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(ECC 2021)

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XI'AN TECHNOLOGICAL UNIVERSITY

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***Online APP*:** Zoom

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***Bilibili Live*:** http://live.bilibili.com/6954765

Programme

3 December 2021		
08:40-09:00	**Opening Ceremony**	
Session I	**ZOOM: 711 647 5830 PWD: 123**	**Chair: Hai-Peng Ren /Yan-Qing Qu**
09:00-10:00	**1**	**James A. Yorke** (University of Maryland) Structured Systems and a legion of Lyapunov functions
10:00-10:40	**2**	**Lin Wang** (Xiamen University) Robust Data Link Based on MDCSK over Non-Stationary Channels for IoT
10:40-11:00	**Break**	
11:00-11:40	**3**	**Jian Zhou** (Xi'an Modern Control Technology Research Institute) Technical Architecture Analysis of Intelligent Drone swarms
Session II	**ZOOM: 711 647 5830 PWD: 123**	**Chair: Chao Bai**
14:30-15:40	**Flash Posters Session**	
15:40-16:00	**Break**	
Session III	**ZOOM: 711 647 5830 PWD: 123**	**Chair: Yan-Qing Qu**
16:00-16:40	**4**	**Henk Nijmeijer** (Eindhoven University of Technology) Synchronization requires sympathetic coupling
16:40-17:20	**5**	**Ulrike Feudel** (Carl von Ossietzky University Oldenburg) Transient chaos in complex networked systems
17:20-17:40	**Break**	
17:40-18:20	**6**	**Ruedi Stoop** (University of Zürich) Misconcepts and misinterpretations of criticality in biological systems
Session IV	**ZOOM: 711 647 5830 PWD: 123**	**Chair: Yu-Fang Zhang**
19:30-20:50	**Invited Young Scholar Session**	

4 December 2021		
Session V		**ZOOM: 711 647 5830 PWD: 123 Chair: Chao-Bo Chen**
09:00-09:40	**7**	**Ying-Cheng Lai** (Arizona State University) Walking with Coffee: a Nonlinear-Dynamics Based Understanding
09:40-10:20	**8**	**Yang-Quan Chen** (University of California) Two Triangles: Complexity / Inverse Power Law / Fractional Calculus; and Fractional Calculus/Renormalization Group/Machine Learning (FC-RG-ML)
10:20-10:40	**Break**	
10:40-11:20	**9**	**You-Min Zhang** (Concordia University) Towards Safer and More Resilient Cyber-Physical Systems with Applications to Smart Grids and Unmanned Systems
11:20-12:00	**10**	**Qing-Lai Wei** (Institute of Automation, Chinese Academy of Science) Discrete-Time Self-Learning Parallel Control
Session VI		**ZOOM: 711 647 5830 PWD: 123 Chair: Kun Yan**
14:30-15:40	**Flash Posters Session**	
15:40-16:00	**Break**	
Session VII		**ZOOM: 711 647 5830 PWD: 123 Chair: Grebogi Celso**
16:00-17:00	**11**	**Jürgen Kurths** (Potsdam Inst. for Climate Impact Research & Humboldt University) Importance of Complexity Science: from the 2021 Physics Nobel Price to Stability in Power Grids
17:00-17:40	**12**	**Asghar Taheri** (University of Zanjan) A Unified Approach to Near Optimal Switching Surface Control of DC/DC and Resonant converters
17:40-18:20	**13**	**Lin Du** (Northwestern Polytechnical University) Dynamic Modeling and Regulation of Parkinson’s Disease Network
Session VIII		**ZOOM: 711 647 5830 PWD: 123 Chair: Yong-Sheng Fu**
19:30-20:50	**Invited Young Scholar Session**	

5 December 2021		
Session IX		**ZOOM: 711 647 5830 PWD: 123 Chair: Su-Ping Zhao**
09:00-09:40	**14**	**Antonio M. Batista** (State University of Ponta Grossa) Chimera States in Neuronal Networks
09:40-10:20	**15**	**Kelly C. Iarosz** (Faculdade de Telêmaco Borba) Neuronal Synchronisation in a Plastic Brain
10:20-10:40	**Break**	
10:40-11:20	**16**	**Bin Xu** (Northwestern Polytechnical University) Robust Intelligent Control towards Hypersonic Flight Process
11:20-12:00	**17**	**Yong Xu** (Northwestern Polytechnical University) Early warning and suppression of noise-induced critical transitions
Session X		**ZOOM: 711 647 5830 PWD: 123 Chair: Kun Tian**
14:30-15:40	**Flash Posters Session**	
15:40-16:00	**Break**	
Session XI		**ZOOM: 711 647 5830 PWD: 123 Chair: Lin Du / Ruedi Stoop**
16:00-16:40	**18**	**Okyay Kaynak** (Bogazici University) Digital Transformation towards Industrial 5.0
16:40-17:20	**19**	**Grebogi Celso** (University of Aberdeen) Stochastic Transients and Control of Tipping Points in Ecological Networks
17:20-18:00	**20**	**Jian Liu** (Xidian University) Output controllability, output learnability and dynamics learnability for iterative learning control systems
18:00-18:40	**21**	**Antonio Politi** (University of Aberdeen) Permutation entropy revisited
18:50	**Remarks/Closing Session**	

Youth Lectures Abstract		
3 December 2021		
19:30-19:50	**22**	**Tian-Li Ma** Variational Bayesian expectation-maximization filter for systems with uncertain hybrid noises
19:50-20:10	**23**	**Su-Ping Zhao** Nonlinear Model Predictive Control for the Stabilization of a Wheeled Unmanned Aerial Vehicle on a Pipe
20:10-20:30	**24**	**Kai Cao** Multi-mobile Robots System for Radiation Source Localization
20:30-20:50	**25**	**Jiao-Ru Huang** Observer-based robust control for uncertain fractional-order T-S fuzzy systems
4 December 2021		
19:30-19:50	**26**	**Jian-Fei Chen** Topologies and Control of Four-Level Converters
19:50-20:10	**27**	**Xin Guo** The switching control strategy of the three-phase PWM converter based on the switching system theory
20:10-20:30	**28**	**Chao Bai** Wireless communication based on Chaotic Shape-forming Filter
20:30-20:50	**29**	**Kun Tian** Impulse control in complex dynamic systems

Poster Abstract	
30	**Hui-Ping Yin** Direct symbol decoding using GA-SVM in chaotic baseband wireless communication system
31	**Xing-Xing Zhao** An Improved PD Sliding Mode Control of Magnetic Levitation System
32	**Jin Li** Mining Gene-Regulation-Networks with Adaptation via Multi-Objective Optimization
33	**Yin-Yin Cao** Research on Multi-target Detection Method Based on Chaotic shaping Filter
34	**Zheng Fan** Application of Neural Network Integral Sliding Mode Controller in Hydraulic Servo System
35	**Ying Xu** Research on MIMO Wireless Communication Method Based on Chaos

36	**Cui-Cui Song** Negative Pressure Cabin Control Based on PID and Multi-Objective Parameter Optimization
37	**Yun-Rong Liao** Path planning of unmanned vehicle based on binocular vision perception
38	**Min-Feng Jiao** Research on Sliding-Mode Control of Boost converter Based on Switching Control
39	**Fan-Ge Zhang** Research on Fault-tolerant Control of Asynchronous Motor Speed Sensor
40	**Zheng-Rong Ma** Research on Hybrid Modulation of Totem Pole PFC
41	**Jing-Rong Zhang** Robust Trajectory Tracking Control for a Quadrotor Unmanned Aerial Vehicle Using Interv al Observer
42	**Zheng-Ting Jing** Power Loss Analysis of Three-Phase Four-leg Four-Wire Inverter Using SiC/Si HyS
43	**Xing-Yu Hu** Low detection probability communication based on Chaos
44	**Meng-Tao Zhou** Stereo matching based on gwcnet
45	**Yu Chen** Inverter Fault Detection Method Based on Park Transformation and K-means Clustering Algorithm
46	**Jia-Wei Dai** A Variable Structure Modulation Strategy to Suppress CMV and Reduce Switching Losses
47	**Hai-Xin Dang** Real-time path planning algorithm based on ROS mobile robot
48	**Kang-Bo Dang** Prediction of Strip Width in Roughing-mill Group Based on PSO-LSSVM
49	**Xiao-Qian He** Object Detection of Water Float Based on Improved YOLOv5
50	**Wen-Jie Li** Three-Phase Inverter Fault Diagnosis Strategy Based on Compressed Sensing and Wavelet Packet Decomposition
51	**Shuang-Lu** Permanent Magnet Synchronous Motor Torque Control Based on Fuzzy Adaptive Sliding Mode Algorithm
52	**Jing Wang** Underwater magnetic target detection method based on lightweight YOLOv3

