15th IWCFTA

International Workshop on Complex-Systems for Future Technologies and Applications 2022

November 25-28 | Guangzhou China

广东工业大学

Guangdong University of Technology

广东省信息光子技术重点实验室

Guangdong Provincial Key Laboratory of Photonics Information Technology

Contents

IWCFTA 2022

Welcome

The 15th International Workshop on Complex-systems for Future Technologies and Applications (IWCFTA 2022) will be officially organized by Guangdong University of Technology, Guangzhou, China, during November 25-28, 2022.

Adhering to the tenet of the previous fourteen conferences, the 15th IWCFTA is organized by Guangdong University of Technology. This conference aims to provide a regular channel for discussion and scholarly exchanges in the basic theories and key technologies of chaos and fractals, share the state-of-the-art advancements and practical approaches, and promote the applications of related technologies.

The conference will discuss chaos and fractal theory and their applications in information science, including but not limited to the following topics: chaotic dynamical systems, chaos control and optimization, nonlinear memristor devices and systems, chaotic circuit design and modeling, chaos cryptography, complex network dynamical systems, chaotic secure communication, optical chaos, chaotic optical communication, fractal signal processing, fractal image processing, fractal graphs and fractal art.

Sponsor

- 广东工业大学 **Guangdong University of Technology**

Initiators

- 东北大学 **Northeastern University**
- 香港城市大学 **City University of Hong Kong**

Organizers

- 广东省信息光子技术重点实验室 **Guangdong Provincial Key Laboratory of Photonics Information Technology，Guangdong University of Technology**
- 广东工业大学信息工程学院 **School of Information Engineering，Guangdong University of Technology**

Technical Supports

Committee

Honorary Chair：

Prof. Leon O. Chua, University of California at Berkeley, USA, Member of Academia Europaea, IEEE Fellow

General Chairs：

Prof. Guanrong (Ron) Chen, City University of Hong Kong, China, Member of Academia Europaea, Fellow of The World Academy of Sciences, IEEE Fellow, Editor-in-Chief of International Journal of Bifurcation and Chaos

Prof. Zhiliang Zhu, Northeastern University, China

Prof. C. K. Michael Tse, City University of Hong Kong, China, IEEE Fellow, IEAust Fellow

Prof. Yuncai Wang, Guangdong University of Technology, China

Program Committee:

Prof. Aziz-Alaoui M. A, University of Le Harve, France

Prof. Bocheng Bao, Changzhou University, China

Prof. Jinde Cao, Southeast University, China

Prof. Nelson Sze-Chun Chan, City University of Hong Kong, China

Prof. Fangyue Chen, Hangzhou Dianzi University, China

Prof. Zengqiang Chen, Nankai University, China

Prof. Qun Ding, Heilongjiang University, China

Prof. Shukai Duan, Southwest University, China

Prof. Zhisheng Duan, Peking University, China

Prof. Amed Elwakil, University of Sharjah, Emirates

Prof. Zhaosheng Feng, University of Texas Rio Grande Valley, USA

Prof. Chong Fu, Northeastern University, China

Prof. Xinchu Fu, Shanghai University, China

Prof. Zhensen Gao, Guangdong University of Technology, China

Prof. Xiaofang Hu, Southwest University, China

Prof. Cuncai Hua, Yunnan Normal University, China

Prof. Guoping Jiang, Nanjing University of Posts and Telecommunications, China

Prof. Geza Kolumban, Pázmány Péter Catholic University, Hungary

Prof. Francis C. M. Lau, The Hong Kong Polytechnic University, China

Prof. Yuxia Li, Shandong University of Science and Technology, China

Prof. Zhong Li, Fern University at Hagen, Germany

Prof. Chengqing Li, Xiangtan University, China

Prof. Chunbiao Li, Nanjing University of Information Science and Technology, China

Prof. Xiaofeng Liao, Chongqing University, China

Prof. Wei Lin, Fudan University, China

Prof. Jian Liu, University of Jinan, China

Prof. Riccardo Meucci, University of Florence, Italy

Prof. Fuhong Min, Nanjing Normal University, China

Prof. Guoyuan Qi, Tianjin Polytechnic University, China

Prof. Kehui Sun, Central South University, China

Prof. Chuanjun Tian, Shenzhen University, China

Prof. Xiaojun Tong, Harbin University of Technology at Weihai, China

Prof. Chunhua Wang, Hunan University, China

Prof. Guangyi Wang, Hangzhou Dianzi University, China

Prof. Lidong Wang, Zhuhai College of Jilin University, China

Prof. Lin Wang, Xiamen University, China

Prof. Xiaofeng Wu, Minnan normal university, China

Prof. Qigui Yang, South China University of Technology, China

Prof. Xiaosong Yang, Huazhong University of Science and Technology, China

Prof. Guodong Ye, Guangdong Ocean University, China

Assoc. Prof. Hai Yu, Northeastern University, China

Prof. Xinghuo Yu, RMIT University, Australia

Prof. Wenwu Yu, Southeast University, China

Prof. Tianshou Zhou, Sun Yat-sen University, China

Prof. Yicong Zhou, University of Macau, China

Organizing Committee:

Chair：

Prof. Anbang Wang, Guangdong University of Technology, China

Co-chairs：

Prof. Guojun Han, Guangdong University of Technology, China

Assoc. Prof. Hai Yu, Northeastern University, China

Prof. Yi Fang, Guangdong University of Technology, China

Assoc. Prof. Yuehui Sun, Guangdong University of Technology, China

Assoc. Prof. Guofa Cai, Guangdong University of Technology, China

Track Chairs:

Track 1: Nonlinearity, chaos, fractal theory and models

Prof. Qigui Yang, South China University of Technology, China

Prof. Chunbiao Li, Nanjing University of Information Science and Technology, China

Track 2: Memristors, chaotic circuit and application

Prof. Guangyi Wang, Hangzhou Dianzi University, China

Prof. Chunhua Wang, Hunan University, China

Prof. Kehui Sun, Central South University, China

Track 3: AI, Complex systems, neural networks and applications

Prof. Shukai Duan, Southwest University, China

Prof. Chengqing Li, Xiangtan University, China

Track 4: Chaotic communications, chaotic cryptography, optics chaos, etc

Prof. Qun Ding, Heilongjiang University, China

Prof. Lin Wang, Xiamen University, China

Prof. Zhensen Gao, Guangdong University of Technology, China

Agenda Overview

SATURDAY | 26 November, 2022				
Opening Ceremony (Tencent ID: 526-8586-7938)				
09:00-09:10	Opening Remark: Prof. Guanrong (Ron) Chen			Presider: Zhiliang Zhu
	Online Photography			
Plenary session				
09:10-09:50	Prof. Zhaosheng Feng, University of Texas-RGV			Presider: Zhiliang Zhu
09:50-10:30	Prof. Xiaofeng Wu, Minnan Normal University			
10:30-10:45	**Coffee Break**			
10:45-11:25	Prof. Kening Lu, Sichuan University			Presider: Guanrong Chen
11:25-12:05	Prof. Pu Li, Guangdong University of Technology			
Track sessions				
	Track 1: Nonlinearity, chaos, fractal theory and models Tencent ID: 730-468-345	**Track 2: Memristors, chaotic circuit and application** Tencent ID: 527-330-140	**Track 3: AI, Complex systems, neural networks and applications** Tencent ID: 794-176-531	**Track 4: Chaotic communications, chaotic cryptography, optics chaos** Tencent ID: 492-560-852
Session 1	Invited Session (2) **14:00-14:40**	Invited Session (2) **14:00-14:40**	Invited Session (2) **14:00-14:40**	Invited Session (2) **14:00-14:36**
	Oral Session (5) **14:40-15:55**	Oral Session (5) **14:40-15:55**	Oral Session (5) **14:40-15:55**	Oral Session (7) **14:36-16:00**
Coffee Break				

Session 2	Invited Session (2) **16:05-16:45**	Invited Session (2) **16:05-16:45**	Invited Session (2) **16:05-16:45**	Invited Session (2) **16:05-16:41**
	Oral Session (3) **16:45-17:30**	Oral Session (5) **16:45-18:00**	Oral Session (5) **16:45-18:00**	Oral Session (7) **16:41-18:05**

SUNDAY | 27 November, 2022				
Plenary session (Tencent ID: 526-8586-7938)				
08:30-09:10	Prof. Riccardo Meucci, Istituto Nazionale di Ottica		Presider: Anbang Wang	
09:10-09:20	**CLOSING Ceremony**			
Track sessions				
	Track 1: Nonlinearity, chaos, fractal theory and models Tencent ID: 730-468-345	**Track 2: Memristors, chaotic circuit and application** Tencent ID: 527-330-140	**Track 3: AI, Complex systems, neural networks and applications** Tencent ID: 794-176-531	**Track 4: Chaotic communications, chaotic cryptography, optics chaos** Tencent ID: 492-560-852
Session 3	Invited Session (2) **9:20-10:00**	Invited Session (2) **9:20-10:00**	Invited Session (2) **9:20-10:00**	Invited Session (2) **9:20-9:56**
	Oral Session (6) **10:00-11:30**	Oral Session (5) **10:00-11:15**	Oral Session (3) **10:00-10:45**	Oral Session (7) **9:56-11:20**
Coffee Break				
Session 4	/	Invited Session (2) **11:25-12:05**	Invited Session (2) **10:55-11:35**	Invited Session (2) **11:25-12:00**
Track sessions				
Session 5	Invited Session (2) **14:00-14:40**	Invited Session (1) **14:00-14:20**	Oral Session (8) **14:00-16:00**	Invited Session (3) **14:00-14:54**

	Oral Session (3) **14:40-15:25**	Oral Session (5) **14:20-15:35**		Oral Session (7) **14:54-16:18**
Coffee Break				
Session 6	/	Oral Session (7) **15:45-17:30**	Oral Session (6) **16:10-17:35**	Oral Session (7) **16:25-17:50**
End				

Plenary Speakers

Prof. Zhaosheng Feng (冯兆生)

University of Texas-RGV, USA

Web site: https://faculty.utrgv.edu/zhaosheng.feng/

Dynamical Behaviors of KdV-Burgers-type Systems

Abstract: In this talk, we consider dynamics of a class of the KdV-Burgers-type systems by starting with Burgers-type equations, and then focus on the higher-order KdV-Burgers equation, a partial differential equation that occupies a prominent position in describing some physical processes in motion of turbulence and other unstable process systems. We limit our attention to various wave phenomena and their asymptotic behaviors based on the bifurcation theory and dynamical analysis.

Biography: Zhaosheng Feng, Carlos and Stephanie Manrique de Lara Endowed Chair Professor at the School of Mathematical and Statistical Sciences of University of Texas-RGV, USA. He is the recipient of UTRGV Outstanding Award in Research/Scholarship/Creative Work in 2015 and 2021. His research interests lie in nonlinear analysis, computational methods and simulations, mathematical physics, bifurcation-chaos and mathematical biology etc.

Prof. Xiaofeng Wu (吴晓锋)

Minnan Normal University, China

An Ambiguity-aware Classifier of Lumbar Disc Degeneration

Abstract: Diagnostic ambiguity is prevalent in medicine, and may lead to undesirable medical consequences. The existing classification algorithms designed by machine learning and deep learning of medical images are incapable of dealing with the diagnostic ambiguity of lumbar disc degeneration (LDD). In this talk, a label distribution is introduced to quantitatively express the diagnostic ambiguity of LDD, based on which, a new classifier that can perceive and predict the diagnostic ambiguity of LDD is proposed and modeled by integrating the cell metabonomics, subjective probability quantification, and label distribution learning. Numerical experiments demonstrate the ability of the proposed classifier to automatically diagnose the ambiguous grading of LDD.

Biography: Xiaofeng Wu is currently a distinguished professor at the School of Mathematics and Statistics, Minnan Normal University, Zhangzhou, China. He received the Ph.D. degree of Operational Research and Cybernetics from Sun Yat-Sen University, Guangzhou, China, and once worked at University of California, Riverside, USA, and University of Alberta, Canada, as a senior visiting scholar or a visiting professor. His research interests include chaos synchronization, information consensus of multi-agents, information fusion, and machine learning with applications to medicine, etc.

Prof. Kening Lu (吕克宁)

Sichuan University, China

Chaotic Behavior of Dynamical Systems Driven by an External Forcing

Abstract: This talk contains three parts: (1) The existence of SRB measures and their properties for infinite dimensional dynamical systems and SRB measures for parabolic PDEs undergoing Hopf bifurcations driven by a periodic forcing with applications to the Brusselator; (2) Positive entropy implying the existence of horseshoes for infinite dimensional random dynamical systems；(3) Chaotic behavior of Anosov systems driven by an external forcing. This is based on the joint works with Wen Huang, Zeng Lian, Peidong Liu, Qiudong Wang, and Lai-Sang Young.

Biography: Professor Lu Kening is an expert in differential equations and infinite dimensional dynamical systems. He was the professor of Brigham Young University and Michigan State University. He is currently the professor of Sichuan University. He won the first "Zhang Zhifen Prize in Mathematics" in 2017 and was elected to AMS fellow in 2020. He is also the Editors-in-Chief of Journal of Differential Equations. He has done a lot of iconic work in invariant manifolds, invariant foliations, Sinai-Ruelle-Bowen measures, entropy and Lyapunov exponents, smooth conjugate theory of random dynamical systems, and dynamics of stochastic partial differential equations. Related papers have been published in top journals including Inventions Mathematics, Communications on Pure and Applied Mathematics, Memoirs of the American Mathematical Society.

Prof. Pu Li (李璞)

Guangdong University of Technology, China

Broadband optical chaos generation and its applications

Abstract: Optical chaos is a ubiquitous phenomenon of instability in laser diodes. As a special form of laser outputs, optical chaos commonly exhibits some unique characteristics: large-amplitude noise-like fluctuation and broadband power spectrum. With the development of optical chaos generation and control techniques, some novel applications based on chaotic light have been proposed or greatly improved in recent years. According to current international research progresses, we give an overview of broadband chaos generation and its application such as Gb/s high-speed physical random number production, sub-Gb/s fast secure key distribution based on chaos synchronization, and cm high resolution chaotic ranging/lidars. In addition, some possible development orientations in the future are pointed.

Reporter: Prof. Li is currently working at Guangdong University of Technology. His main research field is optical chaos generation and its application. In recent years, he exploits laser chaos in laser diodes as a new generation of broadband physical entropy source, and innovatively proposes a series of techniques for ultrafast physical random number extraction through merging with optoelectronic/all-optical signal processing. On this basis, he successfully develops 2.5 Gb/s optoelectronic random number generator and 10 Gb/s all-optical random number generator, The two types of random number equipment improve the real-time rate of traditional physical random bit generator by 2 ~ 3 orders of magnitude, and have been applied to military and civilian fields such as secure communication and communication tests with remarkable economic and social benefits.

Focusing on optical chaos, Prof. Li has hosted 4 national funds and 10 provincial and ministerial funds. He won 4 science and technology awards at the provincial and ministerial level, published over 50 SCI papers including 1 ESI highly cited paper in AP, PR, APL Photonics, OL, JLT etc, and was authorized over 20 national and international invention patents as the first inventor. In addition, Prof. Li won the support of excellent youth fund of Shanxi province, and was selected as the outstanding young academic leader of Shanxi Province and the leader of Shanxi national defense science and technology innovation team. He currently serves as a guest editor of Nonlinear Theory and Its Applications, IEICE (NOLTA). He is also a senior member of Chinese Optical Society, and a member of Technical committee on chaos and nonlinear circuits of Chinese Institute of Electronics.

Prof. Riccardo Meucci

Istituto Nazionale di Ottica—CNR, Largo E. Fermi 6, 50125 Firenze, Italy

Web site:

https://www.unifi.it/p-doc2-2017-0-A-2b333c30352a-1.html

40 Years of Chaos in Lasers and its Control

Abstract: We revisit the laser model with cavity loss modulation, from which evidence of chaos and generalized multistability was discovered in 1982 [1]. Multistability refers to the coexistence of two or more attractors in a nonlinear dynamical system. Despite its relative simplicity, this model shows how the multistability depends on the dissipation of the system. The model was tested under the action of a secondary sinusoidal perturbation, which can remove bistability when a suitable relative phase is chosen [2]. Such a control strategy is universally known as “phase control” and it was first implemented in the same physical system but at different resonance frequencies [3].

We also revisit the model describing the laser with electro-optic feedback that constitutes the natural evolution of the one described above [4]. In this case, we demonstrate that it represents a minimal universal model for chaos in a laser with an impact comparable to that of other paradigmatic models such as the Lorenz, Chua and Chen system models [5].

References

[1] F. T. Arecchi, R. Meucci, G. Puccioni, and J. Tredicce, “Experimental evidence of subharmonic bifurcations, multistability, and turbulence in a Q-switched gas laser,” Phys. Rev. Lett. 49(17), 1217–1220 (1982).

[2] R. Meucci, J. M. Ginoux, M. Mehrabbeik, S. Jafari, and J. C. Sprott “Generalized multistability and its control in a laser,” Chaos 32, 083111 (2022); doi: 10.1063/5.0093727.

[3] R. Meucci, W. Gadomski, M. Ciofini, and F. T. Arecchi, “Experimental control of chaos by means of weak parametric perturbations,” Phys. Rev. E 49(4), R2528–R2531 (1994).

[4] F. T. Arecchi, W. Gadomski, R. Meucci, “Generation of chaotic dynamics by feedback on a laser,” Phys. Rev. A 34 (2), 1617 (1986)
[5] R. Meucci, S. Euzzor, F. Tito Arecchi, and J. M. Ginoux, “Minimal universal model for chaos in laser with feedback,” International Journal of Bifurcation and Chaos 31 (04), 2130013 (2021).

Biography: Prof. Riccardo Meucci received the doctor degree in Physics in 1982 and the specialization degree in Optics (PhD), both from University of Florence, Italy. From 1984 to 1987, he was research fellow at the Istituto di Cibernetica of the National Research Council (CNR) of Italy. Since 1987, he joined with the National Institute of Optics, Firenze, Italy, where he holds the position of Research Director. He is also contract professor of physical optics and mathematical methods for optics at University of Firenze. Riccardo Meucci is associate editor for the International Journal of Bifurcation and Chaos (IJBC) from 1 January 2018.

His research interests include nonlinear dynamics, chaos, control of chaos, synchronization and infrared digital holography.He is IEEE Senior Member since 17 November 2018.

General Information

Transportation：

Guangzhou Baiyun International Airport (59.1 km to the Aloft Guangzhou University Park)：

1. Take a taxi, takes about 1 hour and 15 minutes, about 250 yuan (RMB).
2. Metro: take No.3 Line, bound for Panyu Square, interchange with Line 5 (bound for Wenchong) at Zhujiang New Town station, interchange with Line 4 (bound for Nansha Passenger Port) at Chebeinan station, get off at Higher Education Mega Center South station, leave the station in Exit B or C, walk 800m to the hotel. It will takes about 1 hour and 50 minutes, about 12 yuan (RMB) per person.

Guangzhou South Railway Station (30.8 km to the Aloft Guangzhou University Park)：

1. Take taxi, takes about 38 minutes, about 100 yuan (RMB).
2. Metro: take No.7 Line, bound for Higher Education Mega Center South, get off at Higher Education Mega Center South station, leave the station in Exit B or C, walk 800m to the hotel. It will takes about 45 minutes, about 5 yuan (RMB) per person.

Guangzhou Railway Station (29.2 km to the Aloft Guangzhou University Park):

1. Take taxi, takes about 44 minutes, about 100 yuan.
2. Metro: take No.5 Line, bound for Wenchong, interchange with Line 4 (bound for Nansha Passenger Port) at Chebeinan station, get off at Higher Education Mega Center South station, leave the station in Exit B or C, walk 800m to the hotel. It will takes about 1 hour and 20 minutes, about 9 yuan (RMB) per person.

