institutes of Health (NIH). His current research involves dynamical systems theory applied to physiological systems including the regulation of cell proliferation and differentiation as well as gene regulatory networks. Additionally, Prof. Mackey works on problems related to the origins of microscopic irreversibility and foundational issues inn non-equilibrium statistical mechanics.

Keynote: Using mathematical modeling to understand and treat periodic hematological disease
There are a range of fascinating periodic hematological diseases in humans. These are characterized by oscillations in the numbers of one or more blood cell types (white blood cells, red blood cells, or platelets) with periods ranging from days to months. Extensive mathematical modeling efforts over the past 30 years have yielded progressively more detailed models for the regulation of blood cell production that now allow us, in some instances, to pinpoint the location of the dynamic defects that lead to there periodic hematological diseases. All of the defects that have been identified have been associated, in one way or another, with derangements of cellular death mechanisms (apoptosis) and have given rise to supercritical Hopf bifurcations. In this talk I will discuss three of these: cyclical neutropenia, periodic leukemia, and cyclical thrombocytopenia. In the case of cyclical neutropenia the mathematical modeling has actually offered insight into how the clinical symptoms can be brought under control (though not eliminated).

Dr. Nikolai Rulkov, ***University of California, San Diego, USA***

Nikolai F. Rulkov received the M.S. and Ph.D. degrees, both in physics and mathematics, from the University of Nizhny Novgorod, Nizhny Novgorod, Russia, in 1983 and 1991, respectively. In 1983, he joined the Radio Physics Department of the University of Nizhny Novgorod, where he worked as a Researcher until 1993. He has been with the Institute for Nonlinear Science, University of California, San Diego, from 1993 through the present. His research interests are in the areas of bifurcation theory, nonlinear phenomena, theory of synchronization, chaos and applications of nonlinear dynamics in science and engineering. Starting form 2004 he is with the Information Systems Labs, San Diego, where he works on a wide spectrum of nonlinear problems in the areas of signal processing, biologically inspired control systems, biomimetic robotics and modeling of neurobiological networks.

Keynote: Modeling of oscillations and synchronization phenomena in large-scale neuronal networks

Intrinsic neuronal and synaptic properties control the responses of networks of thousands of neurons by creating spatio-temporal patterns of activities, which are used for muscle control, sensory processing, memory formation and other cognitive tasks. The modeling of such systems requires single neuron models capable of displaying both realistic response properties and computational efficiency.

We use difference equations (map-based models) to simulate the individual dynamics of neurons and synapses. Such phenomenological models can be designed to capture the main intrinsic dynamical properties of specific type of neurons. This approach allows fast simulation and efficient parametric analysis of networks containing hundreds of thousands of neurons of different cell types using a conventional workstation.

This paper presents results of the modeling of spatio-temporal behavior of large-scale models of a cortical network, formation and synchronization of fast oscillations and restructuring of synchronization patterns as a function of parameters of synaptic interconnections and the intrinsic states of the neurons. The paper also discusses the application of map-based models in the design of a real-time CPG network model that controls undulatory locomotion of a biomimetic lamprey-based robot.

Dr. Michael Rosenblum, ***Potsdam University, Germany***
Michael Rosenblum has been a research associate in the Department of Physics, University of Potsdam, since 1997. His main research interests are synchronization theory, time series analysis, and application of nonlinear dynamics to biological systems. He was a Humboldt fellow in the Max-Planck research group on nonlinear dynamics at Potsdam University, and a visiting scientist at Boston University. Michael Rosenblum studied physics at Moscow Pedagogical University, and went on to work in the Mechanical Engineering Research Institute of the USSR Academy of Sciences, where he was awarded a PhD in physics and mathematics. He received his habilitation degree in theoretical physics from Potsdam University.

Keynote: Self-organized quasiperiodic dynamics in ensembles of nonlinearly coupled oscillators
We briefly discuss synchronization and appearance of collective motion in large ensembles of all-to-all coupled oscillators. We illustrate the effect by several real world examples and present a theoretical description in the framework of the Kuramoto model. Next, we present recent results on collective dynamics of populations of nonlinearly coupled oscillators and discuss a corresponding generalization of the Kuramoto model. In particular, we demonstrate a transition from fully synchronous periodic oscillations to partially synchronous quasiperiodic dynamics in ensembles of identical oscillators with coupling that nonlinearly depends on the generalized order parameters. We present an analytically solvable model that predicts a regime where the mean field does not entrain individual oscillators, but has a frequency incommensurate to theirs. The self-organized onset of quasiperiodicity is illustrated with Landau-Stuart oscillators, Josephson junction array with a nonlinear coupling, and ensembles of chaotic Roessler oscillators.

Invited Talk

H. Brian Hwarng, PhD, ***National University of Singapore, Singapore***

H. Brian Hwarng is an Associate Professor at the Department of Decision Sciences and a former Academic Director of Asia-Pacific Executive (APEX) MBA Program, School of Business, National University of Singapore. He received his Ph.D. in Industrial and Management Systems Engineering from Arizona State University, USA. Prior to joining National University of Singapore, he worked as an Industrial Engineer for Delta Electronics in Taiwan and as a Material System Analyst for Allied-Signal Aerospace in Phoenix, Arizona, USA. His current research interests focus on applying computational algorithms and techniques such as chaos analysis, neural networks and simulation modeling to investigate system dynamics and quality issues in the context of process control and supply chain management. His pioneer works in pattern recognition on statistical process control charts have been widely cited. He was a recipient of the 2000 Commonwealth Fellowship Award in the UK and has been involved in a global supply chain modeling effort for Glaxo Wellcome and a large-scale innovative technology research project for the specialty chemical industry. Brian is a member of the Decision Science Institute (USA), a senior member of the American Society for Quality (ASQ), of the ASQ Six Sigma Forum and a life-time member of Alpha Pi Mu (American Industrial Engineering Honor Society).

Decisions and chaos in a complex supply chain

A supply chain involves multiple entities encompassing activities of moving goods and adding value from the raw material state to the final delivery stage. Along the chain, there exist various types of uncertainties, e.g. demand uncertainty, production uncertainty and delivery uncertainty. Making decisions as to how much and when to replenish, often involves a feedback process triggering interaction between system entities, which may result in system nonlinearity. A time delay is observed when there is a lag between when a decision is made and when its effect is felt, which often further complicates the interaction between entities. Feedback, time delay and interaction are inherent to many processes in a supply chain. Feedback, time delay and interaction induce variability, instability and complex behaviors that make supply chain management awfully challenging.

In this talk, I would like to discuss, under various supply chain factors, how decisions concerning inventory replenishment contribute to the complex dynamics and chaotic behaviors. We are interested in a general class of multi-level supply chains that can be represented by the well-known beer distribution model. Various supply chain factors are considered, such as demand pattern, ordering policy, demand-information sharing and lead time, with different options or levels. Simulation models are developed to observe system dynamics, particularly the inventory across all levels of the supply chain. Using the Lyapunov exponent, we quantify the degree of system chaos in terms of inventory across all supply chain levels.

The primary purpose of this talk is to share our findings, from a chaos perspective, on (1) how inventory replenishment decisions may impact a complex supply-chain system; (2) how various supply-chain factors act or interact to affect the system dynamics which in many cases lead to chaos; and (3) some managerial insights into more effective management of supply chains.

Content

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Parallel Session P3 - Theory of Synchronization

Parallel Session P4 - Application of NDS - 2 (Computational Intelligence Issues)