53	**Chang Xu** Terminal Sliding Mode Control of Permanent Magnet Synchronous Motor Based on A Novel Adaptive Reaching Law
54	**Yan-Ping Xue** Neutral-point Balance Control Strategy of Three-level NPC Inverter Based on Proportional Resonant Algorithm
55	**Jia Yang** A hybrid Captcha recognition algorithm research
56	**Jie Zhang** Dyna-VO: A Semantic Visual Odometry in Dynamic Environment
57	**Qi Zhang** Multi-extended target tracking algorithm with unknown clutter information

Plenary Lectures

1. Structured Systems and a legion of Lyapunov functions

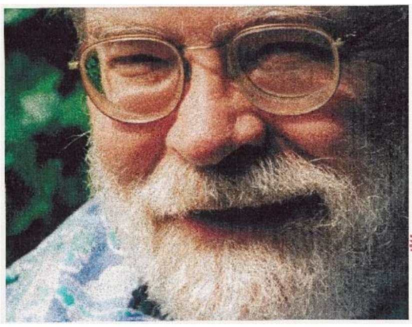
James A Yorke
(*University of Maryland*)

Abstract: This is joint work with Sana Jahedi, Tim Sauer, Naghmen Akhaven I will begin by describing "structured systems" of equations $F(x) = c$, a topic well known in the engineering literature, and especially control theory. Systems of M equations in N unknowns are ubiquitous in mathematical modeling. These systems, often nonlinear, are used to identify equilibria of dynamical systems in ecology, genomics, and many other areas. Structured systems, where the variables that are allowed to appear in each equation are prespecied, are especially common.

I will introduce a new idea of collections or legions of Lyapunov functions. This is for situations where some variables (or species) die out. In some cases we show it is necessary to investigate large numbers of Lyapunov functions to determine what will happen. We consider an n- dimension competitive Lotka-Volterra system of form

$$x_i' = \frac{d}{dt} x_i = x_i \left(c_i + \sum_{j=1}^{d} s_{ij} x_j \right), \qquad \text{where } i = 1, \ldots, d.$$

Let S be the $d \times d$ matrix (s_{ij}). When the system satisfies our "trophic" condition, all solutions are bounded. When there is a bottleneck indicating that k species must die out, we construct k distinct Lyapunov functions, each of which shows that a different species must die out exponentially fast. Each Lyapunov function is based on a different null vector of S and these are species in the bottle of the bottleneck.



Short Biography

A.B., Columbia University 1963;
James Yorke has been at the University of Maryland since 1963.
Ph.D. in Mathematics: University of Maryland at College Park 1966.
Currently: Distinguished University Research Professor of Mathematics and Physics, Univ. of Maryland, College Park, MD, USA.

James Yorke is perhaps best known for coining the mathematical term chaos in his 1975 paper with Tien-Yien Li "Period Three Implies Chaos". He came to the University of Maryland as a math graduate student in 1963 hoping to explore interdisciplinary mathematics. Those hopes were fully realized after he received his Ph.D. and joined the faculty of the University of Maryland. He feels that a Ph.D. in mathematics is a license to investigate the universe. His current research interests include simple models for covid-19, for ecosystems, for ergodic chaotic systems with multiple instabilities.

In 2003 he was awarded the Japan Prize jointly with Benoit Mandelbrot for their work in chaos and fractals in a ceremony presided over by the Emperor of Japan.

2. Robust Data Link Based on MDCSK over Non-Stationary Channels for IoT

Lin Wang
(*Xiamen University*)

Abstract: For 6G, esp. Internet of Things (loT), there is obvious demand about low power consumption, low cost, and low delay for the connectivity chips. The non-stationary transmission properties need to be considered over the data links, such as PLC and underwater acoustic channels. Not only the single chip design methodologies integrating different function chips together but also new signal design techniques with strong against interferes over non-standard or non-stationary channels will become popular in 6G. As one of these cases, joint spreading spectrum and modulations, DCSK has been confirmed to achieve remarkable advantages under the non-stationary channels since it has lower implementation complexity and stronger robustness against interference. The talk will show you how M-ary DCSK (MDCSK) systems and their coded modulation schemes (i.e., BCM modes) are designed and analyzed over non-stationary channels, particularly over underwater acoustic communications and PLC. It is found that the proposed systems have several advantages (including low power consumption, low cost, high robustness, etc) compared to traditional counterparts over harsh transmission environments.

Short Biography

Lin Wang (S’99-M’03-SM’09) received the Ph.D. degree in electronics engineering from the University of Electronic Science and Technology of China in 2001. He had earned his MS in Applied Mathematics in Kunming University of Technology in 1989 and BS in Mathematics in Chongqing Normal University in 1984. From 1984 to 1986, he was a Teaching Assistant with the Mathematics Department, Chongqing Normal University. From 1989 to 2002, he was a Teaching Assistant, a Lecturer, and then an Associate Professor in applied mathematics and communication engineering with the Chongqing University of Post and Telecommunication, China. From 1995 to 1996, he spent one year with the Mathematics Department, University of New England, Australia. In 2003, he spent three months as a Visiting Researcher with the Center for Chaos and Complexity, Department of Electronic Engineering, City University of Hong Kong. In 2013, he was a Senior Visiting Researcher with the Department of ECE, UC Davis. From 2003 to present, he was a Full Professor with the School of Informatics, Xiamen University, China. He had been a Distinguished Professor with Xiamen University since 2012 to 2017. He has authored over 200 journal and conference papers (over 74 IEEE journal papers). He holds 21 patents in physical layer in digital communications. His current research interests include source coding/channel coding, joint source and channel coding /decoding, chaos modulation, and their applications to wired/wireless communication (underwater acoustic communications/PLC). He has hold several IEEE Conferences as General co-chairs and TPC co-chairs and also been editors several SCI Journals. He is senior member of IEEE since 2009 and member of executive council of Chinese Institute of Electronics since 2019.

3. Technical Architecture Analysis of Intelligent Drone swarms

Jian Zhou

(*Xi'an Modern Control Technology Research Institute*)

Abstract: With the support of network communication and cooperative control technology, the field of drone swarms develops rapidly. Especially with the application of artificial intelligence technology, the autonomy and self-organization of drone swarms has been continuously improved. Due to the significant application prospect of drone swarms in reconnaissance and surveillance, regional containment, logistics, post-disaster rescue and other aspects, many countries have taken it as a key development object. In this paper, a number of drone swarms research and development projects in various countries are analyzed. As the commonality of these projects shows, drone swarms system often adopts a multi-level open architecture, consists of many low-cost drones with heterogeneous payloads, is capable of adaptive functional refactoring and self-learning. This paper also constructs a drone swarms system research and development paradigm based on universal technology architecture, and puts forward specific development suggestions for the technical bottlenecks in current product research and development.