Conference site

Aloft Guangzhou University Park （广州大学城雅乐轩酒店）

Hotel Location:

No.66 Li De Street, Xiaoguwei, Panyu District, Guangzhou, Guangdong, China (广东省广州市番禺区小谷围街立德街 66 号)

Room rates: Kingbed Room/Twinbed Room ￥430 (breakfast for one person included, extra breakfast ￥50)

Booking phone: 86 - 18926222648

Hotel Website: www.alofthotels.com

Optional hotels

1. Southern Club Hotel Business Class (广州南国会国际会议中心)，about 2.2 km's away from the conference site.

Hotel Location: 280 East Waihuan Road, Xiaoguwei, Panyu District, Guangzhou, Guangdong, China (广东省广州市番禺区小谷围街外环东路 280 号)

Hotel Tel: 86-02039338888

Hotel Website: https://southern-club.guangzhoutophotels.com

2. The University Town International Hotel （广州华工大学城中心酒店）, about 2.1 km away from the conference site. Hotel Location: Hua Gong Bei Road 68th, Xiaoguwei, Panyu District, Guangzhou, Guangdong, China (广东省广州市番禺区小谷围街华工北路 68 号)

Hotel Tel: 86-02039388888

Hotel Website: https://www.scuthotel.com

Track 1: Nonlinearity, chaos, fractal theory and models

Time	Speaker	Affiliation	Title
Session 01-T1——Presider: Chunbiao Li, Jian Liu Time: Nov 26, 14:00-15:55 | (Tencent ID: 730-468-345)			
14:00-14:20	**Xu Zhang (invited)**	Shandong University	The coexistence of attractors in several classes of chaotic systems
14:20-14:40	**Zhouchao Wei (invited)**	China University of Geosciences	Melnikov-type method of homoclinic orbits for a class of planar hybrid piecewise-smoot systems with impulsive effect and noise excitation
14:40-14:55	Jingming Pi	Sichuan University of Science and Engineering	Sensitivity and Transitivity of Non-autonomous Discrete Dynamical Systems Under the Product Operation
14:55-15:10	Yongxin Li	Nanjing University of Information Science & Technology	A 2-D conditional symmetric hyperchaotic map with complete control
15:10-15:25	Qiaomin Xiang	Foshan University	Nonisotropic chaotic oscillations of 1D and 2D hyperbolic PDEs with superlinear boundary conditions
15:25-15:40	Qiu Huang	Guangxi University	Homoclinic chaos in a four-dimensional manifold piecewise linear system
15:40-15:55	Chengwei Dong	North University of China	Hidden and coexisting attractors in a novel 4D hyperchaotic system with no equilibrium point
Coffee Break			
Session 02-T1——Presider: Qigui Yang, Lijun Pei Time: Nov 26, 16:05-17:30 | (Tencent ID: 730-468-345)			
16:05-16:25	**Yongjian Liu (invited)**	Yulin Normal University	Attractor and bifurcation of forced Lorenz-84 system

16:25-16:45	**Tianxiu Lu (invited)**	Sichuan University of Science & Engineering	Some stronger forms of topological transitivity for a sequence of uniformly convergent continuous maps
16:45-17:00	Ruonan Liu	Xi'an Jiaotong University	Stochastic Resonance and Bifurcation of Order Parameter in a Coupled System of Underdamped Duffing Oscillator
17:00-17:15	Xiongjian Chen	Changzhou University	Dynamical analysis of an improved Fitz Hugh-Nagumo neuron model with multiplier-free implementation
17:15-17:30	Dengwei Yan	Chongqing Normal University	An Improved Gumowski-Mira Map with Symmetric Lyapunov Exponents
Session 03-T1——Presider: Tianxiu Lu, Xu Zhang Time: Nov 27, 9:20-11:30 | (Tencent ID: 730-468-345)			
9:20-9:40	**Dawei Ding (invited)**	Anhui University	Dynamic analysis of fractional-order memristor-coupled neurons and its applications in image encryption
9:40-10:00	**Jian Liu (invited)**	University of Jinan	Generalized Synchronization and Parameters Identification of Different-Dimensional Chaotic Systems in the Complex Field
10:00-10:15	Heng Xiao	Anhui University	Fractional-order heterogeneous neuron network with HR neuron and FHN neuron based on coupled locally-active memristors and its application
10:15-10:30	Li Ye	Guangxi Normal University	Pseudo-almost periodic C^0-solution for evolution inclusion with mixed nonlocal plus local initial conditions
10:30-10:45	Zhenghui Wen	Hunan University	Regulating memristive neuronal dynamical properties via excitatory or inhibitory magnetic field coupling
10:45-11:00	Yang Yang	Lanzhou University of Technology	Fractal Evolution in Internet Information Propagation
11:00-11:20	Yang Gu	Changzhou University	Parallel bi-memristor hyperchaotic map with extreme multistability

11:20-11:30	Xiezhen Huang	Yulin Normal University	Qualitative geometric analysis of traveling wave solutions of the modified equal width Burgers equation
Launch Break			
Session 05-T1——Presider: Dawei Ding, Zhouchao Wei Time: Nov 27, 14:00-15:25 | (Tencent ID: 730-468-345)			
14:00-14:20	**Lijun Pei (invited)**	Zhengzhou University	Average price prediction of Chinese new energy stocks via Auto-Reservoir Neural Network (ARNN)
14:20-14:40	**Chunbiao Li (invited)**	Nanjing University of Information Science & Technology	Offset parameter cancellation produces countless coexisting attractors
14:40-14:55	Zedi Zhang	Hunan University	Multidirectional Associative Memory Neural Network Circuit based on Memristor
14:55-15:10	Kang Rong	Changzhou University	Memristive Hénon Map with Hidden Neimark-Sacker Bifurcations
15:10-15:25	Jianchao Liang	University of Jinan	Observer-based Synchronization of Time-Delay Complex-Variable Chaotic Systems with Complex Parameters

The coexistence of attractors in several classes of chaotic systems (invited)

Xu Zhang

Shandong University, China

Abstract：The study of the strange attractors is one of the interesting and amazing topics in chaos theory. In this talk, we will report the coexistence of many or infinitely many attractors in several classes of systems, for example, the Lorenz-type systems, Chua-type systems, fractional-order systems, and so on.

Melnikov-type method of homoclinic orbits for a class of planar hybrid piecewise-smooth systems with impulsive effect and noise excitation (invited)

Zhouchao Wei

School of Mathematics and Physics, China University of Geosciences, Wuhan 430074, China

*Corresponding author: weizhouchao@163.com

Abstract: The Melnikov method is extended to a class of hybrid piecewise-smooth systems with impulsive effect and noise excitation when an unperturbed system is a piecewise Hamiltonian system with a homoclinic orbit. The homoclinic orbit continuously crosses the first switching manifold and transversally jumps across the second switching manifold by the impulsive effect. The trajectory of the corresponding perturbed system crosses the first switching manifold by applying the reset map describing the impact rule instantaneously. Then, the random Melnikov process of such systems is derived and the criteria for the onset of chaos with or without noise excitation are established. In addition, the complicated dynamics of concrete piecewise-smooth systems with or without noise excitation under the reset maps, impulsive effect, and non-autonomous periodic and damping perturbations are investigated by this extended method and numerical simulations.

Keywords: Melnikov-type method; homoclinic orbits; piecewise-smooth system; impulsive effect; noise excitation.

Speaker's biography: Dr. Zhouchao Wei is currently a full Professor at China University of Geosciences (Wuhan). He received his BSc degree in Applied Mathematics in 2006. In 2011, he received a PhD degree in Applied Mathematics from South China University of Technology. He joined the College of Mechanical Engineering of Beijing University of Technology in 2014 as a Postdoctoral Fellow, and the Faculty of Mechanical Engineering, Technical University of Lodz in Poland in 2015 as a Visiting Researcher. He has also been as a Visiting scholar at the Mathematical Institute, University of Oxford, UK, between 2016 and 2017. His current research interests include the qualitative theory of differential equations, chaos and bifurcation theory. He has been supported by four National Natural Science Funds and the Young Top-notch Talent Cultivation Program of Hubei Province. He was selected into the "Elsevier list of highly cited scholars in China" and "highly cited scientists" by the web of science and clarivate analytics in 2021.

Sensitivity and Transitivity of Non-autonomous Discrete Dynamical Systems Under the Product Operation

Jingmin Pi[1,A], Tianxiu Lu[1,B,*]

[1]College of Mathematics and Statistics, Sichuan University of Science and Engineering, Zigong, 643000, China
[A]Email: pi1011225770@126.com, [B]Email: lubeeltx@163.com
[*]Corresponding author: lubeeltx@163.com

Abstract: The research of chaos mathematical theory is not only of great scientific significance, but also has broad application prospects. Chaos theory involves almost every field of natural science and social science, and becomes an effective tool to explain or solve nonlinear complex problems. Considering chaotic properties in the sense of Devaney in non-autonomous discrete dynamical systems (including autonomous discrete dynamical system as its special case), this study seek the relationship between product system and factor systems. It is proved that sensitivity (resp. infinitely sensitive) of the product system is equivalent to sensitivity (resp. infinitely sensitive) of one of the factor systems. The product system is accessible (resp. mixing) if and only if the two factor systems are accessible (resp. mixing) at the same time. While, transitivity or point-transitivity of the factor systems can not deduce to the product system. Some examples are given to illustrate the above conclusions. The results in this paper show that, for sensitivity, accessibility, and mixing, the discussion in two-dimensional case can be simplified into one-dimensional case.

Keywords: Sensitivity, transitivity, non-autonomous discrete dynamical systems, product mapping

A 2-D conditional symmetric hyperchaotic map with complete control

Yongxin Li[1,A], Chunbiao Li[1,B *], Sicong Liu[2], Zhongyun Hua[3], Haibo Jiang[4]

[1]*School of Artificial Intelligence, Nanjing University of Information Science & Technology, Nanjing 210044, China*
[2]*School of Life Science, University of Electronic Science and Technology of China, Chengdu 611731, China*
[3]*School of Computer Science and Technology, Harbin Institute of Technology Shenzhen Graduate School, Shenzhen 518055, China*
[4]*School of Mathematics and Statistics, Yancheng Teachers University, Yancheng 224002, China*
[A]Email: yxlinuist@163.com, [B]Email: goontry@126.com
[*]Corresponding author: goontry@126.com

Abstract：By introducing an absolute value function for polarity balance, a unique hyperchaotic map with complete control and conditional symmetry is designed. Firstly, coexisting conditional symmetric bifurcations and hyperchaotic phase trajectories are found in the map. Then, two independent parameters are proven to provide a direct knob for partial and total amplitude control. Finally, a STM32-based hardware experiment is carried out to verify the theoretical finding.

Keywords：Hyperchaotic map, conditional symmetry, complete control.

Yongxin Li: is currently working toward the doctor's degree in information and communication engineering from the Nanjing University of Information Science and Technology, Nanjing, China. His research interests include nonlinear dynamics and memristive circuits, including nonlinear circuits, systems, and corresponding applications.

Nonisotropic chaotic oscillations of 1D and 2D hyperbolic PDEs with superlinear boundary conditions

Qiaomin Xiang[1,A]

[1]School of Mathematics and Big Data, Foshan University, Foshan 528000, China
[A]Email: qmxiangncu@163.com

Abstract: In this talk, I will briefly introduce the nonisotropic chaotic oscillations of 1D and 2D hyperbolic PDEs with mixed derivative terms and a superlinear type boundary condition. The 1D and 2D hyperbolic systems are rigorously proved to be chaotic. Numerical examples are carried out to demonstrate the theoretical results.

Speaker's biography: Dr. Qiaomin Xiang received the B.S. and M.S. degrees in mathematics from Nanchang University, Nanchang, China, in 2012 and 2015, respectively, and the Ph.D. degree in mathematics from the South China University of Technology, Guangzhou, China, in 2018. She is currently an Associate Professor with Foshan University, Foshan, China. Her research interests include chaos in PDE and control theory.

Homoclinic chaos in a four-dimensional manifold piecewise linear system

Qiu Huang[1,A], Yongjian Liu[2,*], Chunbiao Li[3,B], Aimin Liu[2,C]

[1]Institute 1, Guangxi University, Nanning, 530004,China
[2]Institute 2, Yulin Normal University, Yulin, 537000, China
[3]Institute 3, Nanjing University of Information Science & Technology, Nanjing 210044, China
[A]Email: 1447037844@qq.com, [B]Email: goontry@126.com,
[C]Email:254016933@qq.com
[*]Corresponding author: liuyongjianmaths@126.com

Abstract: The existence of homoclinic orbits is discussed analytically for a class of four-dimensional manifold piecewise linear systems (4MPWL) with one switching manifold. An interesting phenomenon is found, that is, under the same parameter setting, homoclinic orbits and chaos appear simultaneously in the system. In addition, homoclinic chaos can be suppressed to a periodic orbit by adding a nonlinear control switch with memory. These theoretical results are illustrated with numerical simulations.

Keywords: piecewise linear system; homoclinic orbit; homoclinic chaos; periodic orbit.

Hidden and coexisting attractors in a novel 4D hyperchaotic system with no equilibrium point

Chengwei Dong[1,*], Jiahui Wang[1,*]
[1]Department of Physics, North University of China, Taiyuan 030051, China
[*]Corresponding authors: dongchengwei@tsinghua.org.cn; wangjiahui2021wuli@163.com

Abstract: The investigation of chaotic systems containing hidden and coexisting attractors has attracted extensive attention. This paper presents a four-dimensional (4D) novel hyperchaotic system, evolved by adding a linear state feedback controller to a 3D chaotic system with two stable nodefocus points. The proposed system has no equilibrium point or two lines of equilibria, depending on the value of the constant term. Complex dynamical behaviors such as hidden chaotic and hyperchaotic attractors and five types of coexisting attractors of the simple 4D autonomous system are investigated and discussed, and are numerically verified by analyzing phase diagrams, Poincaré maps, the Lyapunov exponent spectrum, and its bifurcation diagram. The short unstable cycles in the hyperchaotic system are systematically explored via the variational method, and symbol codings of the cycles with four letters are realized based on the topological properties of the trajectory projection on the 2D phase space. The bifurcations of the cycles are explored through a homotopy evolution approach. Finally, the novel 4D system is implemented by an analog electronic circuit and is found to be consistent with the numerical simulation results.

Keywords: hyperchaos; hidden attractor; coexisting attractors; bifurcation; circuit implementation

Speaker's biography: Dr. Chengwei Dong received the B.S. degree in applied physics from Tianjin University of Technonlogy, Tianjin, China, in 2008, and Ph.D. degree in physics from Tsinghua University, Beijing, China, in 2014. He is currently an associate professor in North University of China, Taiyuan. His research interests include chaos, complex system, hidden attractors, etc.

Attractor and bifurcation of forced Lorenz-84 system （invited）

Yongjian Liu[1], Zhouchao Wei[2], Chunbiao Li[3], Aimin Liu[1], Lijie Li[1]
[1]*Guangxi Colleges and Universities Key Laboratory of Complex System Optimization and Big Data Processing, Yulin Normal University Yulin, Guangxi 537000, P. R. China*
[2]*School of Mathematics and Physics, China University of Geosciences Wuhan 430074, P. R. China*
[3]*Jiangsu Key Laboratory of Meteorological Observation and Information Processing, Nanjing University of Information Science and Technology, Nanjing 210044, P. R. China*
*liuyongjianmaths@126.com

Abstract：In this talk, global dynamics of forced Lorenz-84 system are discussed, and some new results are presented. The periodic attractor is analyzed for the almost periodic Lorenz-84 system with almost periodically forcing, including the existence and the boundedness of those almost periodic solutions, and the bifurcation phenomenon in the driven system. Some numerical simulations are also presented for verifying obtained theoretical results.

Keywords：Forced Lorenz-84 system; almost periodic attractor; bifurcation.

Speaker's biography: 刘永建，教授，重庆大学博士生导师，广西大学、广西师范大学硕士研究生导师；1998 年湘潭大学数学专业毕业，于 2010 年华南理工大应用数学专业获博士学位。广西优秀教师，广西高校卓越学者，广西科学技术奖自然科学奖和广西高校自治区级教学成果奖获得者。现任玉林师范学院党委常委、副院长。主要从事混沌理论与应用研究。在混沌复杂性分析、吸引子几何解析、高维连续系统的闭轨相对位置等方面做出大量工作，获得了一些新结果。

Some stronger forms of topological transitivity for a sequence of uniformly convergent continuous maps （invited）

Tianxiu Lu [1,A,*], Guanrong Chen[2,B]

[1]College of Mathematics and Statistics, Sichuan University of Science and Engineering, Zigong, 643000, China
[2]Department of Electrical Engineering, City University of Hong Kong, 999077, Hong Kong Special Administrative Region, China
[A]Email: lubeeltx@163.com, [B]Email: eegchen@cityu.edu.hk
[*]Corresponding author: lubeeltx@163.com

Abstract：Transitivity (or ergodicity) is a prominent feature of chaotic behavior, and ergodicity is the research field of Furstenberg, who won the fields award in 2020. The method of transitive theory can bridge different fields in mathematics. The purpose of this research is to simplify the chaotic properties of map sequences to a single map, such as its limit map.

Let (H,d) be a metric space, F be a Furstenberg family, and $g_m(m\in ¥)$ is a sequence of continuous self-maps on H, which converges uniformly to a map g on H. Let $T\in \not\phi^{+}$ is an infinite set and

$$\lim_{m\in T,m\to\infty} d_{\infty}(g_m^m, g^m)=0$$

,

then some necessary and sufficient conditions, or sufficient conditions, for g to be some stronger forms of topological transitivity, syndetically transitive, double syndetically transitive, topologically ergodic, topologically strong ergodic, or topologically double ergodic are obtained.

Keywords：Transitive, ergodic, syndetic, map sequence

Stochastic Resonance and Bifurcation of Order Parameter in a Coupled System of Underdamped Duffing Oscillators

Ruonan Liu[1]，Yanmei kang[1,*]，Yuxuan Fu[1]，Guanrong Chen[2]

[1] School of Mathematics and Statistics, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049, China

[2] Department of Electronic Engineering, City University of Hong Kong, Hong Kong SAR, China

[*]Corresponding author: ymkang@xjtu.edu.cn

Abstract：The long-term mean-field dynamics of coupled underdamped Duffing oscillators driven by an external periodic signal with Gaussian noise is investigated. A Boltzmann-type *H*-theorem is proved for the associated nonlinear Fokker-Planck equation to ensure that the system can always be relaxed to one of the stationary states as time is long enough. Based on a general framework of the linear response theory, the linear dynamical susceptibility of the system order parameter is explicitly deduced. With the spectral amplification factor as a quantifying index, calculation by the method of moments discloses that both mono-peak and double-peak resonance might appear, and that noise can greatly signify the peak of the resonance curve of the coupled underdamped system as compared with a single-element bistable system. Then, with the input signals taken from laboratory experiments, further observations show that the mean-field coupled stochastic resonance system can amplify the periodic input signal. Also, it reveals that for some driving frequencies, the optimal stochastic resonance parameter and the critical bifurcation parameter have a close relationship. Moreover, it is found that the damping coefficient can also give rise to nontrivial non-monotonic behaviors of the resonance curve, and the resultant resonant peak attains its maximal height if the noise intensity or the coupling strength takes the critical value. The new findings reveal the role of the order parameter in a coupled system of chaotic oscillators.

Keywords：Duffing oscillator, order parameter, Boltzmann-type *H*-theorem, pitchfork bifurcation, stochastic resonance

Speaker's biography: Dr. Liu received the Ph.D. degree in applied mathematics from Xi'an Jiaotong University, Xi'an, China, in 2020. She is currently a lecturer with XuZhou University of Technology. Her research interests include stochastic resonance, nonlinear stochastic system, etc.

Dynamical analysis of an improved FitzHugh-Nagumo neuron model with multiplier-free implementation

Quan Xu[A]，Xiongjian Chen[B]，Bei Chen[C]，Huagan Wu[D]， Han Bao[E*]

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

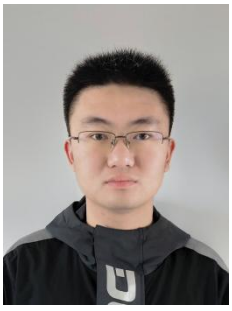
[A]Email: xuquan@cczu.edu.cn, [B]Email: chenxiongjian21@163.com, [C]Email: chenbei@cczu.edu.cn, [D]Email: wuhg@cczu.edu.cn, [E]Email: hanbao@cczu.edu.cn

[*]Corresponding author:hanbao@cczu.edu.cn

Abstract：The cubic-polynomial nonlinearity with N-shaped curve plays a crucial role in generating abundant electrical activities for the original FitzHugh-Nagumo (FHN) neuron model. The pioneer FHN neuron model is efficient in theoretical analysis and numerical simulation for the abundant electrical activities, but analog multipliers are indispensable in hardware implementation since the involvement of cubic-polynomial nonlinearity. Analog multiplier goes against the circuit integration of FHN neuron model due to its huge implementation costs. To avoid the involvement of analog multiplier in hardware implementation, a nonlinear function possessing N-shaped curve and multiplier-free implementation is presented in this paper. To confirm the availability of this nonlinear function in generating electrical activities, numerical simulations and hardware experiments are successfully executed on an improved two-dimensional (2D) FHN neuron model with externally applied stimulus. The results declare that the improved FHN neuron model can generate rich electrical activities of periodic spiking behavior, chaotic behavior, and quasi-periodic behavior. Analog circuit implementation without any multiplier and its hardware experiment show the availability of the proposed nonlinearity, which is appropriate for analog circuit implementation of FHN neuron-based neuromorphic intelligence.

Keywords：Multiplier-free implementation; Improved FitzHugh-Nagumo neuron model; Nonlinearity; Electrical activity; Hardware experiment

Speaker's biography: Xiongjian Chen received the BS degree inElectrical engineering and automation from Changzhou University Huaide College, Taizhou, China, in 2021. He is currently pursuing the MS degree in Electronics and science and technology under the secondary subject circuits and systems at Changzhou University. His research interest includes the design of neuromorphic circuit and memristive chaotic circuit.



An Improved Gumowski-Mira Map with Symmetric Lyapunov Exponents

Dengwei Yan[1,A], Lidan Wang[2*]，Shuankai Duan[2,B]

[1] College of Computer and Information Science, School of Chongqing Normal University, Chongqing, 401331, China
[2] College of Artificial Intelligence, School of Southwest University, Chongqing 400715, China
[A]Email: 411354525@qq.com, [B]Email: skduan@swu.edu.cn
[*]Corresponding author: ldwang@swu.edu.cn

Abstract：The symmetric Lyapunov exponents (LEs) are known to be an inherent property of continuous-time conservative systems. However, the research on this interesting phenomenon in a discrete-time chaotic map has not been reported. Thus, this paper presents an improved 2D chaotic map based on Gumowski-Mira (GM) transformation, which has a stable fixed point or an unstable fixed point depending on its control parameters. Furthermore, it can display symmetric LEs and an infinite number of coexisting attractors with different amplitudes and different shapes. To demonstrate the complex dynamics of the 2D chaotic map, this paper studies its control parameters related to dynamical behaviors employing numerical analysis methods. Then, the hardware implementation based on STM32 platform is established for illustrating the numerical simulation results. Next, the random performance of the 2D chaotic map is tested by NIST FIPS140-2 suite. Finally, an image encryption algorithm based on the 2D chaotic map is designed, and the results obtained reveal that the proposed chaotic map has excellent randomness and is more suitable for many chaos-based image encryptions.

Keywords：Chaotic map；symmetric Lyapunov exponent；coexisting attractor；image encryption；hardware implementation

Speaker's biography: Dengwei Yan received the ph.D. degree in Artificial Intelligence Academy from Southwest University, Chongqing, China, in 2022, where he is working in the School of Computer and Information Science at Chongqing Normal University.

His current research interests include nonlinear circuits and systems and fractal science.

Dynamic analysis of fractional-order memristor-coupled neurons and its applications in image encryption (invited)

Dawei Ding[1,A]，Heng Xiao，Zongli Yang

[1]Institute 1, School of Anhui University, Hefei, 230601, China

[A]Email: dwding@ahu.edu.cn

Abstract：Memristive neuron models can effectively simulate the dynamic behaviors of neurons in the human brain because of the nonlinearity and memorability characteristics of the memristor. Meanwhile, the dynamic behaviors of each neuron are different because of the heterogeneity, which may be derived from the different parameters or external drives of the same kind of neurons. In this talk, some fractional-order memristor-coupled neurons (FOMCN) were constructed through coupling heterogeneous neurons. It is found that the proposed FOMCN have rich dynamic behaviors by phase diagram, bifurcation diagram, Lyapunov exponents, and attraction basin. With the study of initial-depending bifurcation behaviors of FOMCN, it is found that FOMCN exhibit abundant coexisting multi-stability, such as periodic attractors, quasi-periodic attractors, chaotic attractors and hyperchaotic attractors. Furthermore, color image encryption based on FOMCN and the DNA encoding owns great keyspace and a good encryption effect. Finally, the digital implementations based on Advanced RISC Machine (ARM) are in good coincidence with numerical simulations.

Keywords： Fractional-order system, Memristor-coupled neurons, Coexisting multi-stability, Image encryption，ARM implementation

Dr. Dawei Ding is currently an Professor at the School of Electronic Information Engineering at Anhui University. He received the B.S. and M.S. degrees in School of Electronic and Information Engineering at Anhui University in 1997 and 2004, respectively, and Ph.D. degree in Department of Electronic Engineering at Shanghai Jiao Tong University in 2008. His research interests include nonlinear circuits, memristive neural networks, chaos and their application in information security. He has published near 100 journal and conference papers, and authorized more than 10 patents and software copyrights. He is now a member of IEEE, a member of IEEE CAS Nonlinear Circuits and Systems Technical Committee, a member of Chaos and Nonlinear Technical Committee of Circuits and Systems Branch of the Chinese Institute of Electronics, a member of Chaotic Secure Communication Special Committee of Chinese Association for Cryptologic Research, and a standing director of Anhui Communications Society.

Generalized Synchronization and Parameters Identification of Different-Dimensional Chaotic Systems in the Complex Field（invited）

Jian Liu[1,A,*]，Guanrong Chen[2]，Xiu Zhao[1]

[1]School of Mathematical Sciences, University of Jinan, Jinan, Shandong, China
[2]Department of Electrical Engineering, City University of Hong Kong, Hong Kong, China
[A]Email: ss_liuj@ujn.edu.cn, liujian1990@163.com
[*]Corresponding author: ss_liuj@ujn.edu.cn, liujian1990@163.com

Abstract: Generalized synchronization is a typical dynamical phenomenon in nonlinear systems, for which the real-valued setting has been widely investigated. The complex-valued functions relationship in generalized synchronization is equally important for complex-valued dynamical systems, which however are seldom studied. Complex parameters identification on the synchronization manifold remains an open problem owing to the absence of the persistent excitation (PE) condition in the complex field. This paper investigates generalized synchronization via a complex-valued vector mapping (CGS) for different-dimensional complex-variable chaotic (hyper-chaotic) systems (CVCSs) with complex parameters identification. Based on Lyapunov stability theory in the complex field and using an adaptive control method, some sufficient criteria are established to achieve CGS for CVCSs. Moreover, some necessary and sufficient criteria are derived to ensure complex parameters identification. Finally, the theoretical results are verified and demonstrated by reduced-order and increased-order simulation examples.

Keywords:
Complex-Variable Chaos (Hyper-Chaos); Complex-Valued Mapping; Nonlinear System; Generalized Synchronization.

Speaker's biography: Jian Liu received the B.S. degree in mathematics from Qufu Normal University, and the M.S. and Ph.D. degrees in control science and control engineering from Shandong University, China. She is currently a Full Professor with the School of Mathematical Sciences, University of Jinan, Shandong, China. Her research interest mainly focuses on nonlinear dynamics, synchronization, and control of complex systems.

Fractional-order heterogeneous neuron network with HR neuron and FHN neuron based on coupled locally-active memristors and its application

Dawei Ding[1,A], Heng Xiao[1,B], Zongli Yang[1,*]

[1]Institute 1, School of Anhui University, Hefei, 230601, China
[A]Email: dwding@ahu.edu.cn, [B]Email: 2506689834@qq.com
[*]Corresponding author: 07115@ahu.edu.cn

Abstract: Locally-active memristor can simulate the synapses of neural network, which plays a vital role in the research of neural networks. In this paper, a fractional-order locally-active memristor was proposed and its pinched hysteresis loops, locally-activity and non-volatile characteristics were analyzed. In order to probe into the firing behaviors of neural network, we put forth a neural network with a Hindmarsh-Rose(HR) neuron and a FitzHugh-Nagumo (FHN) neuron, which connectted by coupled fractional-order locally-active memristors. As revealed by the experimental results, coupled locally-active memristors as synapses can affect the coexisting firing behaviors of the network, and the recommended heterogeneous neural network has super coexisting firing behavior. Meanwhile, with the change of the coupling coefficient of the memristor, antimonotonicity appeared in the neural network. The complex dynamics is numerically explored by local attraction basin, bifurcation diagrams, Lyapunov exponential spectrum and phase plots. In particular, it can also produce complex bursting behaviors with external current and electromagnetic radiation. Furthermore, an image encryption method based on this fractional-order heterogeneous neural network model was introduced. Finally, the proposed fractional-order heterogeneous neural network and the image encryption scheme based on this neural network model were implemented by adopting STM32F103 microcontroller. The experimental results are highly consistent with the numerical simulation.

Keywords: Fractional-order system, Locally-active memristor, Heterogeneous neural network, Super coexisting firing behaviors, Bursting behaviors, Image encryption

Pseudo-almost periodic C^0-solution for evolution inclusion with mixed nonlocal plus local initial conditions

Li Ye[1,A], Yongjian Liu[2,*]

[1] School of mathematics and statistics, Guangxi Normal University, Guilin, Guangxi 541000, P.R. China.
[2]Guangxi Colleges and Universities Key Laboratory of Complex System Optimization and Big Data Processing, Yulin Normal University, Yulin, Guangxi 537000, P.R. China.[3]Institute 3, School of XXX, City, Postcode, China
[A]Email: 1508793310@qq.com
[*]Corresponding author: liuyongjianmaths@126.com

Abstract: This paper is devoted to the study of a class of evolution inclusion in Banach spaces with nonlocal plus local mixed initial conditions. Under some mild assumptions, a unique solvability result to the multivalued evolution problem is obtained via the arguments of fixed point principle and the theory of C^0-semigroup.

Keywords：evolution inclusion, almost periodic solution, pseudo-almost periodic solution, mixed nonlocal plus local initial conditions, existence and uniqueness

Regulating memristive neuronal dynamical properties via excitatory or inhibitory magnetic field coupling

Zhenghui Wen[1]，Chunhua Wang[1,*]，Quanli Deng[1]，Hairong Lin[1]

[1]Institute 1, College of Computer Science and Electronic Engineering, Hunan University, Changsha 410082, China
[*]Corresponding author: wch1227164@hnu.edu.cn

Abstract： The ion exchange in neurons can trigger time-varying magnetic fields. According to the superposition field principle, each neuron is exposed to the integrated magnetic field generated by the other neurons. This paper considers the effect of magnetic field coupling between two neurons on neuron dynamics. The magnetic flux of the memristor describes the impact of the magnetic field. According to the different coupling types of neurons, the excitatory coupling between excitatory neurons. The inhibitory magnetic coupling between excitatory and inhibitory neurons is also considered. And then, the excitatory and inhibitory magnetic field coupling is studied under different external excitation currents. The excitatory magnetic field coupling can promote the firing of neurons. When the intensity of inhibitory magnetic field coupling is large enough, the neuronal firing mode is static. The firing mode of neurons can be changed by adjusting the coupling intensity. Therefore, magnetic field coupling can provide new insights into the mechanism of information interaction between neurons. Finally, the excitability and inhibition of magnetic field coupling are improved by comparing magnetic field coupling with synaptic coupling. These results indicate that magnetic field coupling has the same function as a synapse to some extent and has the characteristics of radiation propagation.

Keywords： Magnetic field coupling · Inhibition and excitation · Electromagnetic induction · Hindmarsh– Rose neuron · Memristor

Speaker's biography: Wen zhenghui received the Bachelor's degree in College of Computer Science and Electronic Engineering, Hunan Normal University, Changsha, China. He is currently pursuing the M.E. degree in the College of Information Science and Engineering, Hunan University, Changsha, China. His main research interest is memristor-based non-linear neuronal dynamical system.

Fractal Evolution in Internet Information Propagation

Yang Yang[1,A], Fuzhong Nian[1,B,*]

[1] School of Computer and Communication, Lanzhou University of Technology, Lanzhou 730050, China

[A] YY_yy151@163.com, [B] gdnfz@lut.edu.cn.

[*]Corresponding author: gdnfz@lut.edu.cn

Abstract：In view of the fractal evolution phenomenon in Internet information dissemination, this paper constructs a generalized fractal network by analyzing the characteristics of user dissemination behavior and according to the dissemination trend of actual information. On this basis, it reveals the fractal evolution mechanism in Internet information dissemination and its dissemination dynamic characteristics and rules. First, based on node similarity, a fractal propagation model of Internet information is constructed. Secondly, based on the scale-free network and according to the user characteristics, the information dissemination process is simulated and a generalized fractal network is evolved. Then, the key factors influencing the formation of fractal networks, the characteristics, and the rules of propagation dynamics are analyzed. Finally, the rationality and validity of the model are verified by crawling the real user forwarded data in the micro-blog.

Keywords：Information Propagation, Fractal Network, Node Similarity, Micro-Blog.

Speaker's biography: Yang Yang received the B.S. degree in engineering from Lanzhou University of Technology, Lanzhou, China, in 2019. In 2021, she switched from a master's degree in computer application to a doctoral degree, and is currently pursuing a doctoral degree in manufacturing information systems at Lanzhou University of Technology. Her main research interests include modeling and analysis of complex networks, and applications of fractal theory.

Parallel bi-memristor hyperchaotic map with extreme multistability

Han Bao[A]，Yang Gu[B]，Quan Xu[C]，Xi Zhang[D]，Bocheng Bao[E*]

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: hanbao@cczu.edu.cn, [B]Email: gu_yang@126.com, [C]Email: xuquan@cczu.edu.cn [D]Email: zhangxi.98@163.com, [E]Email: mervinbao@126.com

[*]Corresponding author: mervinbao@126.com

Abstract：Discrete memristors can be used to construct chaotic and hyperchaotic mapping models by self-feedback or coupling method, but these constructed maps do not have multistability or extreme multistability. Towards this end, by connecting two identical discrete memristors in parallel, this paper presents a novel parallel bi-memristor hyperchaotic map using the self-feedback method. This map has a plane fixed point set and its stability is entirely determined by memristor initial states. The control parameters-reliant hyperchaotic behaviors and the initial states-reliant coexisting behaviors are disclosed using several numerical methods. Complex dynamical behaviors closely relative to memristor and non-memristor initial states are demonstrated, indicating the occurrence of extreme multistability. Besides, a digital hardware platform is developed and the experimental results are captured to well validate the numerical ones. Consequently, the presented parallel bi-memristor map can display hyperchaotic dynamics and it is flexible to show extreme multistability.

Keywords：Discrete memristor; plane fixed point set; initial state; extreme multistability; parallel bi-memristor map

Speaker's biography: Yang Gu received the B.S. degree in microelectronics science and engineering from the Wenzheng College of Soochow University, Suzhou, China, in 2019. He is currently working toward the M.S. degree in electronics science and technology with the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China.
His research interest is nonlinear circuits and systems.

Qualitative geometric analysis of traveling wave solutions of the modified equal width Burgers equation

Yongjian Liu[1,A]，Biyu Chen[2]，Xiezhen Huang[1,*]，Li Ye[2]，Zhouchao Wei[3]

[1]Institute 1, Yulin Normal University, Yulin, 537000, China
[2]Institute 2, Guangxi Normal University, Guilin, China
[3]Institute 3, China University of Geosciences, Wuhan,China
[A]Email: liuyongjianmaths@126.com
[*]Corresponding author: 270923365@qq.com

Abstract：This paper devotes to the qualitative geometric analysis of the traveling wave solutions of MEW-Burgers wave equation. Firstly, MEW-Burgers equation is transformed into an equivalent planar dynamical system by using traveling wave transformation. Then the global structure of the planar system is presented, and solitary waves, kink waves (anti-kink waves), and periodic waves are found. Secondly, Jacobi stability for the planar system is studied based on KCC theory, and Jacobi stability of any point on the trajectory of system is dicussed. The dynamical behavior of the deviation vector near the equilibrium points is analyzed, and the numerical simulation is consistent with the theoretical analysis. Lyapunov stability and Jacobi stability of the equilibrium points are also compared and analyzed. The obtaining results show that Lyapunov stability of the equilibrium points of the system is not exactly consistent with Jacobi stability. Finally, the planar system with periodic disturbance is transformed into a six dimensional nonlinear system, and the periodic, quasi-periodic, and chaotic dynamical behaviors of the system are numerically simulated.

Keywords：chaos; global analysis; Jacobi stability; Lyapunov stability; MEW-Burgers equation

Average price prediction of Chinese new energy stocks via Auto-Reservoir Neural Network （ARNN）

Lijun Pei[1,A,*]，Jingxin Song[1,B]

[1]School of Mathematics and Statistics, Zhengzhou University, Zhengzhou, 450001, Henan, P.R. China

[A,*]Corresponding author. Email: peilijun@zzu.edu.cn, [B]Email: xin15038036486@163.com

Abstract：Stock prediction is always a hot issue in financial market, but it is very difficult to predict accurately by traditional methods since the average stock price is unstable and non-linear. In order to improve the accuracy of stock prediction, based on the Auto-Reservoir Neural Network (ARNN) combining Reservoir Computing (RC) structure and Spatiotemporal Information (STI) transformation, 13 dimensions of historical data of 15 new energy stocks are taken as the research object for empirical research in this paper. ARNN directly translates the observed high-dimensional dynamics into its reservoir, mapping the high-dimensional/spatial data to future temporal values of the target variable based on STI transformation. It is found that Pearson Correlation Coefficients (PCC) between the predicted values and the true value of the stock average price is basically 0.80, and even more than 0.90, and Root Mean Square Error (RMSE) is low. In this paper, the results indicate that ARNN can achieve the accurate multi-step prediction only through short-term time series, and the errors between the predicted values and the real values is very small. Traditional stock prediction is mostly based on stock price time series, but this paper uses 13 dimensions of historical data to predict the stock average price, which has a good performance in terms of accuracy and efficiency, and has a high potential to predict the average prices excellently.

Keywords：Auto-Reservoir Neural Network (ARNN), stock forecast, Spatiotemporal Information (STI) transformation, Reservoir Computing (RC)

Speaker's biography: Dr. Lijun Pei received the B.S. degree in basic mathematics, the M.S. degree in applied mathematics from Henan Normal Univ. in Xinxiang, Henan, China and the Ph.D. degree in dynamics and control from Tongji Univ., Shanghai, China, in 1996, 2002 and 2005, respectively. He is currently a Professor and PHD supervisor with the Zhengzhou University. His research interests include delayed differential equations, reservior computing with delayed feedback, synchronization, analysis and predication of chaotic time series, etc.

Offset parameter cancellation produces countless coexisting attractors (invited)

Chunbiao Li [1, 2 a]), Tengfei Lei [3], and Zuohua Liu [4]

[1]*School of Artificial Intelligence, Nanjing University of Information Science & Technology, Nanjing 210044, China*
[2]*Collaborative Innovation Center on Forecast and Evaluation of Meteorological Disasters, Nanjing University of Information Science & Technology, Nanjing 210044, China*
[3]*Collaborative Innovation Center of Memristive Computing Application (CICMCA), Qilu Institute of Technology, Jinan 250200, China*
[4]*State Key Laboratory of Coal Mine Disaster Dynamics and Control， Chongqing University, Chongqing 400044, China*

Abstract： The average value of a system variable determines the position of its attractor. When the offset parameters come together and get disappeared after an algebraic operation, the location of the attractor is then only governed by an initial condition. In this case, parameter-dominated offset control turns out to be the initial condition-defined coexisting attractors. In this letter, a special mechanism for generating countless coexisting attractors is disclosed. Furthermore, the new regime of multistability is revealed, which explains where and how countless coexisting attractors are born and arranged.

a) Corresponding author, E-mail address: goontry@126.com; chunbiaolee@nuist.edu.cn

Multidirectional Associative Memory Neural Network Circuit based on Memristor

Sichun Du[1,A], Zedi Zhang[1,B], Jun Li[1], Chen Sun[1], Jingru Sun[1], Qinghui Hong[1,*]

[1]Institute 1, Hunan University, Changsha, 410082, China
[A]Email: jt_dsc@hnu.edu.cn, [B]Email: zhangzedi@hnu.edu.cn
[*]Corresponding author: hongqinghui@hnu.edu.cn

Abstract：Multidirectional associative memory neural network(MAMNN) is a direct extension of bidirectional associative memory neural network, which can handle multiple associations. In this work, a circuit of MAMNN based on memristor is proposed for the first time, which simulates the complex associative memory behavior more in line with the brain mechanism. Firstly, the basic associative memory circuit is designed, which is mainly composed of memristive weight matrix circuit, adder module and activation circuit. It realizes the associative memory function of single-layer neurons input and single-layer neurons output, so that the information can be transmitted unidirectionally between double-layer neurons. Secondly, on this basis, an associative memory circuit with multi-layer neurons input and single-layer neurons output is realized, which makes information transfer unidirectionally between multi-layer neurons. Finally, several identical circuit architectures are extended, and they are combined into a MAMNN circuit through the feedback connection from the output to the input, which realizes the bidirectional transmission of information between multi-layer neurons. Pspice simulation shows that: 1) When single-layer neurons are selected to input data, the circuit can associate data from other multi-layer neurons, realizing one-to-many associative memory function in the brain. 2) When multi-layer neurons are selected to input data, the circuit can associate the target data and realize the many-to-one associative memory function in the brain. The MAMNN circuit is applied to to the field of image processing, which can associate and restore damaged binary images, showing strong robustness.