Short Biography

Jian Zhou, Ph.D., fellow senior engineer, young science and technology leader in intelligent drone swarms field of China North Industries Group, deputy director of drone swarms general department of Xi 'an Institute of Modern Control Technology. He is a member of Precision Guidance Technology Innovation Workstation, member of Key Laboratory of Transmedia Vehical Technology, member of Key Laboratory of Aerospace Micro-nano System, member of Key Laboratory of Intelligent Drone System, outside tutor of Northwestern Polytechnical University and Beijing institute of technology. Mainly engaged in drone system development, take the lead in the key technology research and development ability construction of intelligence drone swarms. He served as the deputy chief designer of a certain type of drone system, the executive deputy chief designer of a certain type of drone swarms system, and the leader of more than ten R&D projects. He has won one first prize of National Defense Technology invention, one first prize and one third prize of Science Progress Award of China North Industries Group. He has published more than 20 invention patents and more than 30 papers.

4. Synchronization requires sympathetic coupling

Henk Nijmeijer
(*Eindhoven University of Technology*)

Abstract: In the talk experimental results on oscillator synchronization under dynamic coupling/interactions are discussed. Tools to analyse the results are developed and demonstrated in connection to the experiments.

Short Biography

Henk Nijmeijer (1955) is a full professor at Eindhoven University of Technology and member of the Dynamics and Control group. He is Chief Editor of the Frontiers journal on Control Engineering. He is a fellow of the IEEE since 2000 and was awarded in 1990 the IEE Heaviside premium. He is appointed honorary knight of the 'golden feedback loop' (NTNU, Trondheim) in 2011. Per January 2015 he is scientific director of the Dutch Institute of Systems and Control (DISC). He is recipient of the 2015 IEEE Control Systems Technology Award and a member of the Mexican Academy of Sciences. He has been Graduate Program director of the TU/e Automotive Systems program from 2017-2021. He is an IFAC Fellow since 2019 and as of January 2021 an IEEE Life Fellow.

5. Transient chaos in complex networked systems

Ulrike Feudel
(*Carl von Ossietzky University Oldenburg*)

Abstract: Transient chaos is a well-known phenomenon in low-dimensional systems which is related to the existence of unstable chaotic sets, so-called chaotic saddles, in state space. Such saddles result from global bifurcations changing substantially the overall dynamics of a system. Chaotic saddles can either be created in a basin boundary metamorphosis, when smooth basin boundaries are turned into fractal ones and as a result of a boundary crisis where a chaotic attractor loses its stability. The implications of the two different kinds of chaotic saddles on the dynamics of networks are manifold. The networks considered here consist of nodes possessing different dynamical states, mainly periodic, but sometimes also chaotic, while the links are related to diffusive or delay coupling. We will discuss three phenomena: (i) the switching between various network patterns realized by a chaotic saddle containing three different space-time patterns including extreme events; (ii) desynchronization in globally stable networks of identical oscillators due to perturbation and (iii) state-dependent vulnerability of synchronization. In the first two cases fractal and riddled basins of attraction play a fundamental role in the formation of a chaotic saddle leading to extremely long chaotic transients. In the last two cases that chaotic saddle is embedded in the basin of attraction of the globally stable attractor. We show exemplarily the complexity of the dynamics resulting from the transient chaos in the system and discuss methods to analyze it.

For a network of non-identical relaxation oscillators we report on self-induced switching between multiple distinct space–time patterns in the dynamics of a spatially extended excitable system [1]. These switchings between low-amplitude oscillations, nonlinear waves, and extreme events strongly resemble a random process, although the system is deterministic. We show that a chaotic saddle— which contains all the patterns as well as channel-like structures that mediate the transitions between them—is the backbone of such a pattern switching dynamics. Our analyses indicate that essential ingredients for the observed phenomena are that the system behaves like an inhomogeneous oscillatory medium that is capable of self-generating spatially localized excitations and that is dominated by short-range connections but also features long-range connections. Our findings contribute to an improvement of our understanding of pattern switching in spatially extended natural dynamical systems like the brain and the heart.

Furthermore, we analyze the final state sensitivity of nonlocal networks of Duffing oscillators with respect to the initial conditions of their units. By changing the initial conditions of a single network unit, we perturb an initially synchronized state, which is the only, globally stable attractor for a single unit. Depending on the perturbation strength, we observe the existence of two possible network long-term states: (i) The network neutralizes the perturbation effects and returns to its synchronized configuration. (ii) The perturbation leads the network to an alternative desynchronized state. By computing uncertainty exponents of a two-dimensional cross section of the state space, we find the existence of a fractal set of initial conditions converging to this desynchronized solution, which appears to be either a new attractor or a chaotic saddle, i.e. an unstable chaotic set on which trajectories persist for extremely long times [2]. Finally, we report the existence of an intricate time dependence of the vulnerability of the synchronized states in a network composed of identical electronic circuits [3]. By perturbing the synchronized dynamics in consecutive instants of time, we find that synchronization breaks down for some time instants while it

persists for others. The mechanism behind this intriguing phenomenon is again the existence of an unstable chaotic set close to the synchronized trajectory.

All those phenomena highlight the crucial role played by unstable chaotic set leading to transient chaotic dynamics in networked systems. Most of these phenomena are generic for large classes of nonlinear dynamical systems.

References:

[1] Ansmann G, Lehnertz K, Feudel U (2016) Self-induced switchings between multiple space-time patterns on complex networks of excitable units. Phys. Rev. X 6, 011030.

[2] Medeiros ES, Medrano-T RO, Caldas IL, Feudel U (2018): The boundaries of synchronization in oscillator networks. Phys. Rev. E 98, 030201.

[3] Medeiros E, Medrano-T RO, Caldas IL, Tel T, Feudel U (2019) State-dependent vulnerability of synchronized states, Phys. Rev. E 100, 052201.

Short Biography

Ulrike Feudel is a professor for theoretical physics and complex systems at the Institute for Chemistry and Biology of the Sea (ICBM) at the Carl von Ossietzky University of Oldenburg. From 1983 to 1987 she worked at the Institute for Geography and Geoecology and then until 1991 at the Central Institute for Cybernetics and Information Processes of the Academy of Sciences of the GDR. From 1992 to 1996 she worked in the Max Planck working group on non-linear dynamics at the Institute for Physics at the University of Potsdam. In 2000, she was appointed to the chair of theoretical physics and complex systems at the Institute for Chemistry and Biology of the Marine Environment (ICBM) of the University of Oldenburg called. She is a member of the editorial board of the scientific journals Mathematical Biosciences and Engineering (since 2003), Nonlinear Processes in Geophysics (since 2004) and the Russian Journal of Nonlinear Dynamics. She has been a member of the scientific advisory board of Chaos magazine since 2007.

Her research interests include complex systems. She deals conceptually with nonlinear dynamics, stability theory, in particular multi-stability, extreme events and phase transitions, and she transfers the findings to environmental science.

6. Misconcepts and misinterpretations of criticality in biological systems

Ruedi Stoop
(*University of Zürich*)

Abstract: Biological systems often change their behavior in a more or less abrupt manner, which for a physicist is reminiscent of phase transitions. In physics, a phase transition can normally be easily captured; a precise definition of 'phase', however, is actually more difficult, in particular when applied to domains of biology. A special case of the phase transition phenomenon are critical points. An influential hypothesis has been that biology self-organises itself into a critical state, and a more specific one claims that 'brains are, or compute, in a critical state'.

We take a look at these statements from the evidence provided by the example of hearing, the prototype of biological sensory systems, where we pass from the evolution of such systems to investigating how the mammalian hearing system actually works. The gathered insights will demonstrate that several of the general conclusions and statements made in the given context are misleading, need to be specified, or even have to be revised.

Short Biography

Professor Ruedi (Rudolf Robert) Stoop is currently an emeritus professor at the University of Zürich, Eidgenössische Technische Hochschule Zürich, and the Swiss Higher Professional Institute of Northwestern Switzerland. Professor Stoop obtained a bachelor's degree in mathematics from the University of Zürich in 1977, and a doctorate in physics from the University of Zürich and the ETH Zurich in 1990. Professor Stoop has published dozens of papers in internationally renowned journals such as PRL and Phil. Trans. Roy. Soc. His research fields include biological computing, statistical physics, and cochlear modeling. Professor Stoop is a member of the editorial board of Norta Journal, a member of the board of directors of the International School of Scientific Computing in Johannesburg, a member of the external steering committee of the NOLTA IEEE conference, and a member of the board of directors of the NDES conference.