Keywords：Multidirectional associative memory neural network, Memristor, Circuit design, Association and restoration of binary images.

Speaker's biography: Zedi Zhang received the B.S. degree from Nanjing Normal University, Nanjing, China, in 2021. She is currently pursuing the M.S. degree with the College of Computer Science and Electronic Engineering,Hunan University, Changsha, China. Her current research interests are the circuit design of memristors and its application.

Memristive Hénon Map with Hidden Neimark-Sacker Bifurcations

Kang Rong[1,A], Bocheng Bao[1,B*], Han Bao[1,C], Houzhen Li[1,D], Zhongyun Hua[2,E]

[1]Institute 1, Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[2]Institute 2, Harbin Institute of Technology, Shenzhen, School of Computer Science and Technology, Shenzhen, 518055, China

[1,A] Email: rk807020262@163.com, [1,B*]Email: mervinbao@126.com, [1,C]Email: leehzh@126.com, [2,D]Email: huazyum@gmail.com

[*]Corresponding author: mervinbao@126.com

Abstract：Due to the nonlinearity with inner state, memristors have been applied in vast continuous dynamical systems. However, the application of memristors in discrete dynamical systems has not received enough attention, yet. Toward this end, this paper presents a three-dimensional (3D) memristive Hénon map by coupling a memristor to the classical Hénon map. Using numerical measures, the memristor effects on the presented map are exhibited and the complex dynamical behaviors with multistability are disclosed therein. Particularly, since the presented map has no invariant points, a dimension-reduction conversion method is proposed to investigate its properties and its hidden Neimark-Sacker bifurcations are effectively interpreted. The results demonstrate that the introduction of discrete memristor makes the presented map own complex hidden dynamical behaviors, which greatly enhances the fractal structure complexity of the chaotic attractors. In addition, a digital hardware set is exploited to implement the 3D memristive Hénon map and the chaotic attractors are physically acquired thereby.

Keywords：Memristive Hénon map; memristor; dynamical effect; hidden Neimark-Sacker bifurcation; chaotic attractor

Speaker's biography: Kang Rong received the B.S. degree from the Faculty of Electronic Information Engineering, Huaiyin Institute of Technology, Huaian, China, in 2020, where he is currently pursuing the M.S. degree from the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. His research interests include discrete nonlinear chaotic systems and synchronization.

Observer-based Synchronization of Time-Delay Complex-Variable Chaotic Systems with Complex Parameters

Jianchao Liang[1,A], Jian Liu[1,B,*], Guanrong Chen[2]

[1]School of Mathematical Sciences, University of Jinan, Jinan, Shandong, China
[2]Department of Electrical Engineering, City University of Hong Kong, Hong Kong, China
[A]Email: liangjianchao2017@163.com, [B]Email: ss_liuj@ujn.edu.cn, liujian1990@163.com
[*]Corresponding author: ss_liuj@ujn.edu.cn, liujian1990@163.com

Abstract: Time-delay and unavailability of system states bring extra difficulties to synchronization of chaotic systems. This paper investigates observer-based synchronization of time-delay complex-variable chaotic systems (CVCSs) with complex parameters. Differing from the existing works that considered time delay only in the linear term of some special CVCSs, the two cases of time delay in and out of nonlinear terms in general CVCSs are considered here, respectively. In addition, for the case that system states are not available for control, an observer-based output feedback control approach is developed to estimate the system states and guarantee the time-delay CVCSs to achieve synchronization. Moreover, by combining Lyapunov-Krasovskii function with linear matrix inequality in the complex field, two sufficient criteria are derived to ensure complete synchronization of time-delay CVCSs. Finally, a numerical example is presented to illustrate the theoretical results.

Keywords: Complete synchronization; Complex-variable chaotic system; Complex parameter; Observer-based synchronization; Time delay

Speaker's biography: Jianchao Liang received the B.S. degree in applied mathematics from the Shandong University of Technology, Zibo, China, in 2021, where she is currently pursuing the M.S. degree in University of Jinan, Jinan, China. Her research interests mainly include nonlinear dynamics, synchronization, and control of complex systems.

Track 2: Memristors, chaotic circuit and application

Time	Speaker	Affiliation	Title
Session 01-T2—— Presider: Prof. Guangyi Wang, Bocheng Bao Time: Nov 26, 14:00-15:55 | (Tencent ID: 527-330-140)			
14:00-14:20	**Min Fuhong (invited)**	Nanjing Normal University	Switching dynamics of a non-smooth memristive Hindmarsh-Rose neuron system
14:20-14:40	**Jingru Sun (invited)**	Hunan University	An Efficient Memristive Alternating Crossbar Array and The Design of Full Adder
14:40-14:55	Yujiao Dong	Hangzhou Dianzi University	Smale Paradox of Chua Circuit-based Coupled Networks
14:55-15:10	Hairong Lin	Hunan University	A Memristive Synapse Control Method to Generate Diversified Multi-Structure Chaotic Attractors
15:10-15:25	Jingting Hu	Changzhou University	Memristor-induced mode transitions and extreme multistability in a map-based neuron model
15:25-15:40	Jianming Cai	Changzhou University	Analog/digital multiplier less implementations for nullcline-characteristics-based piecewise linear Hindmarsh-Rose neuron model
15:40-15:55	Xu Ma	Nanjing University of Information Science & Technology	Rotation control of an HR neuron with a locally active memristor
Coffee Break			
Session 02-T2——Presider: Prof. Chunhua Wang，Zhijun Li Time: Nov 26, 16:05-18:00 | (Tencent ID: 527-330-140)			
16:05-16:25	**Zhijun Li (invited)**	Xiangtan University	Electrical activities of heterogeneous networks with memristive synapses
16:25-16:45	**Shaobo He (invited)**	Central South University	Modeling and circuit realization of discrete memristor

16:45-17:00	Jiajie Ying	Hangzhou Dianzi University	Neuromorphic behaviors in VO_2 memristor-based circuits
17:00-17:15	Yicheng Jiang	Nanjing University of Information Science & Technology	Constructing meminductive chaotic oscillator
17:15-17:30	Zhuowu Wang	Changzhou University	Multi-scroll hyperchaos in discrete Tabu Learning neuron model
17:30-17:45	Ying-Fei Sun	Hangzhou Dianzi University	Ternary combinational logic gates design based on tri-valued memristors
17:45-18:00	Jianlin Zhang	Changzhou University	Adaptive synapse-based neuron model with heterogeneous multistability and riddled basins
Session 03-T2——Presider: Prof. Kehui Sun, Jun Mou Time: Nov 27, 9:20-11:15 | (Tencent ID: 527-330-140)			
9:20-9:40	**Quan Xu (invited)**	Changzhou University	Modeling analysis and hardware implementation of memristive neuromorphic circuits
9:40-10:00	**Yan Liang (invited)**	Hangzhou Dianzi University	Locally-active memristor and its application in neuromorphic computing
10:00-10:15	Yizi Cheng	Nanjing Normal University	Symmetric multistability and initial-related boosting in flux-charge domain of a memristive Shinriki oscillator
10:15-10:30	Ankai Wang	Changzhou University	DC-offset-induced hidden and asymmetric dynamics in Memristive Chua's circuit
10:30-10:45	Wei Zhou	Hangzhou Dianzi University	Edge of Chaos Kernel and memristive neurons
10:45-11:00	Xihong Yu	Changzhou University	Three-dimensional memristive Morris-Lecar model with magnetic induction effects and its FPGA implementation
11:00-11:15	Longxiang Fu	Central South University	A Memristive Hénon Map Based on the State Variable Difference and Its Analog Circuit Implementation
Coffee Break			

Session 04-T2——Presider: Prof. Chunhua Wang, Zhijun Li Time: Nov 27, 11:25-12:05 | (Tencent ID: 527-330-140)			
11:25-11:45	**Kehui Sun (invited)**	Central South University	Modeling of discrete memristor and its applications in chaotic systems
11:45-12:05	**Fang Yuan (invited)**	Shandong University of Science and Technology	Ti/ZrO2/Cu-based memristor for synaptic learning and memory functions
Launch Break			
Session 05-T2——Presider: Prof. Kehui Sun, Jun Mou Time: Nov 27, 14:00-15:35 | (Tencent ID: 527-330-140)			
14:00-14:20	**Zuohua Liu (invited)**	Chongqing University	Coupling mechanism of chaotic circuit strengthening electrolytic manganese
14:20-14:35	Yan-Mei Lu	Hunan University	The dynamics of a memristor-based Rulkov neuron with fractional-order difference
14:35-14:50	Xin-Rui Zhang	Hangzhou Dianzi University	Memristive balanced ternary single variable logic circuit and its application
14:50-15:05	Zhuguan Chen	Changzhou University	Memristive cyclic three-neuron-based neural network with chaos and global coexisting attractors
15:05-15:20	Xiao-Jing Li	Hangzhou Dianzi University	Design and Application of Crossbar Based on Tri-valued Memristors
15:20-15:35	Donglin Zhan	Central South University	Dynamics of a fractional-order Colpitts oscillator and its FPGA implementation
Coffee Break			
Session 06-T2——Presider: Prof. Kehui Sun, Jun Mou Time: Nov 27, 15:45-17:30 | (Tencent ID: 527-330-140)			
15:45-16:00	Xuefeng Luo	Changzhou University	Hidden extreme multistability and synchronicity of memristor-coupled non-autonomous memristive Fitzhugh-Nagumo models
16:00-16:15	Chengjie Chen	Nanjing Normal University	Memristive Hopfield neural network with coexisting symmetric behaviors

16:15-16:30	Xin-Rui Zhang	Hangzhou Dianzi University	Tri-State Memristors based on Composable Discrete Devices
16:30-16:45	Hui-meng Guo	Hangzhou Dianzi University	Simplification of Chua corsage memristor and hardware implementation of its neuron circuit
16:45-17:00	Shuyu Shi	Hangzhou Dianzi University	A Negative Capacitor Emulator Circuit and its Application in Chaotic Circuits
17:00-17:15	Shichang Wang	Hangzhou Dianzi University	Locally-Active Memristor-Based Reactance-Less Oscillator
17:15-17:30	Mengxin Gong	Henan University	A 3D medical model encryption based on chaotic system and partition diffusion

Switching dynamics of a non-smooth memristive Hindmarsh-Rose neuron system（invited）

Min Fuhong

School of Electrical and Automation Engineering, Nanjing Normal University,

Nanjing 210023, China.

*Corresponding author: minfuhong@njnu.edu.cn

Abstract: In this paper, the rich nonlinear dynamics of the non-smooth Hindmarsh-Rose neuron model with locally active memristor is investigated through the theory of discontinuous dynamical system. The switching mechanism of the system in three adjacent connectable domains are discussed through the mapping structures and two boundaries, in which the passable motion and grazing motion are analyzed at the separation boundaries, such as. By defining, classifying and judging various mapping structures, the state of period or chaotic motion can be better distinguished. The evolution of mapping structures in the system and the coexistence behaviors are explored via the coexistence bifurcation diagrams, phase planes, parameter maps, and attraction basins. By using the timing diagrams and changing the initial values, the coexistence behavior of firing activities under two different patterns in the HR system is comprehensively revealed. Finally, the hardware circuit implement of the HR system is established to validate the numerical results.

Keywords： Memristor, Hindmarsh-Rose neuron model, Switching Dynamics

Speaker's biography: Dr. Min Fuhong received the master's degree from the School of Communication and Control Engineering, Jiangnan University, in 2003, and the Ph.D. degree from the School of Automation, Nanjing University of Science and Technology, in 2007. From 2009 to 2010, she was a Post-Doctoral Research Fellow with the School of Mechanical Engineering, Southern Illinois University, USA. She is currently a Professor with the School of Electrical and Automation Engineering, Nanjing Normal University. Her research interests include chaos, memristive circuits, control and synchronization of chaotic circuits, and complex behavior of nonlinear power electronic circuits. She is IEEE Member.

An Efficient Memristive Alternating Crossbar Array and The Design of Full Adder（invited）

Jingru Sun[1,A], Meiqi Jiang[1,B], Zirao Liao[2,C], Qinghui Hong[1,D], Chunhua Wang[1,E]

[1]Hunan University, College of Computer Science and Electronic Engineering, Changsha, 410082, China
[2]Shanghai Jiao Tong University, College of Electronic Science and Technology, Shanghai, 200030, China
[A]Email: jt_sunjr@hnu.edu.cn, [B]Email: meiqi@hnu.edu.cn, [C] Email: 1911538379@qq.com, [D]Email: hongqinghui@hnu.edu.cn, [E]Email: wch1227164@hnu.edu.cn
[*]Corresponding author: jt_sunjr@hnu.edu.cn

Abstract： Memristor is one of the most promising emerging technology to solve the von Neumann bottleneck problem due to its non-volatile and binary characteristics. This paper studies the design method of high-efficiency logic circuit based on memristor. First, a Multiple Input Multiple Output (MIMO) logic circuit design scheme based on IMPLY and AND logic is proposed, which can derive multiple new efficient logic operation methods, and complete complex logic with fewer steps and memristors. Second, in order to perform rapid interactive operations between different rows, an alternating crossbar array structure is designed, which can quickly complete cross-row logic operations. Finally, a high-efficient Full Adder (FA) based on MIMO logic and alternating crossbar array is proposed. To accomplish 32-bit add operation, the proposed FA needs 160 memristors and only 41 steps. Compared with the state of art FA, our work has faster execution speed and fewer memristors

Keywords： Memristor, IMPLY Logic, crossbar array, multiinput logic, multi-output logic, full adder

Speaker's biography: Jingru Sun graduated from Hunan University, China. in 2014 with a Ph.D. degree in computer science and technology. Currently, she is an associate professor in College of Computer Science and Electronic Engineering, Hunan University. She has published more than 20 papers and her research interests include memristive storage circuit, memristive logic circuit and neuromorphic network, intelligent transportation.

Smale Paradox of Chua Circuit-based Coupled Networks

Yujiao Dong[A]，Yan Liang[B]，Guangyi Wang[*]

Institute of Modern Circuit and Intelligent Information, Hangzhou Dianzi University, Hangzhou, 310018

[A]Email: yjdong@hdu.edu.cn, [B]Email: liangyan@hdu.edu.cn

[*]Corresponding author: wanggyi@163.com

Abstract： Smale paradox is a kind of exotic dynamics in nonlinear systems or human brains. This paper focuses on the theoretical analyses of smale paradox phenomena in the Chua circuit-based coupled networks. The edge of chaos domain of the classical Chua circuit is obtained by calculating its small-signal impedance function. When the Chua circuit is operated at the edge of chaos, the coupled networks are established by using resistive coupling and capacitive coupling. According to the edge of chaos theory, the Chua circuit at the edge of chaos showing rest states may be destabilized by a coupled passive resistor, and then generates periodic attractors or even chaos, i.e., smale paradox. However, no smale paradox phenomenon is found in the capacitor-coupling network. The quantitative analyses verify the resistive coupling in the Chua circuit-based network has the ability to cause Turing instability and then generate smale paradox phenomena. The study of this kind of special spatio-temporal phenomenon provides a theoretical basis for understanding some action potentials of neurons and brains.

Keywords： Chua circuit; Chaos; Edge of chaos; Smale paradox; Coupled networks

Speaker'sbiography: Yujiao Dong received the B.Eng.and Ph.D.degrees from the School of Electrical and Electronic Engineering, Shandong University of Technology, Shandong, China in 2017 and Electronic Science and Technology from Hangzhou Dianzi University, Hangzhou, China in 2022, respectively. She was a research assistant in the University of Hong Kong from June, 2021 to June, 2022. She is currently a lecturer with Hangzhou Dianzi University. She focuses on memristors, chaos, nonlinear dynamics, memristive neurons, memristive neural networks, etc.

A Memristive Synapse Control Method to Generate Diversified Multi-Structure Chaotic Attractors

Lin Hairong[1,A]，Wang Chunhua[1*]，Xu Cong[1]，Zhang Xin[2]，Herbert H. C. Iu[3]
[1]Institute 1, College of Computer
Science and Electronic Engineering, Hunan University, Changsha, 410082, China
[2]Institute 2, College of Electrical and Information Engineering,
Hunan University, Changsha 410082, China
[3]Institute 3, School of Electrical, Electronic and Computer
Engineering, University of Western Australia, Perth, WA 6009, Australia
[A]Email: haironglin@hnu.edu.cn
[*]Corresponding author: wch1227164@hnu.edu.cn

Abstract： Due to the synapse-like nonlinearity and memory characteristics, memristor is often used to construct memristive neural networks with complex dynamical behaviors. However, memristive neural networks with multi-structure chaotic attractors have not been found yet. In this paper, a novel method for designing multi-structure chaotic attractors in memristive neural networks is proposed. By utilizing a multi-piecewise memristive synapse control in a Hopfield neural network (HNN), various complex multistructure chaotic attractors can be produced. Theoretical analysis and numerical simulation demonstrate that multiple multi-structure chaotic attractors with different topologies can be generated by conducting the memristive synapse-control in different synaptic coupling positions. Differing from traditional multi-scroll attractors, the generated multi-structure attractors contain multiple irregular shapes instead of simple scrolls. Meanwhile, the number of structures can be easily controlled with the memristor control parameters. Furthermore, we design a module-based analog memristive neural network circuit and the arbitrary number of multi-structure attractors can be obtained by selecting corresponding control voltages. Finally, based on the memristive HNNs, a novel image encryption cryptosystem with a permutation-diffusion structure is designed and evaluated, exhibiting its excellent encryption performances, especially the extremely high key sensitivity.

Keywords：Memristor, Hopfield neural network, multistructure attractor, extreme multistability, circuit implementation, image encryption

Speaker's biography: Dr. Hairong Lin received M.S. and Ph.D. degree in information and communication engineering and computer science and technology from Hunan University, China, in 2015 and 2021, respectively. He is currently a postdoctoral research fellow at the College of Computer Science and Electronic Engineering, Hunan University, Changsha, China. His main research interest includes memristive neural network modeling, Chaotic dynamical analysis, nonlinear circuit and neuromorphic engineering. He has published more than 20 papers in related international journals, such as IEEE-TII, IEEETIE, IEEE-TCAS-I, IEEE-TCAS-II, IEEE-TCAD, Nonlinear Dynamics, etc. He is IEEE Member.

Memristor-induced mode transitions and extreme multistability in a map-based neuron model

Bocheng Bao[A]，Jingting Hu[B]，Jingming Cai[C]，Xi Zhang[D]，Han Bao[E*]

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: mervinbao@126.com, [B]Email: hu_jt17205060207@163.com, [C]Email: caijianming0603@126.com, [D]Email: zhangxi.98@163.com, [E]Email: hanbao@cczu.edu.cn

[*]Corresponding author: hanbao@cczu.edu.cn

Abstract：Because of the advent of discrete memristor, memristor effect in discrete map has become the important subject deserving discussion. To this end, this paper constructs a memristor-based neuron model considering magnetic induction by combining an existing map-based neuron model and a discrete memristor with absolute value memductance. Taking the coupling strength and initial state of the memristor as variables, complex mode transition behaviors induced by the introduced memristor are disclosed using numerical methods, including spiking-bursting behaviors, mode transition behaviors, and hyperchaotic spiking behaviors. In particular, all of these behaviors are greatly dependent on the memristor initial state, resulting in the existence of extreme multistability in the memristive neuron model. Therefore, this memristive neuron model can be used to effectively imitate the magnetic induction effects when complex mode transition behaviors appear in the neuronal action potential. Besides, a hardware platform based on FPGA is developed for implementing the memristive neuron model and various spiking-bursting sequences are experimentally captured therein. The results show that when biophysical memory effect is present, the memristive neuron model can better represent the firing activities of biological neurons than the original map-based neuron model.