7. Walking with Coffee: a Nonlinear-Dynamics Based Understanding

Ying-Cheng Lai
(*Arizona State University*)

Abstract: A complex object is a system with internal degrees of freedom, such as a cup of hot coffee hand-held by a human in walking. In spite of the natural ability of humans to handle complex objects, an understanding of how this is accomplished is lacking, yet the issue is fundamental to applied fields such as soft robotics. Recent virtual experiments on how humans handle a moving bowl with a mechanical ball inside have revealed that humans typically use two strategies to handle a complex object: a low-frequency strategy in which the motions of the bowl and ball synchronized in phase and a high-frequency strategy where antiphase synchronization occurs. Utilizing a nonlinear dynamical model of a pendulum attached to a moving cart, subject to external periodic forcing, we study the transition between in-phase and antiphase synchronization. We find that, in the weakly forcing regime, as the external driving frequency is varied, the transition is abrupt and occurs at the frequency of resonance, which can be fully understood using the linear systems control theory. Beyond this regime, a transition region emerges in between in-phase and antiphase synchronization, where the motions of the cart and the pendulum are not synchronized. We also find that there is bistability in and near the transition region on the low-frequency side. Overall, our results indicate that humans are able to switch abruptly and efficiently from one synchronous attractor to another, a mechanism that can be exploited for designing smart robots to adaptively handle complex objects in a changing environment. [B. Wallace, L.-W. Kong, A. Rodriguez, and Y.-C. Lai, "Synchronous transition in complex object control," Physical Review Applied 16, 034012, 1-13 (2021).]

Short Biography

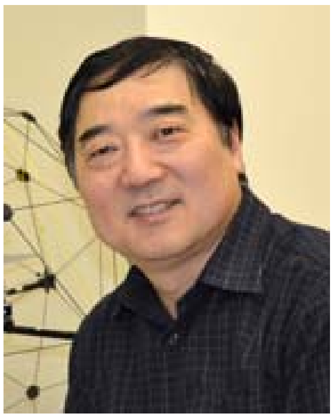
Ying-Cheng Lai is the ISS Endowed Professor of Electrical Engineering and a Professor of Physics at Arizona State University. He was a PECASE recipient in 1997 and has been a Fellow of the American Physical Society since 1999. In 2016, he was selected by the Pentagon for the Vannevar Bush Faculty Fellowship. In 2018, he was elected as a Foreign Member of the National Academy of Science and Letters of Scotland. In 2020, he was elected as a Foreign Member of Academia Europaea (The Academy of Europe) and as a Fellow of the American Association for the Advancement of Science (AAAS). Y.-C. Lai has published 510+ refereed-journal papers with 26,000+ citations (H-index: 76; i-10 index: 400).

8. Towards Safer and More Resilient Cyber-Physical Systems with Applications to Smart Grids and Unmanned Systems

You-Min Zhang
(*Department of Mechanical, Industrial & Aerospace Engineering*
& Concordia Institute of Aerospace Design and Innovation (CIADI)
Concordia University)

Abstract: Condition monitoring, fault detection and diagnosis (FDD), and fault-tolerant control (FTC) in traditional safety-critical systems, such as airplanes, nuclear power plants, chemical plants and cars etc. have been progressively and extensively investigated worldwide since the 1970s. However, the two catastrophic accidents induced by the crashes of two Boeing 737 MAX 800 airplanes in 2019 have highlighted again the necessity and urgency for FDD and FTC research development for airplanes and unmanned systems. In power engineering field, the famous blackout that shut down the power in many of the American northeast areas in 2003 and recently occurred cyber-attacks on the power/energy systems have also promoted the research and development on renewable energy and smart grids as well as their *safety* and *security* issues in recent years. Electrical microgrids with sustainable distributed complex power systems, in particular wind and solar powers, are essential to provide services that are optimal, reliable, cost effective, and environmentally responsible. One of key techniques for ensuring the viability and effectiveness of microgrids is to make use of advanced condition monitoring, FDD and FTC techniques at all levels of power generation, integration into grid, distribution through networks, and also the recent trend for handling cyber-attacks in such type of complex cyber-physical systems (CPS). In this talk, a brief overall view on the challenges and latest developments on condition monitoring, fault/attack detection and diagnosis, FTC, and fault-tolerant cooperative control (FTCC) in smart grids (with renewable wind and solar energies) and unmanned systems (with air, land, marine vehicles) are given first. Our latest research works on the above-mentioned subjects will then be introduced as examples among recently fast-developing research works in the field.

Short Biography



Dr. Youmin Zhang is currently a Professor at the Department of Mechanical, Industrial and Aerospace Engineering and the Concordia Institute of Aerospace Design and Innovation (CIADI) at Concordia University, Canada. His main research interests and experience are in the areas of condition monitoring, health management, fault diagnosis and fault-tolerant control systems; cooperative guidance, navigation and control of unmanned aerial/space/ground/marine vehicles with applications to forest fires, pipelines, power lines, wind farms, solar panels arrays, environment, natural resources and natural disasters monitoring, detection, and protection by combining with remote sensing techniques; dynamic systems modeling, estimation, identification and advanced control techniques; and advanced signal processing techniques for diagnosis, prognosis, fault-tolerant and health management of safety-critical systems with application to renewable and hybrid energy systems and smart grids, and smart cities. He has published 8 books, over 550 journal and conference papers, and book chapters. He was awarded as a Concordia University Research Fellow in the Strategic Research Cluster 'Technology, Industry and the Environment' in 2018 in recognition of his outstanding research works and contributions. His research works on developments of unmanned systems with applications to forest fires detection and autonomous transportation have been reported by public media in national (CTV News, Radio-Canada International, Canadian Science Publishing), citywide (La Presse, Ville.Montreal), and organizational (Concordia News, Quanser Inc., Amtek Company) levels for several times. Dr. Zhang is a Fellow of Canadian Society of Mechanical Engineering (CSME), a Senior Member of AIAA and IEEE, President of International Society of Intelligent Unmanned Systems (ISIUS), Executive Committee Member of International Conference on Unmanned Aircraft Systems (ICUAS), Steering Committee Member of International Symposium on Autonomous Systems (ISAS), and a member of the Technical Committee for several international and national scientific societies. He has been an Editor-in-Chief, an Editor-at-Large, an Editorial Board Member, and Associate Editor of several international journals, including as a Board Member of Governors and Regional Representative (North America) for "Journal of Intelligent & Robotic Systems", Associate Editor for "IEEE Transactions on Neural Networks & Learning Systems", "IET Cyber-systems and Robotics", "Unmanned Systems", "Journal of Systems Science and Complexity", "Chinese Journal of Aeronautics", Deputy Editor-in-Chief for "Guidance, Navigation and Control" etc. He has served as General Chair, Program Chair of several unmanned systems and renewable energy relevant international conferences, including as Program Chair of the IEEE 4th Int. Conf. on Renewable Energy and Power Engineering (REPE), Beijing, Oct. 9-11, 2021 (http://www.repe.net/), a General Chair of the 5th Int. Symp. on Autonomous Systems (ISAS), Hangzhou, Dec. 17-19, 2021 (www.isas-conference.com), and 2022 Int. Conf. on Unmanned Aircraft Systems (ICUAS) to be held at Dubrovnik, Croatia during June 21-24, 2022 (http://www.uasconferences.com/). More detailed information can be found at http://users.encs.concordia.ca/~ymzhang/

9. Two Triangles: Complexity / Inverse Power Law / Fractional Calculus; and Fractional Calculus / Renormalization Group / Machine Learning (FC-RG-ML)

Yang-Quan Chen
(*School of Engineering, University of California*)

Abstract: In the 1st part of this talk, I will introduce a triangle that connects “complexity”, “inverse power law” (IPL) and “fractional calculus” (FC). The key message is that, to better understand complexity one has to use FC. Based on this foundation, in the 2nd part of this talk, I will mainly discuss how FC, renormalization group (RG) theory and machine learning (ML) are connected. FC has been shown to help us better understand complex systems, improve the processing of complex signals, enhance the control of complex networks, increase optimization performance, and even extend the enabling of the potential for creativity. RG allows one to investigate the changes of a dynamical system at different scales. Although extensive research has been carried out on the three topics separately, few studies have investigated the association triangle between the FC, RG, and ML. In the FC and RG, scaling laws reveal the complexity of the phenomena discussed. It is emphasized that the FC's and RG's critical connection is the form of inverse power laws (IPL), and the IPL index provides a measure of the level of complexity. For FC and ML, the critical connections in big data, wherein variability, optimization, and non-local models are described. In the end, the association between the RG and ML is also explained. The mutual information, feature extraction, and locality are also discussed. Many of the cross-sectional studies suggest a connection between the RG and ML. It is shown that the new triangle between FC, RG, and ML, forms a stool on which the foundation to complexity science might comfortably sit for a wide range of future research topics.

Short Biography

YangQuan Chen earned his Ph.D. from Nanyang Technological University, Singapore, in 1998. He had been a faculty of Electrical Engineering at Utah State University (USU) from 2000-12. He joined the School of Engineering, University of California, Merced (UCM) in summer 2012 teaching “Mechatronics”, “Engineering Service Learning” and “Unmanned Aerial Systems” for undergraduates; “Fractional Order Mechanics”, “Linear Multivariable Control”, “Nonlinear Controls” and “Advanced Controls: Optimality and Robustness” for graduates. His research interests include mechatronics for sustainability, cognitive process control (smart control engineering enabled by digital twins), small multi-UAV based cooperative multi-spectral “personal remote sensing”, applied fractional calculus in controls, modeling and complex signal processing; distributed measurement and control of distributed parameter systems with mobile actuator and sensor networks. He received Research of the Year awards from USU (2012) and UCM (2020). He was listed in Highly Cited Researchers by Clarivate Analytics in 2018, 2019, 2020 and 2021. His lab website is http://mechatronics.ucmerced.edu/

10. Discrete-Time Self-Learning Parallel Control

Qing-Lai Wei

(*Institute of Automation, Chinese Academy of Science*)

Abstract: This talk mainly introduces the basic principle and research progress of self-learning control method for nonlinear systems based on adaptive dynamic programming (ADP). Adaptive dynamic programming was first proposed by American scholar P. J. werbos. Based on the optimality principle and the advanced method of integrating artificial intelligence, it is a method to solve the intelligent optimal control problem of large-scale complex nonlinear systems. Adaptive dynamic programming is based on the principle of enhanced learning, uses the nonlinear function fitting method to approximate the performance index of dynamic programming, simulates the idea of human learning through environmental feedback, and effectively solves the problem of "dimension disaster" of dynamic programming. In recent years, it is considered to be a learning control method very close to human brain intelligence. In this talk, a self-learning optimal parallel control by ADP method is proposed, the criteria of the parallel control are presented. Finally, numerical results and analysis are presented to demonstrate the effectiveness of the parallel control method.

Short Biography

Qinglai Wei received the B.S. degree in Automation, and the Ph.D. degree in control theory and control engineering, from the Northeastern University, Shenyang, China, in 2002 and 2009, respectively. From 2009--2011, he was a postdoctoral fellow with The State Key Laboratory of Management and Control for Complex Systems, Institute of Automation, Chinese Academy of Sciences, Beijing, China. He is currently a professor of the institute and the associate director of the State Key Laboratory. He has authored four books, and published over 80 international journal papers. He was a recipient of the Outstanding Paper Award of IEEE Transactions on Neural Network and Learning Systems and IEEE System, Man, and Cybernetics Society, Andrew P. Sage Best Transactions Paper Award. He was Associate Editors of 6 IEEE Transaction journals. His research interests include parallel control, adaptive dynamic programming, computational intelligence, neural-networks-based control, optimal control, nonlinear systems and their industrial applications.

11. Importance of Complexity Science: from the 2021 Physics Nobel Price to Stability in Power Grids

Jürgen Kurths
(*Potsdam Institute for Climate Impact Research & Humboldt University, Department of Physics, Berlin*)

Abstract: The Earth system is a very complex and dynamical one basing on various feedbacks. This makes predictions and risk analysis even of very strong (sometime extreme) events as floods, landslides, heatwaves, and earthquakes etc. a challenging task. After introducing physical models for weather forecast already in 1922 by L.F. Richardson, a fundamental open problem has been the understanding of basic physical mechanisms and exploring anthropogenic influences on climate. In 2021 Hasselmann and Manabe got the Physics Nobel Price for their pioneering works on describing complex physical systems including foundational research that created a pioneering mathematical model of Earth's climate and predicted that increasing levels of carbon dioxide in Earth's atmosphere would raise global temperatures. I will shortly review their main seminal contributions and mention recent challenges in this field.
Next, I will discuss (multi-)stability problems in engineering systems, in particular in power grids. For them, the strongly ongoing transition to distributed renewable energy sources leads to a proliferation of dynamical actors. The desynchronization of a few or even one of those would likely result in a substantial blackout. Thus, the dynamical stability of the synchronous state has become a leading topic in power grid research. Here we claim that the traditional linearization-based approach to stability is in several cases too local to adequately assess how stable a state is. Instead, we quantify it in terms of basin stability, a measure related to the volume of the basin of attraction. Basin stability is non-local, nonlinear and easily applicable, even to high-dimensional systems. It provides a long-sought-after explanation for the surprisingly regular topologies of neural networks and power grids, which have eluded theoretical description based solely on linear stability. Remarkably, when taking physical losses in the network into account, the back-reaction of the network induces new exotic solitary states in the individual actors, and the stability characteristics of the synchronous state are dramatically altered. These novel effects will have to be explicitly taken into account in the design of future power grids, and their existence poses a challenge for control.

Short Biography

Jürgen Kurths is Senior Advisor at Research Department "Complexity Science" at Potsdam Institute for Climate Impact Research (PIK) as well as Professor and Senior Advisor at Humboldt University Berlin. He is an expert in the fields of theoretical physics, complex systems science as well as applications to the Earth system, infrastructure (e.g. power grids), the human brain, and other systems which are characterized by a high degree of complexity and nonlinearity.

12. A Unified Approach to Near Optimal Switching Surface Control of DC/DC and Resonant converters

Asghar Taheri
(*University of Zanjan*)

Abstract: In DC/DC converters, the Equivalent Series Resistance (ESR) of the output capacitor, may cause output voltage jumps, that are not modeled commonly in the literature. These jump discontinuities in output voltage lead to performance issues in Switching Surface (SS) controllers. In this project, these ESR effects are modeled using switched systems with state jumps, called Jump-Flow Switched (JFS) systems. Furthermore, it is shown that approximating the capacitor voltage with output voltage can cause undesired limit cycles, oscillations, chattering or instability issues. To resolve these issues, a non-jumping normal switched system is defined for JFS systems, that is equivalent to the internal continuous dynamics. Also, the challenges of designing SS controllers, for this equivalent switched system is studied, and the Constrained Near Optimal (CNO) SS is designed for the equivalent switched system of the DC/DC and resonant DC/DC converters. To eliminate the required estimations, a general class of switching methods are defined, that also avoids chattering and eliminates the conventional hysteresis blocks. The proposed controller is implemented using analog op-amp circuits.

Short Biography

Asghar Taheri was born in Zanjan, Iran, in 1977. He received the B.S., M.S., and Ph.D. degrees in electronics engineering from Amirkabir University of Technology, Tehran, Iran, and Iran University of Science and Technology, Tehran, in 1999, 2001, and 2011, respectively.