Keywords：Map-based neuron model; discrete memristor · mode transition; spiking-bursting; initial state; extreme multistability; hardware platform

Speaker's biography: Jingting Hu received the B.S. degree in building electrical and intelligence from the Anhui Jianzhu University, Anhui, China, in 2021. She is currently pursuing the M.S. degree in electronics science and technology with the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. Her research interest is memristor-based neuron.

Analog/digital multiplierless implementations for nullcline-characteristics-based piecewise linear Hindmarsh-Rose neuron model

Jianming Cai[A]，Han Bao[B]，Mo Chen[C]，Quan Xu[D]，Bocheng Bao[E*]

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: caijianming0603@126.com, [B]Email: hanbao@cczu.edu.cn, [C]Email: mchen@cczu.edu.cn, [D]Email: xuquan@cczu.edu.cn, [E]Email: mervinbao@126.com

[*]Corresponding author: mervinbao@126.com

Abstract：Multipliers are essential in implementing nonlinear neuron models, but they take huge implementation costs. Many multiplierless fitting schemes have been proposed to simplify the implementation of nonlinearities in neuron models. To optimize these schemes, this paper presents a nullcline-characteristicsbased piecewise linear (NC-PWL) fitting scheme for multiplierless implementations of Hindmarsh-Rose (HR) neuron model. This NC-PWL fitting scheme uses as few line segments as possible to approximate the critical nonlinearity characteristics of the local nullclines. A NC-PWL HR neuron model that reproduces diverse firing patterns of the original one is successfully established. Using off-the-shelf low-cost components, an analog multiplierless circuit is designed for this fitting model and welded on print circuit board (PCB). Meanwhile, by logical shift method, a digital multiplierless circuit with low resource consumption is developed for this fitting model on field-programmable gate array (FPGA) platform. Experimental results of the analog and digital multiplierless hardware implementations verify the numerical simulations and show the simplicity and feasibility of the presented fitting scheme.

Keywords：Multiplierless implementation, neuron dynamics, Hindmarsh-Rose (HR) neuron model, piecewise linear (PWL) fitting scheme.

Speaker's biography: Jianming Cai received the B.S. degree from the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China, in 2020, where he is currently pursuing the M.S. degree in electronic science and technology. His research interests include neuromorphic circuit and nonlinear circuits and systems.

Rotation control of an HR neuron with a locally active memristor

Xu Ma[1,2], Chunbiao Li[1,2,*] , Yaning Li[1,2], Lvqing Bi[3], Zhengya Qi[4]

[1] Jiangsu Collaborative Innovation Center of Atmospheric Environment and Equipment Technology (CICAEET), Nanjing University of Information Science & Technology, Nanjing 210044, China
[2] School of Artificial Intelligence, Nanjing University of Information Science & Technology, Nanjing 210044, China
[3] School of Physics and Telecommunications Engineering, Guangxi Colleges and Universities Key Laboratory of Complex System Optimization and Big Data Processing, Yulin Research Institute of Big Data, Yulin Normal University, Yulin 537000, China
[4] School of Information Science and Technology, Nantong University, Nantong 226019, China

[*]Corresponding author: goontry@126.com; chunbiaolee@nuist.edu.cn

Abstract: When a locally active memristor is applied to the Hindmarsh–Rose neuron, complex neuromorphological dynamics can be observed. Local active memristor leads to neuromorphological oscillation giving various neuron spiking. The rotation control is applied to explore the chaotic bursting. It is found that the amplitude of the neuron bursting changes regularly according to the angle of rotating without dynamics switching. The rotation control is compared with the offset boosting showing the complete control of spiking under selected rotation. The design of the rotation control matrix is the fundamental factor for amplitude control, which does not revise the Lyapunov exponents but only leaves a suitable amplitude and offset modification.

Keywords: HR neuron, local active memristor, rotation control.

Xu Ma: is currently pursuing the master'sdegree in electronic and communication engineering with the Nanjing University of Information Science and Technology, China. Her research interests include the areas of nonlinear dynamics and memristive circuits, including nonlinear circuits, systems, and corresponding applications.

Electrical activities of heterogeneous networks with memristive synapses（invited）

Zhijun Li

School of Automation and Electronic Information, Xiangtan University, Xiangtan, Hunan 41105, China

Email: lizhijun@xtu.edu.cn

Abstract：From sensing external stimuli to responding to them, the brain requires the cooperation of different neurons distributed in different functional areas. Therefore, studying dynamics of neural networks with memristive coupled heterogeneous neurons is of great value for understanding the operating mechanism of the brain. In this study, a memristor-coupled heterogeneous neural network consisting of one two-dimensional FitzHugh–Nagumo neuron and one two-dimensional Hindmarsh–Rose (HR) neuron is developed. Coexisting multiple firing patterns under different initial conditions are investigated by considering the coupling strength as a unique controlled parameter. Furthermore, it is found that the two heterogeneous neurons that initially oscillate independently gradually achieve synchronous firing behavior as the coupled strength gradually increases. In addition, the effect of the time delays in both neurons on firing activities of the heterogeneous neural network is also explored.

Keywords：Memristor; Heterogeneous network; Time delay; Firing pattern

Speaker's biography: Dr. Zhijun Li received the B.S. degree in information and computing science and the Ph.D. degree in physics from Xiangtan University, Xiangtan, China, in 2005 and 2014, respectively. He is currently a Professor with Xiangtan University. His research interests include chaos, memristor, etc.

Modeling and circuit realization of discrete memristor （invited）

Shaobo He[1,A*], Huihai Wang[1,B], Xianming Wu[2,C], Longxiang Fu[1,D], Kehui Sun[1,E]

[1]School of Physics and Electronics, Central South University, Changsha 410083, China
[2]School of Mechanical and Electrical Engineering, Guizhou Normal University, Guiyang 550025, China

[A]Email: heshaobo@csu.edu.cn, [B]Email: wanghuihai_csu@csu.edu.cn, [C]Email: jsdxwxm@126.com, [D]Email: fulongxiang@csu.edu.cn. [E]Email: kehui@csu.edu.cn
[*]Corresponding author: heshaobo@csu.edu.cn

Abstract： At present, modeling of discrete memristor is extended to the discrete domain and it becomes to be a new research hot topic. As a matter of fact, the discrete memrsitor has been widely used to design chaotic systems. In this reported, we focus on modeling and circuit realization of discrete memristors. Firstly, mathematical models of discrete memristor are proposed based on different difference including the forward difference operator, the Caputo fractional difference and the G-L fractional difference. The memory effect and characteristics of the discrete memristors are discussed, and a discrete memristor with short memory effects is designed. Secondly, FPGA digital circuit of fractional-order discrete memrsitors and analog circuit of an integer-order discrete memristor are implemented. Thirdly, discrete memristive systems are designed by introducing the fractional-order discrete memristor and integer-order discrete memristor to the chaotic map. Chaos is found in those systems and it shows that complexity of the systems can be controlled by the parameter of the memristor. Meanwhile, the circuits realization results are presented. The ``8''-type hysteresis loop curves are observed when input is the bipolar periodic signal. It shows that the discrete memristor can be realized using both digital circuit and analogue circuit, satisfies the three finger prints of generalized memristor and has potential application values in the engineering field.

Keywords： Memristor; Digital circuit; Discrete Analogue circuit; Chao

Speaker's biography: Shaobo He (S.87) received his BSc., M.S., and Ph.D. degrees in 2010, 2013, 2016 from School of Physics and Electronics, Central South University, Changsha, China. Currently, he is an associate professor of electronics in the Central South University. His research interests include dynamical analysis and applications of nonlinear systems, artificial intelligence algorithms and their applications in the nonlinear science field.

Neuromorphic behaviors in VO_2 memristor-based circuits

Jiajie Ying [A]，Yan Liang [B]，Guangyi Wang [*]

Institute of Modern Circuit and Intelligent Information, Hangzhou Dianzi University, Hangzhou 310018, China

[A]Email: yingjiajie7@163.com, [B]Email: liangyan@hdu.edu.cn

[*]Corresponding author: wanggyi@163.com

Abstract：Based on the mathematical model of VO_2 locally active memristor proposed by HRL Laboratories in the US, the second-order and third-order neuronal circuits are constructed, respectively, and the complex neuromorphic behaviors of the circuits are analyzed and the generation mechanism is revealed. The local activity and edge of chaos of the VO_2 memristor are analyzed through the small-signal analysis methods and the DC *V* - *I* plot. Theoretical analysis demonstrates the current-controlled VO_2 memristor satisfies the edge of chaos kernel condition. According to the theories of local activity and the edge of chaos, the dynamic characteristics of neuronal circuits are analyzed, showing that the edge of chaos is stable but potentially unstable. It's demonstrated that the biological neurons operate on the edge of chaos, and the neuromorphic behavior emerges on or near the edge of chaos domains. The third-order neuronal circuit has symmetrical oscillation behavior under positive and negative DC currents, whose symmetrical dynamic behaviors are analyzed using the bifurcation diagram, Lyapunov exponent spectrum, dynamics map, and domains distribution map.

Keywords：memristor, local activity, chaos, edge of chaos, neuron, neuromorphic behaviors

Speaker's biography: Jiajie Ying received the B.Eng. degree in Electronic Information Engineering from the School of Electronic Information Engineering, Hebei University of Science and Technology, Hebei, China, in 2016. She is currently pursuing the Ph.D. degree in Electronic Science and Technology at Hangzhou Dianzi University, Hangzhou, China, and will graduate in 2022. From July 2019 to October 2019, she was a Visiting Student with The University of Western Australia, Australia. Her current research interests include, nonlinear dynamics, memristive neuronal circuit, memristive systems, and memristive neural networks. She has published ten papers in these areas.

Constructing meminductive chaotic oscillator

Yicheng Jiang[1,A], Chunbiao Li[1,B *], Chuang Zhang[1], Tengfei Lei[2], Sajad Jafari[3]

[1]*School of Artificial Intelligence, Nanjing University of Information Science & Technology, Nanjing 210044, China*
[2]*Collaborative Innovation Center of Memristive Computing Application (CICMCA), Qilu Institute of Technology, Jinan 250200, China*
[3]*Biomedical Engineering Faculty, Amirkabir University of Technology, 424 Hafez Ave, 15875-4413, Tehran, Iran*
[A]Email: ycjnuist@163.com, [B]Email: goontry@126.com
[*]Corresponding author: goontry@126.com

Abstract: For the second order and nonlinearity with a meminductor, it can be embedded into a system for chaos producing. It is found that a mathematical meminductor can be introduced into a jerk system, which results in the same oscillation. And consequently, the system can be realized based on a new structure dominated by a meminductor. In this paper, a parallel structure with meminductor, resistor, and capacitor is proven to be such a schematic for jerk system realization. Consequently, typical meminductive circuits are constructed in this way providing convenient offset boosting, amplitude control, and coexisting oscillations with conditional symmetry.

Keywords: Meminductive circuit, offset boosting, amplitude control, conditional symmetry.

Yicheng Jiang: is currently working toward the doctor's degree in information and communication engineering from the Nanjing University of Information Science and Technology, Nanjing, China. His research interests include nonlinear dynamics and memristive circuits, including nonlinear circuits, systems, and corresponding applications.

Multi-scroll hyperchaos in discrete Tabu Learning neuron model

Bocheng Bao[A], Zhuowu Wang[B], Zhongyun Hua[C], Han Bao[D*]

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: mervinbao@126.com, [B]Email: wang_zw19851921213@163.com,
[C]Email: huazyum@gmail.com, [D]Email: hanbao@cczu.edu.cn
[*]Corresponding author: hanbao@cczu.edu.cn

Abstract: Most discrete neuron models have simple algebraic structures with easy digital implementation. However, they cannot show the abundant firing regimes of neurons. To address this issue, in this paper, we propose an improved discrete tabu learning neuron (IDTLN) model using sine nonlinearity as the activation function and analyze its fixed points with different stability types. We also investigate its model parameter-related bifurcation and regime transition behaviors as well as heterogeneous multistability using several numerical tools. With the dynamics distribution in the parameter plane, the multi-scroll hyperchaotic behaviors are revealed therein. Besides, we design six pseudorandom number generators (PRNGs) using the IDTLN model and evaluate their randomness using TestU01. The evaluation results show that the IDTLN model has high randomness without chaos degradation, which is particularly suitable for PRNG application. Finally, we develop a digital hardware platform to verify the regime transition and multi-scroll hyperchaos of the IDTLN model.

Keywords: Fixed point; improved discrete tabu learning neuron (IDTLN) model; multi-scroll hyperchaos; multistability; regime transition; pseudorandom number generator (PRNG)

Speaker's biography: Zhuowu Wang received the B.S. degree in automation from the Changzhou University, Changzhou, China, in 2022. He is currently pursuing the M.S. degree in electronics science and technology with the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. His research interest includes neural models and networks.

Ternary combinational logic gates design based on tri-valued memristors

Xiao-Yuan Wang [1,A], Ying-Fei Sun [1,B], Pu Li [1,C], Herbert Ho-Ching Iu[2,D]

[1]School of Electronics and Information, Hangzhou Dianzi University, Hangzhou 310018, China
[2]School of Engineering, The University of Western Australia, Crawley, WA 6009, Australia
[A]youyuan-0213@163.com, [B]13336062763@163.com, [C]ahjzulp@163.com,
[D]herbert.iu@uwa.edu.au
[*]Corresponding author: youyuan-0213@163.com

Abstract: Traditional binary combinational logic circuits are generally obtained by cascading multiple basic logic gate circuits, using more components and complicated wiring. In contrast to the binary logic circuits design in this method, ternary combinational logic circuit implementation is more complicated. In this paper, a ternary circuit design method that does not require cascading basic ternary logic gates are proposed based on a tri-valued memristor, which can directly realize specific logic functions through series connection of memristors. The ternary encoder, ternary decoder, ternary comparator and ternary data selector are implemented by this method and the effectiveness of the circuits are verified by LTSpice simulations.

Keywords: Ternary memristor; ternary encoder; ternary decoder; ternary comparator; ternary data selector

Ying-Fei Sun: Ying-Fei Sun received the B.Eng. degree in Electronic Information Science And Technology from the School of Electrical and Electronic Information of Wenzhou University, China, in 2022. She is currently pursuing a M.S. degree in Electronic Information at Hangzhou Dianzi University. Her current research interests are the application of triple value memristors in the field of digital logic.

Adaptive synapse-based neuron model with heterogeneous multistability and riddled basins

Han Bao[1,A], JianLin Zhang[1,B], Ning Wang[1,C], N.V. Kuznetsov[2,D], BoChen Bao[1,*]

[1]Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

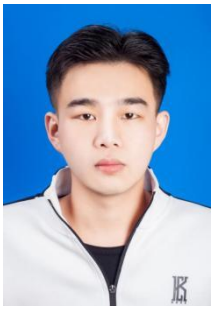
[2] St. Petersburg State University, Faculty of Mathematics and Mechanics, Peterhof, St. Petersburg 198504, Russia

[A]Email: hanbao@cczu.edu.cn, [B]Email: d_revolver@163.com, [C]Email: cczuwangning@163.com, [D]Email: nkuznetsov239@gmail.com

[*]Corresponding author: mervinbao@126.com

Abstract: Biological neurons can exhibit complex coexisting multiple firing patterns dependent on initial conditions. To this end, this paper presents a novel adaptive synapse-based neuron (ASN) model with sine activation function. The ASN model has time-varying equilibria with the variation of externally applied current and its equilibrium stability involves transitions between stable and unstable points through fold and Hopf bifurcations, resulting in complex distributions of attractive regions with heterogeneous multi-stability. Globally coexisting heterogeneous behaviors are studied by bifurcation diagram, phase portrait, dynamical distribution, and basin of attraction. The results show that the number of coexisting heterogeneous attractors can be up to 12, but for a simple neuron model, such a large number of coexisting heterogeneous attractors has not been reported in the relevant literature. Most interestingly, the ASN model also has riddled-like complex basins of attraction and four illustrative examples are depicted by the phase portraits with small changes of the initial conditions. Besides, the ASN model is implemented using simple microcontroller platform and various heterogeneous coexisting attractors are acquired experimentally to validate the numerical results.

Keywords: Adaptive synapse-based neuron model; Time-varying equilibrium; Coexisting heterogeneous attractors; Multi-stability; Riddled basin



Speaker's biography: Jianlin Zhang received a bachelor's degree in electronic science and technology from Changzhou University, Changzhou, China, in 2022, He is currently studying for a master's degree in electronic science and technology from Changzhou University. His research interest is brain like network theory and application.

Modeling analysis and hardware implementation of memristive neuromorphic circuits（invited）

Quan Xu[A]，Bocheng Bao[B*]，Mo Chen[C]，Han Bao[D]

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: xuquan@cczu.edu.cn, [B]Email: mervinbao@126.com, [C]Email: mchen@cczu.edu.cn, [D]Email: hanbao@cczu.edu.cn

[*]Corresponding author: mervinbao@126.com

Abstract：Memristive neuromorphic circuits have become a hotspot in the field of computational neuroscience. Regarded as a kind of special non-autonomous nonlinear circuit, the memristive neuromorphic circuits can generate complex firing patterns. But, there needs further perfection in theoretical analysis approaches, numerical simulation techniques, and experimental technique means for this class of memristor application circuits. This report gives some frames of modeling analysis and hardware implementation of memristive neuromorphic circuits. To more preciously demonstrate the electrophysiological characteristics of biological neurons, memristors are meaningfully employed to depict electromagnetic induction, ion channel conductance, and plastic synapse. Then, some examples are illustrated to exhibit these kinds of modeling methods and to disclose the complex firing patterns and dynamics evolutions. Also, the generated spiking/bursting firing patterns and their forming mechanisms are revealed and elaborated. What's more, the initial states associated multiple firing patterns are further disclosed. The analog/digital hardware implementations of the built memristive neuromorphic circuit are briefly introduced. These research achievements are available to establish the suitable theoretical foundation and hardware technical support for the design and engineering application of memristive neuromorphic circuits.

Keywords：Memristive neuromorphic circuit; modeling analysis; hardware implementation; firing pattern

Speaker's biography: Dr. Q. Xu received the B.S. degree in Physics from the Huaiyin Normal University, Huaiyin, China, in 2005, and the Ph.D. degree in Optical Engineering from the University of Electronic Science and Technology of China, Chengdu, China, in 2011. In 2018, he visited the University of Liverpool, United Kingdom.

He is currently an Associate Professor with the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. His research interest includes memristor-based chaotic circuits and memristive neuromorphic circuits. His Google h-index is 34 and i10-index is 65.

Locally-active memristor and its application in neuromorphic computing

Yan Liang[1,*] Guangyi Wang[1,A]

[1] Institute of Modern Circuit and Intelligent Information, Hangzhou Dianzi University, 310018

[A]Email: wanggyi@163.com

[*]Corresponding author: liangyan@hdu.edu.cn

Abstract：Locally-active memristors (LAMs) have broad application prospects in neuromorphic computing due to their nanoscale, low-power consumption, and local activity. LAMs can be categorized into S-type (current-controlled, CC) devices and N-type (voltage-controlled, VC) devices. A VC (or CC) LAM combined with a DC bias and an inductor (or a capacitor) can form an oscillator. We found that the performance of LAMs is closely associated with three crucial physical parameters, i.e., two static parameters (resistance and differential resistance) and one dynamic parameter, which provide benefits for the accurate modelling of memristive devices and designing related oscillators.

Since the LAM exhibits capacitive or inductive impedance characteristic at the specific operating points, it can replace the reactance element and further implement a reactance-less oscillator. The new design has two LAMs and no reactance element, and thus it has the advantages of high integration density.

A neuron circuit based on the N-type LAM is designed, where a variety of neuromorphic behaviors are successfully simulated, such as “all-or-nothing” behavior, spikes, bursting, periodic oscillation, etc. Then, an artificial tactile neuron and its frequency characteristics are presented by using the same neuron circuit topology. Furthermore, the S-type NbOx LAM-based oscillator could generate spiking behaviors and thus can be used as artificial neurons. LAM-based neurons combined with the memristive synaptic crisscross array are applied to construct a 25×10 spiking neural network (SNN). The recognitional function of digital 0 to 9 patterns is effectively realized by using frequency coding and time coding respectively.

Keywords：Memristor, local activity, dynamics, oscillator, artificial neuron.

Speaker’s biography: Yan Liang received the B.Eng. and Ph.D. degrees from the School of Information and Electrical Engineering, China University of Mining and Technology, Xuzhou, China, in 2011 and 2017, respectively. She is currently an associate professor with Hangzhou Dianzi University. Her current research interests include memristive systems, nonlinear dynamics, and artificial neural network. She has published over 20 papers in these areas.

Symmetric multistability and initial-related boosting in flux-charge domain of a memristive Shinriki oscillator

Yizi Cheng[1,A], Fuhong Min[2,*]

[1,2]School of Electrical and Automation Engineerin/School of Computer Science and Technology, Nanjing Normal University, Nanjing, 210023,China
[A]Email: chengyizi96@163.com
[*]Corresponding author: minfuhong@njnu.edu.cn

Abstract: This paper proposed a memristive Shinriki with a σ -controlled memcapacitor and a flux-controlled memristor. The complex 5D model is transform into simplified 3D model by flux-charge analysis. Furthermore, the consistency of symmetric dynamics, such as bubbles, multistability before and after dimensional reduction are discussed by bifurcation diagram, Lyapunov exponents and attraction basin. The initial-related boosting in flux-charge domain is also analyzed through mean graph. Finally, the accuracy of numerical analysis is confirmed via Multisim.

Keywords：Memristive Shinriki oscillator; Symmetric multistability; Flux-chaarge analysis; Initial-related boosting;

Speaker's biography: Mr. Yizi Cheng has received the M.E. degree in electrical engineering. He is currently purchasing the Ph.D. degree in physical electronics from Nanjing Normal University, Nanjing, China. He is a student member of the IEEE and his research interests include chaos, nonlinear circuit, etc.

DC-offset-induced hidden and asymmetric dynamics in Memristive Chua's circuit

Mo Chen[A], Ankai Wang[B], Chao Wang[C], Huagan Wu[D], Bocheng Bao [E*]

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: mchen@cczu.edu.cn, [B]Email: wakwakwak@126.com, [C]Email: 1058931448@qq.com, [D]Email: wuhg@cczu.edu.cn

[*]Corresponding author: mervinbao@126.com

Abstract： Hidden attractors have been discovered in classical Chua's circuits with special Chua's diode nonlinearities. But designing such physical Chua's circuits is a challenge due to the distinct slopes of Chua's diodes. The analog- circuit-based measurements of hidden dynamical behaviors are also difficult since their attraction basins are relatively small and independent of any equilibrium points. In this paper, a DC-offset method is proposed for obtaining hidden dynamics from preexisting nonlinear circuits. An improved memristive Chua's circuit with hidden dynamical behaviors is constructed by inserting a DC voltage source into the inductor branch therein. The DC-offset-induced hidden and asymmetric dynamical behaviors are revealed via equilibrium point analyses, numerical simulations, and experimental measurements. The coexistence of hidden attractors is demonstrated when the modified memristive Chua's circuit possesses at least one unstable equilibrium point or only one stable equilibrium point. Furthermore, a reconstituted model is formulated using the incremental integral transformation method to facilitate the measurements of hidden and coexisting attractors having relatively small attraction basins. With this model, the self-excited and hidden properties of the coexisting attractors are maintained, while their attraction basins are transferred to the neighborhood of the easily circuit-implemented origin point. Thus, the existence of hidden and coexisting attractors is readily verified via hardware circuit measurements.

Keywords： Memristive Chua's circuit; DC-offset; Equilibrium point; Hidden attractor; Asymmetric attractor; Multistability

Speaker's biography: Ankai Wang received the B.S. degree in electronics science and technology with the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China, in 2021. He is currently pursuing the M.S. degree in electronics science and technology with the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. His research interest is nonlinear circuits and systems.

Edge of Chaos Kernel and memristive neurons

Wei Zhou[A]，Yan Liang[B]，Guangyi Wang[*]

School of Electronic and Information, Hangzhou Dianzi University, Hangzhou 310018, China

[A]Email: zhouwei19951995@163.com, [B]Email: liangyan@hdu.edu.cn

[*]Corresponding author: wanggyi@hdu.edu.cn

Abstract：Chua's theory of local activity shows that local activity is the origin of complexity, and the complexity can only occur on or near the stable locally active domain, referred to as Edge of Chaos (EOC). Very recently, a new physical concept dubbed "Edge of Chaos Kernel" (EOCK), which exhibits the EOC phenomenon of being stable yet potentially unstable, was defined and applied to the Hodgkin-Huxley neural circuit model. This paper proposes the dual version of EOCK which consists of the parallel combination between a negative resistance and a negative capacitance, and is called *R*-*C* EOCK. We show that the actual NbO memristor contains an *R*-*C* EOCK and can form a second-order neuron when connected in parallel with a passive capacitor. More importantly, neuromorphic behaviors of static and dynamic pattern formation may emerge in a basic Cellular Neural Network consisting of two identical NbO memristor neurons coupled by a passive resistor, if and only if the single neuron has an *R*-*C* EOCK and is poised on the EOC, within which every neuron is stable but potentially unstable. The analysis in this paper explains the dynamic mechanism of Smale's paradox, in which two mathematically dead neurons coupled by a passive environment may become alive, under suitable conditions where the single neuron is endowed with an EOCK.

Keywords：memristor, edge of chaos, edge of chaos kernel, memristive neurons, smale's paradox

Speaker's biography: Wei Zhou is currently pursuing the Ph.D. degree in Electronic Science and Technology at Hangzhou Dianzi University, Hangzhou, China, and will graduate in 2022. From July 2018 to October 2018, she was a Visiting Student with The University of Western Australia, Australia. Her current research interests include nonlinear dynamics, memristive systems, memcapacitive systems, memristive neuron circuit, and memristive neural networks. She has published seven papers in these areas.

Three-dimensional memristive Morris-Lecar model with magnetic induction effects and its FPGA implementation

Han Bao[A]，Xihong Yu[B]，Quan Xu[C]，Huagan Wu[D]，Bocheng Bao[*]

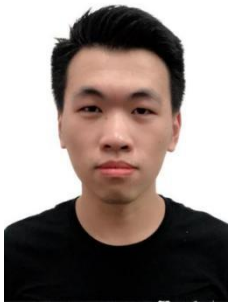
Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: hanbao@cczu.edu.cn, [B]Email: yxh15052315573@163.com, [C]Email: xuquan@cczu.edu.cn, [D]Email: wuhg@cczu.edu.cn

[*]Corresponding author: mervinbao@126.com

Abstract：To characterize the magnetic induction flow induced by neuron membrane potential, a three-dimensional (3D) memristive Morris-Lecar (ML) neuron model is proposed in this paper. It is achieved using a memristor induction current to replace the slow modulation current in the existing 3D ML neuron model with fast-slow structure. The magnetic induction effects on firing activities are explained by the spiking/bursting firings with period-adding bifurcation and periodic/chaotic spiking-bursting patterns, and the bifurcation mechanisms of the bursting patterns are elaborated using the fast-slow analysis method to create two bifurcation sets. In particular, the 3D memristive ML model can also exhibit the homogeneous coexisting bursting patterns when switching the memristor initial states, which are effectively illustrated by the theoretical analysis and numerical simulations. Finally, a digitally FPGA-based hardware platform is developed for the 3D memristive ML model and the experimentally measured results well verify the numerical ones.

Keywords：memristor; Morris-Lecar(ML) neuron model; firing pattern; homogeneous coexisting bursting patterns; hardware platform



Speaker's biography: Xihong Yu received the B.S. degree in electronic information engineering from the Huaide College of Changzhou University, Taizhou, China, in 2021. He is currently pursuing the M.S. degree in electronics science and technology with the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. His research interest is memristor and neural network.

A Memristive Hénon Map Based on the State Variable Difference and Its Analog Circuit Implementation

Longxiang Fu[1], Xianming Wu[2], Shaobo He[1,*], Huihai Wang[1], Kehui Sun[1]

[1] School of Physics and Electronics, Central South University, Changsha 410083, China
[2] School of Mechanical and Electrical Engineering, Guizhou Normal University, Guiyang 550025, China
[*]Corresponding author: heshaobo@csu.edu.cn

Abstract: In this paper, an improved memristive Hénon map is proposed by using the state variable difference instead of the state variable itself as the input of discrete memristor. As a result, the cumulative module in the discrete memristor can avoid the divergence. The bifurcation diagrams, Lyapunov exponent spectrums and spectral entropy complexity analysis results show that the system has rich dynamical behaviors. In addition, circuits of the discrete memristor and the memristive chaotic map are designed. PSIM circuit simulations and breadboard experiments verify the effectiveness of the proposed models. The analog circuits indicate the physical realizability of the discrete memristor. It lays the foundation for the applications of discrete memristor and can help to explain the physics significance.

Keywords: Discrete memristor, Chaos, Hénon map, Analog circuit, PSIM simulation.

Longxiang Fu: is currently pursuing the master's degree in electronic information with the Central South University, China. Her research interests include the areas of nonlinear dynamics and memristive circuits, including nonlinear circuits, systems, and corresponding applications.

Modeling of discrete memristor and its applications in chaotic systems

Kehui Sun

School of Physics and Electronics, Central South University, Changsha 410083, China
Email: kehui@csu.edu.cn

Abstract：Researches about memristor have aroused increasing interests in the last several years, but there are few reports on design of the discrete memristor. Based on the integer-order mathematical models, the discrete memristors are proposed. The discrete memristor is designed, where the amount of charge is determined by an integer-order discrete system. In the numerical simulations, it shows that the pinched hysteresis loops are observed. It also implies that the proposed memristor satisfies the definition of a memristor. As the applications, the discrete memristor are introduced to the discrete chaotic maps, and two discrete memristive chaotic maps are designed and analyzed, including the discrete memristor-based Hénon map, and a higher dimensional chaotic map based on the discrete memristor. Their dynamical behaviors are analyzed by the means of attractor phase diagram, bifurcation diagram, Lyapunov exponent spectrum, and spectral entropy complexity algorithm. Numerical simulations show that the discrete memristor can not only enlarge the hyperchaotic region of the original system, but also enhance the system complexity. Finally, the digital signal processor (DSP) implementation verifies the correctness of the solution algorithm and the physical feasibility of the system. Therefore, the discrete memristor has good application prospects in many fields. This talk also commemorates the 50th anniversary of the proposal of memristor by Prof. Chua L.

Keywords：Memristor, Discrete memristor, Chaos, Chaotic map

Speaker's biography: Prof. Kehui Sun received the BS degree in Applied Physics

in 1991, the Master degree in Industrial Automation in 1998, and the PhD in Control Theory and Control Engineering in 2005 from Central South University respectively. In 2008, as a visiting scholar, he visited the University of Wisconsin - Madison for one year. At present, he is the Dean of School of Physics and Electronics, Central South University, and the deputy director of chaos and nonlinear circuit special committee of circuit and system branch of China Electronics Society. He was awarded the excellent Master's Thesis instructor of Hunan Province from 2012 to 2017, 2019, and 2021, and the Baogang excellent teacher award in 2018. He has published more than 140 papers, and there are 6 highly cited papers among them. He won the title of "China's highly cited scholar" in Elsevier 2020 and 2021. His research interests include nonlinear physics, nonlinear circuits and systems, chaotic secure communication.

Ti/ZrO_2/Cu-based memristor for synaptic learning and memory functions（invited）

Fang Yuan[1,*]（袁方），Guibin Xing[1]（邢贵宾），Yue Deng[1]（邓玥），

Yuxia Li[1]（李玉霞）

[1] College of Electrical Engineering and Automation, Shandong University of Science and Technology, Qingdao, 266590, China

[*]Corresponding author: yuanfang@sdust.edu.cn

Abstract： Two-terminal memristor has become the most promising neural morphology artificial because its structure is similar to the biological synapse and it can simulate a variety of synaptic functions. In this work, the Ti/ZrO_2/Cu memristor with high adjustable resistance state is prepared by magnetron sputtering technology. And the function of neural synapses in different states are further demonstrated, including spike-time-dependent plasticity (STDP), post-tetanic potentiation (PTP) and short-term potentiation (STP). Besides, the synaptic function of learning-forgetting-relearning (LFR) processes is successfully emulated and demonstrated using a 3 × 3 artificial synapse arrays. This work presents an important advance in ZrO_2-based memristor and its application in both memory and neuromorphic computing.

Keywords： Ti/ZrO_2/Cu memristor, synapse, neuromorphic computing

Speaker's biography: Fang Yuan received the master's and Ph.D. degree in succession from the Hangzhou Dianzi University, China, in 2013 and 2017. He is currently an Associate Professor with the Shandong University of Science and Technology. His current research interests include nano-memristor, intelligent information and signal processing circuit design, information processing and encryption, brain-like circuit design.

Coupling mechanism of chaotic circuit strengthening electrolytic manganese

Zuohua Liu[1,*]，Haidong Zhong[1]，Chunbiao Li[2]，Yicheng Jiang[2]

1School of Chemistry and Chemical Engineering, Chongqing University, Chongqing 400044,
China
2School of Electronics and Information Engineering, Nanjing University of Information Science and Technology, Nanjing 210044, China
*Corresponding author: liuzuohua@cqu.edu.cn

Abstract：Manganese metal electrolysis is a typical nonlinear system far from the equilibrium state. In this case, nonlinear behaviors such as electrochemical oscillation and metal fractal occur in the electrode reaction process. This paper presents a new mode of chaotic current electrolysis by introducing a chaotic circuit instead of the original direct current power supply. Galvanostatic polarization, anode polarization, the Tafel test, X-ray diffraction, and scanning electron microscopy were employed to analyze the relationship between the electrochemical oscillation behavior and anodic deposited manganese oxides on lead alloy anodes. Research results show that the potential oscillation behavior of the anode is suppressed to a certain extent. The average oscillation period was increased by 5.6 s, and the average oscillation amplitude was reduced by 38 mV compared with direct current polarization after 350 A·m−2 constant current polarization for 30 min. This would help to reduce the generation of anode slime and additional energy consumption during electrolysis. At the same time,the dendrites at the cathode edge are significantly reduced, and only a single manganese dendrite with a size of about 200-300 μm was observed, and the fractal degree of manganese dendrites was reduced.The comprehensive analysis demonstrated that the application of hyperchaotic current to manganese metal electrolysis could achieve effective regulation of anode electrochemical oscillation, providing a new insight for the further reduction in the energy consumption and pollution emission in the electrolysis process.

Keywords：electrolytic manganese metal; electrochemical oscillation; chaotic circuit; hyperchaotic current

Speaker's biography: Zuohua Liu obtained his BS degree in Chemical Engineering from Chongqing Technology and Business University, MS degree in Physical Chemistry from Chongqing University in 2000. He received his Ph.D degree from Chongqing University in 2005. From Apr., 2007 to Apr., 2011, he was a postdoctoral fellow in Chongqing University. From 2011 to 2014, he was a visiting scholar in Tsinghua University and University of Utah. Prof. Liu,s research interests focus on process intensification of chemical engineering, resource environment chemical industry, and Green Smart Chemical. His research projects are from the National Natural Science Foundation of China, National Science and Technology Support Plan, and the Key Scientific and Technological Projects of Chongqing and so on.

The dynamics of a memristor-based Rulkov neuron with fractional-order difference

Yan-Mei Lu(卢艳梅)[1,A], Chun-Hua Wang(王春华)[1,B], Quan-Li Deng(邓全利)[1,C], Cong Xu(徐聪)[1,D]

[1]College of Computer Science and Electronic Engineering, Hunan University, Changsha 410082, China

[A]Email:LuYanmei@hnu.edu.cn, [B]Email: wch1227164@hnu.edu.cn, [C]Email: quanliden@hnu.edu.cn, [D]Email: xucong0703@163.com

[*]Corresponding author: wch1227164@hnu.edu.cn

Abstract: The exploration of the memristor model in the discrete domain is a fascinating hotspot. The electromagnetic induction on neurons has also begun to be simulated by some discrete memristors. However, most of the current investigations are based on the integer-order discrete memristor, and there are relatively few studies on the form of fractional order. In this paper, a new fractional-order discrete memristor model with prominent nonlinearity is constructed based on the Caputo fractional-order difference operator. Furthermore, the dynamical behaviors of the Rulkov neuron under electromagnetic radiation are simulated by introducing the proposed discrete memristor. The integer-order and fractional-order peculiarities of the system are analyzed through the bifurcation graph, the Lyapunov exponential spectrum, and the iterative graph. The results demonstrate that the fractional-order system has more abundant dynamics than the integer one, such as hyper-chaos, multi-stable and transient chaos. In addition, the complexity of the system in the fractional form is evaluated by the means of the Spectral Entropy complexity algorithm and consequences show that it is affected by the fractional order of the system. The feature of fractional difference lays the foundation for further research and application of the discrete memristor and the neuron map in the future.

Keywords: discrete memristor, Rulkov neuron, fractional-order difference, dynamics

Speaker's biography: Yanmei Lu received the Bachelor's degree in College of Computer Science and Electronic Engineering, Hunan Nurmal University, Changsha, China. She is currently pursuing the M.E. degree in the College of Information Science and Engineering, Hunan University, Changsha, China. Her main research interest is memristor-based non-linear system.

Memristive balanced ternary single variable logic circuit and its application

Xin-Rui Zhang [1,A]，Xiao-Yuan Wang [1,B]，Chun-Tao Dong[1,C]

[1]School of Electronics and Information, Hangzhou Dianzi University, Hangzhou 310018, China

[A]z1204315040@163.com, [B]youyuan-0213@163.com, [C]crazypink@163.com

[*]Corresponding author: youyuan-0213@163.com

Abstract： This paper proposes a novel design scheme of a balanced ternary digital logic circuit based on memristor. First, a design method of a balanced ternary single-variable logic function circuit is proposed. Then on the basis of the designed single variable logic circuit, combined with the balanced ternary multiplexer, some common application-type combinational logic circuits such as balanced ternary half adder, multiplier and numerical comparator are proposed. The above circuits are all simulated and verified in LTSpice, which confirms the feasibility of the proposed scheme.

Keywords： digital logic circuit, memristor, ternary logic

Xin-Rui Zhang: Xin-Rui Zhang received the B.Eng. degree in Electronic information engineering from School of Automation and Electronic Information, Xiangtan University, China, in 2021, where he is currently pursuing a M. S. degree in New generation electronic information technology at Hangzhou Dianzi University. His current research interest is memristor-based Pavlov associated memory.

Memristive cyclic three-neuron-based neural network with chaos and global coexisting attractors

Bao Han[A], Chen ZhuGuan[B], Cai JianMing[C], Xu Quan, Bao BoCheng[E*]

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: hanbao@cczu.edu.cn, [B]gunlin0980@163.com, [C]caijianming0603@126.com, [D]Email: xuquan@cczu.edu.cn

[*]Corresponding author: mervinbao@126.com

Abstract：It has been documented that a cyclic three-neuron-based neural network with resistive synaptic weights cannot exhibit chaos. Towards this end, a memristive cyclic three-neuron-based neural network is presented using a memristive weight to substitute a resistive weight. The memristive cyclic neural network always has five equilibrium points within the parameters of interest, and their stability analysis shows that they are one index-2 saddle-focus, two index-1 saddle-foci, and two stable node-foci, respectively. Dynamical analyses are performed for the memristive cyclic neural network by several numerical simulation methods. The results demonstrate that the memristor synapse-based neural network with the simplest cyclic connection can not only exhibit chaos, but also present global coexisting attractors composed of stable points and unstable periodic or chaotic orbits under different initial conditions. Besides, with the designed implementation circuit, Multisim circuit simulations and hardware experiments are executed to validate the numerical simulations.

Keywords：memristive weight, cyclic neural network, chaos, coexisting attractors, hardware experiment

Speaker's biography: Zhugaun Chen received the B.S. degree in Electronic and Information Engineering from Jiangsu University Jingjiang College, Zhenjiang, China, in 2020. He is currently a postgraduate student with the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. His research interest includes memristive neural network and memristor-based chaotic circuits.