Since 2010, he has been a Faculty Member with the University of Zanjan, where he was an Assistant Professor from 2011 to 2016 and has been an Associate Professor since 2016. His current research interests include modeling, analysis, and control of power converters, motor drives and control, and multiphase machine drives, multilevel inverter, power electronic systems for renewable energy sources, process control, digital-signal-processing and field-programmable-gate-array-based system designs, hardware in the loop, and computer-aided control.

13. Dynamic Modeling and Regulation of Parkinson's Disease Network

Lin Du
(*School of Applied Mathematics and Statistic,*
Northwestern Polytechnical University)

Abstract: Parkinson's disease (PD) is one of the most common neurodegenerative diseases which has various classification, complicated predisposing factors, and difficulty in diagnosis and cure. Plenty clinical and experimental data suggested that during the onset of PD, neurons within Cortex-thalamus-basal ganglia (CTBG) circuit exhibit the pathological phenomenon such as lower reliability, abnormal oscillatory rhythm, and excessive synchronization.

To investigate the pathogenetic mechanisms and therapeutic strategies of PD, based on CTBG circuit, we adopt the dynamic model of PD network from the micro-neural level, revealing the dynamical nature of abnormal oscillatory rhythm and synchronization. Moreover, the effects of two non-invasive stimulation modes, optogenetic stimulation and electromagnetic stimulation, on PD pathological behavior are systematically studied, and corresponding dynamic regulation mechanism of PD is illustrated. This work helps to understand the regulation mechanism of these two noninvasive stimulation technologies in the treatment of PD. What's more, it is of great theoretical significance and potential application value to realize the classification for diverse symptoms and precision therapy of PD.

Short Biography

Lin Du received the B.S., M.S., and Ph.D. degree in applied mathematics from Northwestern Polytechnical University (NPU), Xi'an, China, in 2004, 2007 and 2012, respectively. From 2007-2008, she visited Arizona State University to study with Prof. Ying-Cheng Lai. She is currently a professor, vice president of School of Mathematics and Statistics, NPU, and the deputy director of MIIT Key Laboratory of dynamics and control of Complex System (DCCS). She is mainly engaged in the areas of nonlinear dynamics, computational neuroscience, complex systems and intelligent science. She has presided over 4 National NSF projects of China and published more than 40 papers in academic journals. She has awarded the May Day Labor Medal and excellent teachers of Shaanxi Province, the young outstanding talents of colleges and universities in Shaanxi Province, excellent young teachers and flying star of NPU.

14. Chimera states in neuronal networks

Antonio M. Batista
(*State University of Ponta Grossa*)

Abstract: Many coupled dynamical systems exhibit complex spatiotemporal patterns characterised by coexistence of coherence and incoherence regions, known as chimera states. These patterns were observed in neuronal systems. We focus on the existence of chimera states in neuronal network models based on coupled Hindmarsh-Rose neurons according to the cat cerebral cortex and simmetrically connected adaptive integrate-and-fire neurons. In the neuronal network model of the cat brain, we find spiking and bursting chimera states with desynchronised spikes and bursts, respectively. In an adaptive exponential integrate-and-fire neuronal network, we observe the existence of chimera states with neurons that change between spike and burst activities as the system evolves in time. We also identify multicluster chimera states composed of different groups of neurons with spike and burst patterns.

Short Biography

Bachelor of Physics from Universidade Estadual de Ponta Grossa (1994), Master of Science from Universidade Federal do Paraná (1996), Doctorate in Physics from Universidade Federal do Paraná (2001), Post Doctorate in Physics from Instituto de Física da USP (2004-2006), and Post Doctorate in Biophysics from Institute for Complex Systems and Mathematical Biology in University of Aberdeen UK (2013-2014). He has experience in Physics, acting on the following subjects: networks, plasma, biophysics.

15. Neuronal synchronisation in a plastic brain

Kelly C. Iarosz
(*Faculdade de Telêmaco Borba*)

Abstract: Brain plasticity, also known as neuroplasticity, refers to the ability of the brain to reorganise neuronal pathways in response to new information, environment, development, sensory stimulation or damage. The neuroplasticity plays an important role in our brain development. Scientific advances in neuroimaging and in noninvasive brain stimulation have provided insights to better understand neuroplasticity. Aiming at understanding the fundamental mechanisms behind plasticity, we study the effect of noise on synchronous behavior in coupled Hodgkin-Huxley neurons with spike timing dependent plasticity. In our simulations, we show that spike timing dependent plasticity and noise produce topological complexity in a neuronal network.

Short Biography

Kelly Cristiane Iarosz has a degree in Physics, MSc. in Applied Chemistry and Ph.D. in Science / Physics at State University of Ponta Grossa. She completed her PhD with a period abroad through the PDSE / CAPES Program at the University of Aberdeen, King's College (Scotland). Postdoctoral in mathematical modeling, physics, complex systems, oscillators and control. She is part of the Complex Systems research groups at the State University of Ponta Grossa, Oscillation Control at the Physics Institute of the University of São Paulo and the ICSMB group at the Complex Systems and Mathematical Biology Institute. She is a reviewer of national and international periodicals, and coordinator of the Exact, Natural and Engineering Sciences area at the Faculty of Telêmaco Borba. She is a member of the Postgraduate Programs in Chemical Engineering and Environmental Engineering at the Federal Technological University of Paraná. Dr. Kelly has in mathematical modeling, statistics, oscillation control and applications in biophysics, physical and chemical characterization of diversification, Infrared analysis, X-Ray diffraction, scanning experience electron microscopy, people management, people engineering and active methodologies and neurolearning.

16. Robust Intelligent Control towards Hypersonic Flight Process

Bin Xu
(*Northwestern Polytechnical University*)

Abstract: Hypersonic flight vehicles are referred to vehicles with speeds of Mach 5 and above. With such kind of speed, a reliable and more cost-efficient way to access space can be presented. The studies have shown that there many key technologies that need to be addressed to make hypersonic transportation feasible and efficient. A noteworthy issue is the control design. Towards the control problems under dynamics uncertainty, time-varying disturbance, attitude state constraint and flexible coupling, this talk presents the robust intelligent control for the hypersonic flight dynamics. The main technique is to analyze the system dynamics and employ the robust adaptive methods to construct the control scheme. The results show that the proposed method can improve the system tracking performance during the flight process.

Short Biography

Bin Xu received the B.S. degree in measurement and control from Northwestern Polytechnical University, China, 2006 and the Ph.D. degree in Computer Science from Tsinghua University, China, 2012. He visited ETH Zurich from Mar 2010 to Mar 2011 and from Feb 2012 to Jan 2013 he was Research Fellow with Nanyang Technological University. He is currently professor with School of Automation, Northwestern Polytechnical University. His research interests include intelligent control and adaptive control with application to flight dynamics. He has served on the editorial board of Neurocomputing, Journal of Intelligent & Robotic Systems, International Journal of Control, Automation, and Systems. He was listed in Highly Cited Researchers by Clarivate Analytics in 2019, 2020 and 2021. His website is https://orcid.org/0000-0001-9115-4686.

17. Early warning and suppression of noise-induced critical transitions

Yong Xu
(*Northwestern Polytechnical University*)

Abstract: Noise-induced critical transitions (CTs) from one dynamical state to another contrasting one are widespread in real systems. Once they take place, it is often difficult to restore a system to the previous state, and may cause some catastrophic effects on human living environment, economy and health. Therefore, early warning and suppression of noise-induced CTs have been always the hottest topics in the investigation of nonlinear stochastic dynamics. In this presentation, Gaussian white noise-induced CTs between adjacent states and Lévy noise-induced CTs between two non-adjacent states are shown, respectively. Correspondingly, a more general early-warning indicator, the parameter dependent basin of the unsafe regime (PDBUR), is proposed. This is a new and efficient tool to quantify the ranges of the parameters where Gaussian white noise or Lévy noise-induced CTs may occur. Furthermore, by an external linear augmentation method, a new perspective to suppress noise-induced critical transitions away from a desirable state to another contrasting one is presented. All of these results may provide some guidance for managers to take some measures to avoid such catastrophic noise-induced critical transitions in practical applications.

This is a joint work with Jinzhong Ma (Shanxi University) and Juergen Kurths (Humboldt University and PIK)

Short Biography

Xu Yong has been a professor of mathematics and statistics institute at the Northwestern Polytechnical University. He is the experienced researcher of Humboldt Germany. He is an associate Editor for Complexity, an associate Editor for Frontiers in Physiology/Physics/Molecular Biosciences-Biophysics, an Editorial board for Chaos, Theoretical & Applied Mechanics Letters. His research involves stochastic dynamic systems and applied probability statistics, statistical learning and deep learning.

18. Digital Transformation towards Industrial 5.0

Okyay Kaynak
(*UNESCO Chair on Mechatronics, Bogazici University*)

Abstract: This presentation discusses the profound technological changes that have taken place around us during the last two decades, supported by the new disruptive advances both on the software and the hardware sides, as well as the cross-fertilization of concepts and the amalgamation of information, communication, and control technology-driven approaches. In recent years, in an attempt to change the whole format of industrial automation, these developments have been taken further, especially in Germany, under the label “Industry 4.0”. The dominant feature of Industry 4.0 is the integration of the virtual world with the physical world through the Internet of Things (IoT). Such engineered systems are named Cyber Physical Systems built from, and depend upon, the seamless integration of computational algorithms and physical components. A more comprehensive description of what is happening around us is the digital transformation. After reviewing these profound changes, the presentation is concluded with a discussion of the integration of AI in digital transformation in various forms and a preview of Industry 5.0.

Short Biography

Okyay Kaynak received the B.Sc. degree with first-class honors and Ph.D. degrees in electronic and electrical engineering from the University of Birmingham, UK, in 1969 and 1972, respectively.

From 1972 to 1979, he held various positions within the industry. In 1979, he joined the Department of Electrical and Electronics Engineering, Bogazici University, Istanbul, Turkey, where he is currently a Professor Emeritus, holding the UNESCO Chair on Mechatronics. He is also a 1000 People Plan Professor at the University of Science & Technology Beijing, China. He has held long-term (near to or more than a year) Visiting Professor/Scholar positions at various institutions in Japan, Germany, the U.S., Singapore, and China. His current research interests are in the broad field of intelligent systems. He has authored three books, edited five, and authored or co-authored more than 450 papers that have appeared in various journals and conference proceedings.

Dr. Kaynak has served as the Editor in Chief of IEEE Trans. on Industrial Informatics and IEEE/ASME Trans. on Mechatronics as well as Co-Editor in Chief of IEEE Trans. on Industrial Electronics. Additionally, he is on the Editorial or Advisory Boards of several scholarly journals. He received the Chinese Government’s Friendship Award and Humboldt Research Prize (both in 2016). Most recently, in 2020, he was awarded the Academy Prize of the Turkish Academy of Sciences.

19. Stochastic transients and control of tipping points in ecological networks

Grebogi Celso
(*University of Aberdeen*)

Abstract: A challenging and outstanding problem in interdisciplinary research is to understand the interplay between transients and stochasticity in high-dimensional dynamical systems. Focusing on the tipping-point dynamics in complex mutualistic networks in ecology constructed from empirical data, we investigate the phenomena of noise-induced collapse and noise-induced recovery. Two types of noise are studied: environmental (Gaussian white) noise and state-dependent demographic noise. The dynamical mechanism responsible for both phenomena is a transition from one stable steady state to another driven by stochastic forcing, mediated by an unstable steady state. Exploiting a generic and effective two-dimensional reduced model for real-world mutualistic networks, we find that the average transient lifetime scales algebraically with the noise amplitude, for both environmental and demographic noise. We develop a physical understanding of the scaling laws through an analysis of the mean first passage time from one steady state to another. I will also discuss control strategies that delay the extinction and advances the recovery by controlling the decay rate of pollinators in a stochastic mutualistic complex network, whose control strategies are affected by environmental (Gaussian white) and state-dependent demographic noises. The phenomena of noise-induced collapse and recovery and the associated scaling laws, and the control of tipping point strategies have implications to managing high-dimensional ecological systems.

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Short Biography

Celso Grebogi got his PhD in Physics from the University of Maryland in 1978, Postdoc in Physics and Applied Mathematics at UC Berkeley in 1978-1981. He is the Sixth Century Chair, and the Founding Director of the Institute for Complex Systems and Mathematical Biology, Kings College, University of Aberdeen, UK. He is also an External Scientific Member (Mitglied) of the Max-Planck-Society. He was previously with the University of Sao Paulo as Full Professor of Physics, and, before that, with the University of Maryland as Full Professor of Mathematics. He has made a major impact for his work in the field of chaotic and complex dynamics. He was awarded the Senior Humboldt Prize and the Thomson-Reuters Citation Laureate. The seminal work on chaos control (OGY) was selected by the American Physical Society as a milestone in the last 50 years. He received multiple Doctor Honoris Causa degrees, Humboldt Senior Prize, Fulbright Fellowship, Toshiba Chair, and various Honorary Professorship awards. He is Fellow of the Royal Society of Edinburgh, The World Academy of Sciences, Academia Europaea, Brazilian Academy of Sciences, American Physical Society, and the UK Institute of Physics.

20. Output controllability, output learnability and dynamics learnability for iterative learning control systems

Jian Liu
(*Xidian University*)

Abstract: This article considers iterative learning control (ILC) for a class of discrete-time systems with full learnability and unknown system dynamics. First, we give a framework to analyze the learnability of the control system and build the relationship between the learnability of the control system and the input–output coupling matrix (IOCM). The control system has full learnability if and only if the IOCM is full-row rank and the control system has no learnability almost everywhere if and only if the rank of the IOCM is less than the dimension of system output. Second, by using the repetitiveness of the control system, some data-based learning schemes are developed. It is shown that we can obtain all the needed information on system dynamics through the developed learning schemes if the control system is controllable. Third, by the dynamic characteristics of system outputs of the ILC system along the iteration direction, we show how to use the available information of system dynamics to design the iterative learning gain matrix and the current state feedback gain matrix. And we strictly prove that the iterative learning scheme with the current state feedback mechanism can guarantee the monotone convergence of the ILC process if the IOCM
is full-row rank. Finally, a numerical example is provided to validate the effectiveness of the proposed iterative learning scheme with the current state feedback mechanism.

Short Biography

Jian Liu received the B.S. degree in mathematics from Fuyang Normal University, Fuyang, China, in 2007, the M.S. degree in mathematics from Donghua University, Shanghai, China, in 2010, and the Ph.D. degree in mathematics from Xi'an Jiaotong University, Xi'an, China, in 2017.

Since 2017, he has been with the Center for Complex Systems, School of Mechano-Electronic Engineering, Xidian University, Xi'an. His research interests include iterative learning control, networked control systems, and reinforcement learning.

21. Permutation entropy revisited

Antonio Politi

(*University of Aberdeen*)

Abstract: Quantifying the complexity of a time series is an important subject of research, especially in the perspective of distinguishing deterministic chaotic signals from stochastic ones. The Kolmogorov-Sinai (KS) entropy is, in principle, the most appropriate indicator, but obtaining reliable estimates is quite problematic even in the case of relatively low-dimensional chaos. Many years ago, Bandt and Pompe suggested to encode finite sequences of data as ordinal patterns, by assigning at each datum within a given window its relative order (largest, second largest, and so on). The corresponding entropy, called permutation entropy, is often used as a proxy for the Kolmogorov-Sinay entropy. However, even in the simple, one-dimensional, logistic map, strong deviations are found for the numerically accessible window lengths. Such deviations are essentially due to the implicit refinement of the phase-space partition induced by the symbolic encoding. This refinement leads to a spurious faster increase of the entropy when the window length is increased. I discuss two methods to get rid of this finite-size effect and thereby obtain more reliable estimates of the KS-entropy. The first approach takes into account the underlying fractal structure whose effect can be (approximately) eliminated by minimizing finite-size deviations. The second approach is based on the reconstruction of the corresponding Markov process (for a fixed window length) and the estimate of the resulting entropy, by determining the corresponding stationary state. Finally, I discuss the effect of a weak observational noise on the estimate of the permutation entropy, by varying both the noise amplitude and the window length. An interesting scaling behavior is discovered, whose expanation is however under way.