Design and Application of Crossbar Based on Tri-valued Memristors

Xiao-Yuan Wang [1,A]，Xiao-Jing Li [1,B]，Pu Li [1,C]，Herbert Ho-Ching Iu[2,D]

[1]School of Electronics and Information, Hangzhou Dianzi University, Hangzhou 310018, China
[2]School of Engineering, The University of Western Australia, Crawley, WA 6009, Australia
[A]youyuan-0213@163.com, [B]lixiaojing20210226@163.com, [C]ahjzulp@163.com, [D]herbert.iu@uwa.edu.au
[*]Corresponding author: youyuan-0213@163.com

Abstract： Memristor crossbar array has been widely studied in the fields of non-volatile memory, digital logic circuits and neuromorphic computing due to its ultra-high storage density and powerful information processing capabilities. The current research on memristor cross array is mainly based on the binary memristors, which can only implement binary logic. In this paper, a crossbar based on tri-valued memristor is proposed, and the corresponding reset and read/write operations are designed. Because three-valued memristors can store tri-valued signals, the ternary memristor based crossbar array can effectively improve the storage density of non-volatile memory. Furthermore, an encoding-storing-decoding function circuit for three binary signals is designed using the crossbar as nonvolatile memory, which can restore a three-way binary signal to a one-way three valued signals by the encoder and execute this opposite process by the decoder. This design can be achieved by only one array storage unit, which effectively saves the memory of the storage space. All the effectiveness of the designed circuits are verified by LTSpice simulation.

Keywords ： Ternary memristor; ternary signals; memristor crossbar; encoding-storing-decoding function

Speaker's biography: Xiao-Jing Li received the B.Eng. degree in Electronic Information Engineering from School of Physics and Communications Electronics, Jiangxi Normal University, China, in 2021. She is currently pursuing a M.S. degree in Electronic Information at Hangzhou Dianzi University. Her current research interests are design method of ternary memristor logic circuit with resistance as logic variable and application of memristor crossbar array.

Dynamics of a fractional-order Colpitts oscillator and its FPGA implementation

Huihai Wang[1], Donglin Zhan[1],Xianming Wu[2],and Shaobo He[1]

[1] School of Physics and Electronics, Central South University, Changsha 410083, China

[2] School of Mechanical and Electrical Engineering, Guizhou Normal University, Guiyang 550025, China

Abstract：In this paper, a fractional-order Colpitts oscillator is investigated by employing multi-step frac-tional differential transform method as well as implemented on Field Programmable Gate Array (FPGA).Dynamic characteristics of the fractional-order system are analyzed using bifurcation diagrams, Lyapunov exponents, phase diagrams, and FuzzyEn complexity. Comparisons between the fractional-order Colpitts oscillator and the corresponding integer-order system show that the former has better dynamic properties.Phase diagrams implemented on FPGA are consistent well with simulation results. The main superiority of FPGA implementation is its flexibility in practical applications. It is easy to configure the values of derivative orders, step size, and system parameters in real time without changing hardware architecture, which lays a foundation for the application of the fractional-order Colpitts system.

Speaker's biography: Donglin Zhan received the B.Sc degree in electronic information science and technologyfrom the Central South university, Changsha, China, in 2021. He is currently studying for a master's degree in the School of Physics and Electronics of Central South University.His current research interests are the digital circuit realization of nonlinear chaos and the research of memristor to enhance chaos performance.

Hidden extreme multistability and synchronicity of memristor-coupled non-autonomous memristive Fitzhugh-Nagumo models

Mo Chen[A]，Xuefeng Luo[B]，Quan Xu[C]，Huagan Wu[D]*

Changzhou University, School of Microelectronics and Control Engineering, Changzhou, 213159, China

[A]Email: mchen@cczu.edu.cn, [B]Email: lxf_xz_96@163.com, [C]Email: xuquan@cczu.edu.cn, [D]Email: wuhg@cczu.edu.cn

*Corresponding author: wuhg@cczu.edu.cn

Abstract：

When the memristor is taken as a coupler to bridge two memristive systems, the intricate initial-condition-dependent coexisting and synchronous behaviors could be achieved, which have not been comprehensively concerned in literature. To this end, this paper presents a memristor-coupled homogeneous network consisting of two identical non-autonomous memristive Fitzhugh-Nagumo models and investigates the initial-condition-sensitive coexisting and synchronous behaviors therein. The kinetic analysis results show that the network can exhibit hidden extreme multistability. Complex dynamics of coexisting hidden hyper-chaotic, chaotic, periodic, and quasi-periodic attractors are numerically revealed and their synchronicities are controlled by the initial condition and coupling strength of the coupling memristor. By means of normalized mean synchronization errors, the synchronous effects of coupling memristor and subsystem initial conditions are numerically revealed. Complete and parallel-offset synchronization behaviors are realized with large positive coupling strengths and more negative coupling memristor initial conditions. Besides these two synchronous behaviors, phase synchronization is easily achieved due to the existence of external stimuli. These synchronization states are flexibly controlled by the initial conditions. Furthermore, an analog circuit is designed for the memristor-coupled homogenous network and PSIM circuit simulations are performed to verify the numerical results.

Keywords ： Homogenous network, memristor coupler, synchronization, Fitzhugh-Nagumo model, hidden extreme multistability.

Speaker's biography: Xuefeng Luo received the B.S. degree from the Faculty of Physics and New Energy, Xuzhou University of Technology, Xuzhou, China, in 2019, where he is currently pursuing the M.S. degree from the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. His research interests include nonlinear chaotic systems and synchronization.

Memristive Hopfield neural network with coexisting symmetric behaviors

Chengjie Chen, Fuhong Min*

School of Electrical and Automation Engineering, School of Computer and Electronic Information/School of Artificial Intelligence, Nanjing Normal University, Nanjing 210023, China

Email: chenchengjie77@163.com, Email: minfuhong@njnu.edu.cn

*Corresponding author: minfuhong@njnu.edu.cn

Abstract: Memristor is able to describe the electromagnetic induction evoked by membrane potential of neuron. To this end, the paper presents a simple memristive bi-neuron Hopfield neural network (MBHNN) with electromagnetic induction, where a flux-controlled memristor is used to link one neuron directionally. Coexisting symmetric behaviors are uncovered via theoretical analyses, numerical measures, and circuit simulations. By employing theoretical analyses, we demonstrate that the MBHNN model possesses symmetric solutions and symmetric equilibrium points. Through utilizing numerical measures including one- and two-argument bifurcation diagrams, dynamical maps, Lyapunov exponent spectra, basins of attraction, and phase plane plots, we confirm that the proposed MBHNN model displays coexisting periodic-and chaotic-bubbles and coexisting symmetric attractors. In addition, based on the mathematical model, physical analog circuit is built and the corresponding PSIM circuit simulations are deployed to testify these numerically measured results.

Keywords: Hopfield neural network, coexisting symmetric behavior, memristor, electromagnetic induction

Speaker's biography: Chengjie Chen received the B.S. degree in Electrical engineering and its automation from the Huaiyin Normal University, Huaian, China, in 2018, and the M.S. degree in Circuit and system from the School of Microelectronics and Control Engineering, Changzhou University, Changzhou, China. He is currently working toward the Ph.D. degree in Physical electronics with the School of Computer Science and Technology, Nanjing Normal University, Nanjing, China. He is author and coauthor of 12 peer reviewed articles. His research interests include memristive neural network, nonlinear circuit and system, and artificial intelligence.

Tri-State Memristors based on Composable Discrete Devices

Xin-Rui Zhang [1,A], Xiao-Yuan Wang [1,B], Xiao-Jing Li [1,C], Pu Li [1,D], Herbert Ho-Ching Iu[2,E]

[1]School of Electronics and Information, Hangzhou Dianzi University, Hangzhou 310018, China
[2]School of Engineering, The University of Western Australia, Crawley, WA 6009, Australia
[A]z1204315040@163.com, [B]youyuan-0213@163.com, [C]lixiaojing20210226@163.com, [D]ahjzulp@163.com, [E]herbert.iu@uwa.edu.au
[*]Corresponding author: youyuan-0213@163.com

Abstract: In this paper, we develop a tri-state memristive system based on the series and parallel combinations of binarized memristors, from both a dynamical systems construction to the development of in-house fabricated devices. Firstly, based on the SPICE model of the binary memristor, the series and parallel circuits of binary memristors are designed, and the characteristics of each circuit are analyzed in detail. Secondly, through the analysis of the connection direction and parameters of the two binary memristors, an effective method to construct a tri-state memristor is proposed, and verified using SPICE simulations. Finally, the characteristics of the constructed equivalent tri-state memristor are analyzed, and it is concluded that the amplitude, frequency and type of the input signal can affect the characteristics of the equivalent tri-state memristor. Predictions from this modelling were validated experimentally using Au/Nb2O5/Nb cross-point devices.

Keywords: Binary memristor; series and parallel circuits; tri-state memristor; LTspice; niobium oxide

Speaker's biography: Xin-Rui Zhang received the B.Eng. degree in Electronic information engineering from School of Automation and Electronic Information, Xiangtan University, China, in 2021, where he is currently pursuing a M. S. degree in New generation electronic information technology at Hangzhou Dianzi University. His current research interest is memristor-based Pavlov associated memory.

Simplification of Chua corsage memristor and

hardware implementation of its neuron circuit

Guo Hui-meng[1,A] Liang Yan [1,B*] Dong Yu-jiao[1] Wang Guang-yi[1]
[1]Institute 1, School Electronic Information, Hangzhou Dianzi University, Hangzhou 310018, China
[A]Email: guohm163@163.com, [B]Email: liangyan@hdu.edu.cn
[*]Corresponding author: liangyan@hdu.edu.cn

Abstract: The Chua corsage memristor (CCM) is a voltage-controlled locally-active memristor, which has complex dynamic behaviors and potential applications in the field of neuromorphic computing. According to the DC *V-I* plot, the CCM can be classified into two-lobe, four-lobe, and six-lobe types. The mathematical models of the three CCMs are simplified based on the mechanism of neuromorphic behaviors, namely, local activity. After the model simplification, the absolute value operation disappears, but the locally-active domain remains unchanged. For the simplified CCM, its small-signal equivalent circuit at the locally-active operating point has been established, which is consistent with CCMs before simplification.

To further investigate the application of voltage-controlled locally-active memristor in modeling the neuromorphic behavior of neurons, the simplified CCM model is used to construct a third-order neuron circuit. By applying theoretical analysis methods such as local activity, edge of chaos, and Lyapunov exponents, we predict the parameter domains where different neuromorphic behaviors are generated. According to the simplified CCM mathematical model, the corresponding emulator circuit is designed by using operational amplifiers, multipliers, resistors, and capacitors. Based on the presented memristor emulator circuit, the hardware implementation of the neuron circuit is given. The experimental results show that the simplified CCM-based neuron circuit can produce a variety of neuromorphic behaviors, including resting state, periodic spiking, chaotic state, bimodal response, periodic oscillation, all-or-nothing phenomenon, and spike clustering phenomenon. We expect that this work is helpful to further study the mechanism of neuromorphic behaviors of the neuron circuit and its practical applications.

Keywords: Memristor, local activity, neuron circuit, Chaos, hardware implementation.

Speaker's biography: Guo Hui-meng received the B.S. degree in electronic and information engineering from the North China University of Water Resources and Electric Power, Henan, China, in 2021. She is currently pursuing the master's degree in electronic information with Hangzhou Dianzi University, Zhejiang, China. Her current research interests include locally active memristors and nonlinear circuits.

A Negative Capacitor Emulator Circuit and its Application in Chaotic Circuits

Shuyu Shi[1,A], Yan Liang[1,B,*], Weifeng Lv[1], Meiyuan Gu[1], Guangyi Wang[1]

[1]Institute of Modern Circuits and Intelligent Information, Hangzhou Dianzi University, Hangzhou, 310018, China

[A]Email: 212040270@hdu.edu.cn, [B]Email: liangyan@hdu.edu.cn

[*]Corresponding author: liangyan@hdu.edu.cn

Abstract: Negative capacitance effect usually exists in ferroelectric materials, and its instinct nonlinearity and negative capacitance render its potential applications. At present, ferroelectric materials are mostly used to prepare the Negative Capacitance Field Effect Transistor (NCFET), which exhibits better performance than conventional CMOS. Considering the negative capacitance device is commercially unavailable, it is necessary to build a negative capacitor emulator in hardware for further investigating its electrical characteristics and applications. First, to explore the nonlinearity and negative capacitance effect of negative capacitor devices, based on a simple negative capacitor mathematical model, an emulator circuit that can mimic the S-shaped voltage-charge characteristics of the negative capacitor is proposed. The proposed emulator is composed of commercial off-the-shelf components, such as operational amplifiers, resistors, and capacitors. In addition, we design a new negative capacitor-based chaotic circuit which can generate complex dynamic behaviors. Like the single-period, double-period, single-scroll chaos, double-scroll chaos, and so on. Finally, based on the present negative capacitance emulator circuit, the hardware implementation of the chaotic circuit is given. The theoretical calculation, simulation analysis, and hardware experimental verification manifest that this proposed emulator circuit can be operated as a negative capacitor and applied in the chaotic circuit. Moreover, the circuit can generate stable and continuous chaotic behaviors, which can be used in the fields of information encryption and secure communication.

Keywords: negative capacitor, hardware emulator circuit, chaotic circuit

Speaker's biography: Shuyu Shi received the B.S. degree in electronic and information engineering from the Anhui Jianzhu University, Anhui, China. She is currently pursuing the master's degree in electronic information with Hangzhou Dianzi University, Zhejiang, China. Her current research interests include nonlinear devices and nonlinear circuits.

Locally-Active Memristor-Based Reactance-Less Oscillator

Yan Liang[1,A,*], Shichang Wang[1,B], Yujiao Dong[1], Zhenzhou Lu[1], and Guangyi Wang[1]

[1]Institute, Hangzhou Dianzi University, Hangzhou, 310018, China
[A]Email: liangyan@hdu.edu.cn, [B]Email: wupupup@163.com
[*]Corresponding author: liangyan@hdu.edu.cn

Abstract: Locally-active memristors (LAMs) have broad application prospects in neuromorphic computing due to their nanoscale, low-power consumption, and local activity. There has been much effort devoted to constructing oscillator by applying LAMs. A LAM combined with a DC bias and a reactance element (capacitor or inductor) can form an oscillator. Since the LAM exhibits capacitive or inductive impedance characteristic at the specific operating points, it can replace the reactance element and further implement a reactance-less oscillator, i.e., oscillators that do not contain reactive component such as inductances and capacitances. In this paper, two different LAMs-based reactance-less oscillators are proposed. One is based on two voltage-controlled (VC) LAMs, and the other mainly contains two current-controlled (CC) LAMs. Local activity theory, Hopf bifurcation theory, and the small-signal analysis method are used to quantitatively deduce the oscillation condition of the proposed circuit. A simple VC LAM mathematical model is taken as an example to conduct the analysis and verification. Both simulation and experiment results confirm the feasibility and practicability of the proposed LAMs-based reactance-less oscillator. The new design has no reactance element, and thus it has the advantages of high integration density, which could provide new oscillator topologies for the application of LAMs.

Keywords: memristor, local activity, reactance-less oscillator, Hopf bifurcation, hardware implementation

Speaker's biography: Shichang Wang received the B. S. degree in electronic and information engineering from the Hangzhou Dianzi University, Zhejiang, China, in 2021. He is currently pursuing a master's degree in electronic information at Hangzhou Dianzi University in Zhejiang, China. His current research interests include locally-active memristors and nonlinear circuits.

A 3D medical model encryption based on chaotic system and partition diffusion

Yang Lu[1,2,A*], Mengxin Gong[1,B], Lvchen Cao[2], Zhihua Gan[3], Xiuli Chai[1,2], Binjie Wang[4]

[1]Institute 1, School of Artificial Intelligence, Henan Key Laboratory of Big Data Analysis and Processing, Henan University, Zhengzhou 450046, China
[2]Institute 2, Henan Key Laboratory of Cyberspace Situation Awareness, Zhengzhou 450001, China
[3]Institute 3, School of Software, Intelligent Data Processing Engineering Research Center of Henan Province, Institute of Intelligent Network System, Henan University, Kaifeng 475004, China
[4]Institute 4, Huaihe Hospital of Henan University and the Medical Imaging Research Institute of Henan University, Kaifeng, 475000, China
[A]Email: lyhenu@126.com, [B]Email: 104754201228@henu.edu.cn
[*]Corresponding author: lyhenu@126.com

Abstract: As the digital age progresses, 3D models are widely used as a medium to represent things in a more visual and concrete way in medicine, military, virtual reality, and metaverse. With this comes the risk of data from 3D models being cracked by various attacks during transmission. Therefore, the protection of the data for the 3D models becomes crucial. In this paper, a 3D medical model encryption algorithm based on improved one-dimensional Chebyshev chaotic system (1-DICCS) and partition diffusion is proposed. Wherein, the 1-DICCS is designed on the basis of the Chebyshev chaotic system incorporating the principle of memristors, and experimental analysis verifies that it has better chaotic performance. In particular, the index sequence utilized to permute the vertex data in the 3D model is constructed from the pseudo-random sequence generated by this chaotic system. Further, to improve the security of the algorithm, partition diffusion is implemented for features with floating point coordinates of vertices, meaning that the vertices are decomposed into integer part and decimal part, for which different diffusion methods are applied. Experimental results show that a high level of security is achieved when encrypting 3D medical models.

Keywords: Chaos, 3D model, encryption, diffusion

Speaker's biography: Mengxin Gong received his B.S. degree in the College of Mechanical and Electrical Engineering from Henan Agricultural University, China in 2020. He is currently pursuing his M.S. degree at School of Artificial Intelligence, Henan University. His research interests are image processing, and compressed sensing.