Short Biography

Antonio Politi is 6th Century Chair in the Physics of Life Science at the University of Aberdeen since 2011. He graduated in Physics in 1978 with a Thesis on Optical Bistability. From 1981 to 2005 he worked at the National Institute of Optics (Florence, Italy): from 2001 to 2005, as Director of Research (equivalent to full professor). From 2005 to 2011 he moved to the CNR Institute of complex systems as Director of the Florence sdection.

Antonio Politi has been appointed fellow of the Institute of Physics and of the American Physical Society. He has been awarded the Gutzwiller Prize by the Institute of Complex Systems in Dresden (2004) and Humboldt Prize (2011). AP has co-authored a book on Complexity (with R. Badii) and one on Lyapunov exponents (with A. Pikovsky), both published by CUP. He is associate editor of Physical Review E for the Nonlinear Dynamics session since 1998. AP is member of the International Advisory Board of the Research Center on Theoretical Physics of Complex Systems (Daejeon Korea).

His scientific interests range from nonlinear dynamics to non-equilibrium statistical mechanics thermodynamics (heat conduction, transport problems) and computational neuroscience (collective properties of neural networks). Among the main achievements: the development of a powerful method to compute fractal dimensions; the discovery of anomalous heat conductivity in nonlinear one-dimensional lattices; the discovery of highly irregular collective chaos in neuronal networks; the discovery of the simultaneous presence of conservative and dissipative features in time-reversible models; the development of a general formalism to describe spatio-temporal instabilities in one-dimensional systems (the so-called chronotopic approach).

22. Variational Bayesian expectation-maximization filter for systems with uncerta in hybrid noises

Tian-Li Ma
(*Xi'an Technological University*)

Abstract: The Kalman filter relies upon the hypothesis of known white noises. However, in some cases, the measurements are interrupted by the uncertain stochastic noises and unknown-but-bounded noises simultaneously. The estimated results have a larger bias by using only one single filtering algorithm. In this paper, a variational Bayesian expectation-maximization filter is proposed which model the uncertain hybrid noises model by using the Gaussian mixture model. In the variational Bayesian expectation step, the hyper-parameter of the measurement noises model is calculated. The hidden variables of the noise model are updated in the variational Bayesian maximization step. Through repeated iteration, the state and covariance of the system can be obtained. Simulation results are presented to demonstrate the improved performance of the proposed algorithm in GPS/INS integrated navigation system.

23. Stabilization Control of a Wheeled Unmanned Aerial Vehicle on a Pipe Using the Nonlinear Model Predictive Control Approach

Su-Ping Zhao
(*Xi'an Technological University*)

Abstract: This letter addresses the challenging task of stabilizing a wheeled unmanned aerial vehicle on a pipe, which is an emerging application in oil and gas facilities for non-destructive measurements. After the derivation of the dynamic model of the system, a discrete-time nonlinear model predictive controller is designed over a finite horizon. The analysis of the asymptotic stability of the designed controller is carried out. The robustness of the controller is tested through numerical analysis of several case studies.

24. Multi-mobile Robots System for Radiation Source Localization

Kai Cao

(*Xi'an Technological University*)

Abstract: Radiation is usually invisible. It is very difficult to locate the radiation source under unknown conditions. At present, only professionals, trained animals or remote-controlled robots can detect radiation in the suspected area, which is neither safe nor inefficient. Therefore, it is necessary to realize a safe, efficient, accurate and low-cost radiation source detection and location detection system after accidental or man-made radiation source leakage and loss accidents. The system is composed of multi-robots, which can independently detect the intensity of the radiation field, locate the location of the radiation source, and draw the distribution map of the radiation field.

25. Observer-based robust control for uncertain fractional-order T-S fuzzy systems

Jiao-Ru Huang

(*Xi'an Technological University*)

Abstract: This paper investigates the robust control problem for the more general fractional-order non-linear systems based on the Takagi-Sugeno (T-S) fuzzy model with un-modeled dynamic and incompletely measurable states. A novel observer-based robust control algorithmis proposed based on fractional-order fuzzy observer and parallel distributed compensation theory. Subsequently, a less-conservative sufficient condition for the asymptotical stability of closed-loop fractional-order T-S fuzzy system in the form of linear matrix inequalities (LMI) is derived by using singular value decomposition (SVD). Finally, a numerical example shows the efficiency of the proposed method.

26. Topologies and Voltage Balancing Control Methods of Four-Level Converters

Jian-Fei Chen

(*University of Maryland*)

Abstract: This report will introduce the latest research on topologies and voltage balancing methods of four-level converters. First, several new four-level converter topologies including four-level dual T-type converter, four-level hybrid neutral point clamped converter, four-level five-switch converter, Si/SiC based hybrid four-level converter, and four-level ANNPC converter, are presented and analyzed. Then, a comprehensive analysis of the proposed four-level converters and the existing converters will be presented in terms of component count, component stress, and power loss. Finally, by viewing the four-level converter as a hybrid configuration of a two-level converter and a three-level converter, variable-carrier, variable-reference, and variable-angle voltage balancing methods are proposed to balance the middle bus capacitor voltage. In the meanwhile, the upper and lower capacitor voltages can be balanced by a zero sequence voltage injection method.

27. The switching control strategy of the three-phase PWM converter based on the switching system theory

Xin Guo

(*Xi'an University of Technology*)

Abstract: The power electronic converters, with different switching states of the power switching devices, are working in different subsystems, demonstrating typical switching systems property. The conventional modeling methods of converters were based on linearization, which cannot accurately describe the physical working states of converters, at the same time, the conventional controller design using the linearized model can only achieve the good performance near the predetermined working point. The switching system model of converters built using the switching system theory, can accurately describe the converters working process and reduce the controller design complexity. In this report, a novel switching control strategy based on the switching system theory is proposed for the three-phase PWM converter under unbalanced grid. Two important issue would be repersented in the report. Firstly, comparing with the model predictive control method used in the converter control, the switching control method has simpler control structure and guarantees the stability of the system. Secondly, the switching controller based on the switching model of the three-phase PWM converter is natureally insensitive to the circuit parameters uncertainty and thus easily achieve good performance under uncertain circuit parameters. The proposed algorithm could be extended to other three-phase converters.

28. Wireless communication based on Chaotic Shape-forming Filter

Chao Bai

(*Xi'an Technological University*)

Abstract: Chaotic signals have been applied in communication systems for the last three decades. In this talk, we focus on the mechanism and advantages of chaotic waveform in wireless communication system. A chaotic shape-forming filter (CSF) and its corresponding matched filter are proposed to generate chaotic waveform. Then, the proposed chaotic shape-forming filter are applied to digital baseband communication and chaotic spread spectrum communication, respectively. The chaotic signal generated by CSF not only can carry information itself, but also has a matched filter and inter-symbol interference elimination method to reduce the effect of noise and multipath propagation. The simulation and experimental results show the superior performance can be obtained by the CSF as compared to its competitors.

29. Impulse control in complex dynamic systems

Kun Tian

(*Xi'an Technological University*)

Abstract: The study of impulse control certainly represents a very hot ongoing research topic owing to recently published works. Impulse system has been deeply studied in many field, such as communication networks, ecosystem management, orbital transfer of satellites and currency supply control in the financial market. From control engineering perspectives, it is expected to unify chaos control and anti-control methods by adjusting parameters of the controller without altering the controller structure and the system configuration. The impulse control was shown to be able to generate and control chaos. This talk will give an investigation that chaos generation and synchronization using univariate impulse control. Simulation and circuit experiment show the correctness of the analysis and the feasibility of the proposed method.