Track 3: AI, Complex systems, neural networks and applications

Time	Speaker	Affiliation	Title
Session 01-T3——Presider: Yuexi Peng Time: Nov 26, 14:00-15:55 | (Tencent ID: 794-176-531)			
14:00-14:20	**Heping Wen (invited)**	Zhongshan Institute, University of Electronic Science and Technology of China	Cryptanalysis of image encryption scheme using variant hill cipher and chaos
14:20-14:40	**Yuexi Peng (invited)**	Xiangtan University	Dynamics analysis of chaotic maps: From perspective on parameter estimation by meta-heuristic algorithm
14:40-14:55	Ming-Yang Wu	Hangzhou Dianzi University	A memristive neural network circuit based on the Widrow-Hoff algorithm
14:55-15:10	Kechao Zheng	Southwest University	A spiking encoding circuit implementation based on Negative Photoconductance Memristor
15:10-15:25	Jun Liu	Central South University	A discrete memristive neural network and its application for character recognition
15:25-15:40	Chenxi Shang	Central South University	Dynamics and Chimera State in a Neural Network with Discrete Memristor Coupling
15:40-15:55	Zhao Yao	Central South University	Firing Patterns in a Fractional-order FithzHugh-Nagumo Neuron Model
Coffee Break			
Session 02-T3——Presider: Hegui Zhu Time: Nov 26, 16:05-18:00 | (Tencent ID: 794-176-531)			
16:05-16:25	**Hao Liao (invited)**	Shenzhen University	Deep Explainable Prediction of Online Review Networks
16:25-16:45	**Hegui Zhu (invited)**	Northeastern University	Logish: A New Nonlinear Nonmonotonic Activation Function for Convolutional Neural Network

16:45-17:00	Jinyuan Liu	Chongqing University of Posts and Telecommunications	A chaotic image encryption algorithm based on coupled piecewise sine map and sensitive diffusion structure
17:00-17:15	Zhuo Liu	Guizhou Education University	A Stream Cipher Algorithm Based on 2D Coupled Map Lattice and Partitioned Cellular Automata
17:15-17:30	Jiayang Wang	Hangzhou Dianzi University	Memristive DAE-GRU Network for Lithium-ion battery state of charge estimation
17:30-17:45	Zongwei Tang	Henan University	A hierarchical protection scheme for intellectual property of semi-open source datasets based on double watermarking
17:45-18:00	Wenhao Zhang	Southwest University	A Global Self-Attention Neural Network for Image Restoration Based on Memristor Circuit Implementation
Session 03-T3——Presider: Zhongyun Hua Time: Nov 27, 9:20-10:45 | (Tencent ID: 794-176-531)			
9:20-9:40	**Junxin Chen (invited)**	Dalian University of Technology	On the security of chaos-based image encryption schemes
9:40-10:00	**Zhongyun Hua (invited)**	Harbin Institute of Technology, Shenzhen	Design of chaotic systems with robust chaos
10:00-10:15	Musha Ji'e	Southwest University	A Simple Method for Constructing a Family of Hamiltonian Conservative Chaotic Systems
10:15-10:30	Zeyu Ruan	Southwest University	Exponential synchronization of uncertain delayed inertial neural networks with image encryption application
10:30-10:45	Jinying Liu	Southwest University	Memristive neural network circuit implementation of crossmodal associative learning between olfactory and visual
Coffee Break			
Session 04-T3——Presider: Chengqing Li Time: Nov 27, 10:55-11:35 | (Tencent ID: 794-176-531)			
10:55-11:15	**Fangyue Chen (invited)**	Hangzhou Dianzi University	Perceptron，the starting point of artificial intelligence

11:15-11:35	**Lidan Wang (invited)**	Southwest University	Memristor and memristor chaotic system
Launch break			
Session 05-T3——Presider: Chengqing Li Time: Nov 27, 14:00-16:00 | (Tencent ID: 794-176-531)			
14:00-14:15	Xinyu Du	Southwest University	Desired number of coexisting chaotic attractors using quaternionic fractal
14:15-14:30	Ying Li	Guangdong University of Technology	Chaotic image encryption algorithm based on elliptic curve and adaptive DNA coding
14:30-14:45	Xin Chen	Guangdong University of Technology	A chaotic image encryption method with global dynamic selection
14:45-15:00	Yiyang Huang	Guangdong University of Technology	Security analysis of image encryption algorithm based on two-dimensional infinite folding map
15:00-15:15	Qinmao Jiang	Guangdong University of Technology	A cryptanalysis based on a two-dimensional hyperchaotic mapping image encryption algorithm
15:15-15:30	Dongsheng Kuang	Guangdong University of Technology	Construction and application of high-dimensional digital chaotic system
15:30-15:45	Minzhi Xie	Guangdong University of Technology	Design and Application of a New Echo State Network Based on Chebyshev Map and Chaotic System in Digital Domain
15:45-16:00	Shuqi Sun	Southwest University	Memristor-based time-delay chaotic system with coexisting hidden attractors and pseudo-random sequence generator
Coffee Break			
Session 06-T3——Presider: Xiaofang Hu Time: Nov 27, 16:10-17:35 | (Tencent ID: 794-176-531)			
16:10-16:25	Peng He	Southwest University	Multi-Scale Attentive Neural Network for Image Restoration
16:25-16:40	Tongtong Gao	Southwest University	BSSCN-Net: Binary Neural Networks with Spatial Separable Convolutions and Spectral Normalization

16:40-16:55	Hongxin Peng	Southwest University	Design of pseudorandom number generator for controllable multi double-scroll chaotic system
16:55-17:05	Shengjie Xu	Southwest University	Application of Reservoir Computing Based on a 2D Discrete Memristive Map in Efficient Time Signal Processing
17:05-17:20	Fan Sun	Southwest University	Memristor's characteristics: From non-ideal to ideal
17:20-17:35	Yuanzhi Duan	Southwest University	Network Compression by Maintaining Channel Stability

Cryptanalysis of image encryption scheme using variant hill cipher and chaos（invited）

He-ping Wen[1,2]

[1]School of Electronic Information, Zhongshan Institute, University of Electronic Science and Technology of China, Zhongshan, 528402, China
[2]School of Information and Communication Engineering, University of Electronic Science and Technology of China, Chengdu, 611731, China
[*]Corresponding author: wenheping@uestc.edu.cn

Abstract：In 2019, a chaotic image encryption scheme based on a variant of the Hill cipher (VHC-CIES) was proposed by the Moroccan scholars. The encryption scheme introduces a Hill cipher variant and three improved one-dimensional chaotic maps to enhance the security of image encryption. In this paper, we conduct a comprehensive cryptanalysis of the scheme and find that the encryption scheme cannot resist the chosen-plaintext attack and the chosen-ciphertext attack due to its inherent flaws. When it comes to the chosen-plaintext attack, firstly, we select a plaintext with the pixel values are all zero and obtain its corresponding ciphertext. Then, the algorithm associated with the plaintext in the encryption scheme is eliminated, and its key stream is thus obtained. Secondly, we select a plaintext which the pixel values are invariably 1 and obtain its corresponding ciphertext to obtain some Hill cipher variant parameters in the original algorithm. Finally, we use the resulting steps of the first two and can recover the original plaintext image from the target ciphertext image. Similarly, a chosen ciphertext-attack method can also crack the target encryption algorithm. In addition, this paper verifies the effectiveness of two attack methods through algebraic analysis and experimental simulation. In order to improve the security of the encryption scheme, some suggestions are also given in this paper for further improvement.

Keywords：Image Encryption; Cryptanalysis; chaos

Speaker's biography: Dr. Heping Wen received the Ph.D. degree from the Guangdong University of Technology, Guangzhou, China, in 2019. He was a Post-Doctoral Researcher with the School of Information and Communication Engineering, University of Electronic Science and Technology of China, Chengdu, China from 2019 to 2021. He is currently an associate professor with the Zhongshan College, University of Electronic Science and Technology of China. His research interests include cryptanalysis and design of chaos-based cryptography, etc. He is CCF Senior Member.

Dynamics analysis of chaotic maps: From perspective on parameter estimation by meta-heuristic algorithm （invited）

Yuexi Peng[1], Kehui Sun[2], Shaobo He[2]

[1]School of Computer Science & School of Cyberspace Science, Xiangtan University, Xiangtan 411105, China
[2]School of Physics and Electronics, Central South University, Changsha 410083, China
[*]Corresponding author: yuexipeng@xtu.edu.cn

Abstract: Chaotic encryption is one of hot topics in cryptography, which has received increasing attention. Among many encryption methods, chaotic map is employed as an important source of pseudo-random numbers (PRNS). Although the randomness and the butterfly effect of chaotic map make the generated sequence look very confused, its essence is still the deterministic behavior generated by a set of deterministic parameters. Therefore, the unceasing improved parameter estimation technology becomes one of potential threats for chaotic encryption, enhancing the attacking effect of the deciphering methods. In this paper, for better analyzing the cryptography, we focus on investigating the condition of chaotic maps to resist parameter estimation. An improved particle swarm optimization (IPSO) algorithm is introduced as the estimation method. Furthermore, a new piecewise principle is proposed for increasing estimation precision. Detailed experimental results demonstrate the effectiveness of the new estimation principle, and some new requirements are summarized for a secure chaotic encryption system.

Keywords: Parameter estimation, chaotic map, particle swarm optimization, chaotic encryption

Speaker's biography: Dr. Yuexi Peng received the B.S. degree in Information and communication system from Changsha University of Science & Technology in 2017, and received the Ph.D. degree in physics from Central South University in 2020, respectively. the School of Computer Science & School of Cyberspace Science, Xiangtan University. His research interests include nonlinear dynamics, chaos control, fractional order theory and intelligent algorithm, etc.

A memristive neural network circuit based on the Widrow-Hoff algorithm

Xiao-Yuan Wang [1,A], Ming-Yang Wu[1,B], Zhen-Yu Ge [1,C], Xin-Rui Zhang[1,D], Zhi-Long Li [2,E], Shekhar Suman Borah [1,F]

[1]School of Electronics and Information, Hangzhou Dianzi University, Hangzhou 310018, China
[2]Indian Institute of Information Technology Guwahati, India
[A]youyuan-0213@163.com, [B]wmy1835460107@163.com, [C]pjincu@126.com,
[D]z1204315040@163.com, [E] lizhilong2022@126.com,
[F]borahsumanshekhar90@gmail.com
[*]Corresponding author: youyuan-0213@163.com

Abstract:
The neural network circuit based on memristors is a promising direction to realizing artificial neural networks at the hardware level. With the advantages of non-volatility, nanoscale size, and variable conductance, memristors can effectively simulate the strength of synaptic connections between neurons in neural networks. This paper proposes a new synaptic circuit based on memristor and CMOS, which can realize the adjustment of positive, negative, and zero synaptic weights by only one control signal. The relationship between synaptic weights and the duration of control signals is given in detail. On this basis, by designing the neuron circuit, the memristive neural network circuits based on the Widrow-Hoff algorithm are proposed to solve the recognition of three types of character pictures. Each circuit is simulated and verified by SPICE simulation, which proves the feasibility and effectiveness of the circuit design.

Keywords: memristor; synaptic circuit; neural network circuit; character pictures recognition

MINGYANG WU: received the B.Eng. degree in Electronic information engineering from School of Electronic Information, Hangzhou Dianzi University information engineering college, China, in 2022, where he is currently pursuing a M. S. degree in New generation electronic information technology at Hangzhou Dianzi University. His current research interest is memristor-based neural network.

A spiking encoding circuit implementation based on Negative Photoconductance Memristor

Kechao Zheng[1,A], Xiaofang Hu[1,2*]

[1]College of Artificial Intelligence, Southwest University, Chongqing 400715, China
[2]Brain-inspired Computing & Intelligent Control of Chongqing Key Lab, Chongqing 400715, China
Ministry of Education
[A]Email: zkc_cs@163.com
[*]Corresponding author: huxf@swu.edu.cn

Abstract: As the new generation of neural networks, spiking neural networks has become the focus of research in recent years, which uses biologically plausible neurons to provide faster reasoning and lower energy consumption. However, according to the neural algorithm and learning rules, a encoding part is required to convert external stimuli into spiking signals in the hardware implementation of a Spiking neural network. Unfortunately, traditional spiking neural network circuits mostly use digital signals as input, but the information of real world is mostly analog signal, so neural encoders need to be developed to meet the demand for neuromorphic computing. A hardware encoding design for neurons based on negative photoconductance memristor is introduced in this paper, which can convert optical signals into counting-based spiking neural coding. The encoding circuit proposed in this paper was used to encode the MNIST dataset ,and then the trained SNN was used to judge more than 93.07% accuracy.

Keywords: Memristor, spiking neural network, neuromorphic, circuit implementation.

Speaker's biography: Kechao Zheng received the B.E. degree in computer science and technology from NanJing Institute of Technology, NanJing, China, in 2020. He is currently working toward the M.E. degree with the College of Artificial Intelligence, Southwest University, Chongqing, China. Her current research interests include spiking neural network and circuit implementation.

A discrete memristive neural network and its application for character recognition

Shaobo He[a], Jun Liu[a], Huihai Wang[a,*], Kehui Sun[a]
[a]School of Physics and Electronics, Central South University, Changsha 410083, China
[*]Corresponding author: wanghuihai_csu@csu.edu.cn

Abstract：Design of artificial neural networks based on memristor has attracted increasing attentions from researchers. However, there are no reports on the discrete memristor based neural network. In this work, a novel discrete memristor BP neural network is designed. Firstly, a discrete memristor is introduced, in which the internal state can be controlled by the input discrete current signal. Secondly, theoretical basis of the proposed discrete memristor BP neural network is given where the weights are defined by the memristor resistance and can be adjusted according to discrete feedback errors. Finally, a three layers discrete memristor BP neural network is built to perform MNIST-10 handwriting recognition. Numerical results show a high classification accuracy of 97.16% and it verifies the effectiveness of the proposed method.

Keywords：Memristor, Discrete Memristor, BP Neural Network, Character Recognition.

Jun Liu: Jun Liu received the B.Sc degree in optoelectronic information science and engineering from the Central South university, Changsha, China, in 2021. He is currently a master degree candidate with the department of Electronic Information, Central South University, ChangSha, China. His current research interests include circuits and architectures of ANNs based on emerging memory technoligies and modeling the neural computing based on memristor.

Dynamics and Chimera State in a Neural Network with Discrete Memristor Coupling

Chenxi Shang[1]，Shaobo He[1]，Karthikeyan Rajagopal[2]，Huihai Wang[1]，Kehui Sun[1*]

[1]School of Physics and Electronics, Central South University, Changsha, 410083, China.
[2]Center for Nonlinear Systems, Chennai Institute of Technology, Chennai, India.

[*]Corresponding author: kehui@csu.edu.cn

Abstract：Due to characteristics of memristor are highly similar to the principle and structure of synapses in biological brains, memristor neural networks are widely studied. Discrete memristor made it possible to study the discrete memristor neural network. In this paper, the properties of the individual Chialvo neuron are discussed. The synchronization of two neurons through different firing modes coupled with a discrete memristor is studied by changing the coupling gain. A ring neural network is constructed, and two adjacent neurons are connected by a discrete memristor. Synchronization and chimera state in the network are analyzed from the coupling gain and the number of neurons with different firing modes in the network. Simulation results show that discrete memristor plays the role of synapse well and realizes the synchronization of neurons and neural networks.

Keywords：Discrete memristor model, Neural network, Synchronization, Chimera state, Discrete Neuron

Chenxi Shang: is currently pursuing the master's degree in electronic information with the Central South University, China. Her main research interests are discrete memristor neural networks, including network synchronization, chimera state, and other rich dynamic characteristics.

Firing Patterns in a Fractional-order FithzHugh-Nagumo Neuron Model

Zhao Yao Kehui Sun* Shaobo He

School of Physics and Electronics, Central South University, Changsha, China

*Corresponding author: kehui@csu.edu.cn

Abstract：Various neuron models and circuits have been developed to explore how neurons detect and encode different stimuli. However, relevant researches failed to consider edge effects and non-uniformity of realistic electronic components. In this paper, a fractional-order FithzHugh-Nagumo neuron circuit constructed by fractional order capacitor and inductor is investigated based on Adomain decomposition method. The impacts on firing patterns and Hamilton energy are also discussed with the variation of fractional orders. The variation of the order induces the shifting between bursting firing and chaotic firing, also between spiking firing and chaotic firing. Simulation results indicate that fractional-order FHN neural model is more suitable and experimental to model neural behaviors, and it provides a promising application in construction of the artificial neural network

Keywords：Neural circuit, Fractional calculus, FithzHugh-Nagumo neuron, Hamilton energy

ZhaoYao: is a PHD student in the Central South University (2020.09-present). He received his master degree in the Lanzhou University of Technology in June 2020. His research interests include nonlinear system, dynamical control, synchronization and computational neuronal dynamics.

Deep Explainable Prediction of Online Review Networks（invited）

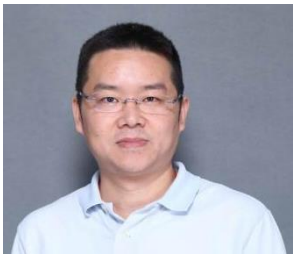
Hao Liao[1,A*]

[1]College of Computer Science and Software Engineering, Shenzhen University, Shenzhen, 518060, China
[A]Email: haoliao@szu.edu.cn
[*]Corresponding author: haoliao@szu.edu.cn

Abstract： The bloom of the Internet and the recent breakthroughs in deep learning techniques open a new door to AI for E-commence, with a trend evolved from using a few financial factors such as liquidity and profitability to using more advanced AI techniques to process complex and multi-modal data. In this paper, we tackle the practical problem of restaurant survival prediction. We argue that traditional methods ignore two essential aspects, which are very helpful for the task: 1) modeling customer reviews and 2) jointly considering status prediction and result explanation. Thus, we propose a novel joint learning framework for explainable restaurant survival prediction based on the multi-modal data of user-restaurant interactions and users' textual reviews. Moreover, we design a graph neural network to capture the high-order interactions and design a co-attention mechanism to capture the most informative and meaningful signal from noisy textual reviews. Our results on two datasets show a significant and consistent improvement than previous results.

Keywords： Online review networks, Restaurant survival prediction, Joint learning framework

Speaker's biography: Dr. Hao Liao received the M.E. degree in Computer Engineering from USTC, Hefei, China and the Ph.D. degree in Theoretical Physics from University of Fribourg, Switzerland, in 2011 and 2015, respectively. He is currently an Associate Professor with the Shenzhen University. His research interests include complex system, AI, information mining etc.



Logish: A New Nonlinear Nonmonotonic Activation Function for Convolutional Neural Network

（invited）

Hegui Zhu[1,*]， Huimin Zeng[1]，Jinhai Liu[2]，Xiangde Zhang[1]

[1]College of Sciences, Northeastern University,Shenyang, 110819, China
[2]College of Information Science and Engineering, Northeastern University, Shenyang, 110819, China
Corresponding author: zhuhegui@mail.neu.edu.cn

Abstract：
Activation function is an important component of the convolutional neural network. Recently, nonlinear nonmonotonic activation functions such as Swish and Mish have illustrated good performance in deep learning structures. In this paper, we propose a new nonlinear nonmonotonic activation function called Logish, which can be represented by $Logish(x)=x\cdot\ln(1+Sigmoid(x))$. Firstly, we take the logarithmic operation to reduce the numerical range of $1+Sigmoid(x)$, then we employ variable *x* to make the negative output have a strong regularization effect. Furthermore, we evaluate the image classification performance of Logish and its variant $Logish_{\alpha,\beta}(x)=\alpha x\cdot\ln[1+Sigmoid(\beta x)]$ in simple and complex networks with top–1 accuracy. Experimental results demonstrate that Logish's variant $\alpha=1$, $\beta=10$ can achieve 94.8% top-1 accuracy with ResNet–50 network on CIFAR 10 dataset, and can reach 99.24% top-1 accuracy with DenseNet on MNIST dataset and 88.52% top-1 accuracy with SE-Inception-v4 network on SVHN dataset respectively. It is higher than the Sigmoid, Tanh, ReLU, Swish and Mish activation functions in the corresponding dataset. It also verifies the performance and effectiveness of Logish.

Keywords: Activation function; convolutional neural network; nonmonotonic activation function; p image classification; top-1 accuracy

Speaker's biography: Hegui Zhu received his B.S. degree in Information and Computation Science in 2003 and his M.S. degree in Applied Mathematics in 2006, both from Northeastern University, Shenyang, China. In 2014, he obtained his Ph.D. degree in Operational Research and Cybernetics from Jilin University, Changchun, China. He is currently an Associate Professor with the Department of Mathematics, College of Sciences, Northeastern University. His current research interests include machine learning, image processing, and multimedia security.

A chaotic image encryption algorithm based on coupled piecewise sine map and sensitive diffusion structure

Jinyuan Liu[1, 2, A], Yong Wang[1, B, *], Zhuo Liu[3], Hong Zhu[4]

[1]College of Computer Science and Technology, Chongqing University of Posts and Telecommunications, Chongqing 400065, China

[2]School of Intelligent Technology and Engineering, Chongqing University of Science and Technology, Chongqing 401331, China

[3]School of Mathematics and Big Data, Guizhou Education University, Guiyang 550018, China

[4]School of Computer Science and Technology, Huazhong University of Science and Technology, Wuhan 430074, China

[A]Email: liujinyuan@cqust.edu.cn, [B]Email: wangyong_cqupt@163.com
[*]Corresponding author: wangyong_cqupt@163.com

Abstract：

This paper proposed a new chaotic system based on sine map, i.e., the coupled piecewise sine map (CPSM), which utilizes the piecewise mechanism to obtain more uniform probability density distribution of state values, and enhances the complexity of chaotic system by coupling parameters between sub-systems. The CPSM can be easily extended to high-dimensional, and each dimension has good characteristics. We analyzed the common chain diffusion structures in chaotic image encryption and find these structures are not sensitive to ciphertext tampering in the decryption stage. This problem may provide convenience for chosen ciphertext attacks. To remedy this problem, we proposed a new chain diffusion structure which makes the output results sensitive to both the plaintext and the ciphertext. Based on the CPSM and the ciphertext sensitive diffusion structure, we proposed a new image encryption algorithm. Since the CPSM can generate chaotic sequences with good cryptographic properties and the diffusion structure has good diffusion performance in both the encryption process and the decryption process, the proposed encryption algorithm is extremely sensitive to the ciphertext tampering. Thus, it can effectively resist the chosen ciphertext attacks. Experimental results and security analysis also confirmed that the proposed algorithm has good security and can ensure the secure transmission of image in the Internet.

Keywords： chaos-based cipher; image encryption; coupled piecewise sine map; cipher sensitive structure

Speaker's biography: Jinyuan Liu received his Master degree in Computer Science from Chongqing University, he is pursuing his Doctor degree in Computer Science at Chongqing University of Posts and Telecommunications. His research interests include chaotic system, differential privacy and biometric security.

A Stream Cipher Algorithm Based on 2D Coupled Map Lattice and Partitioned Cellular Automata

Zhuo Liu[1,2,A], Yang Wang[2,B]

[1]School of Mathematics and Big Data, Guizhou Education University, Guiyang, China
[2]College of Computer Science and Technology, Chongqing University of Posts and Telecommunications, Chongqing, China
[A]Email: liuzhuo1987@outlook.com, [B]wangyong_cqupt@163.com
[*]Corresponding author: wangyong_cqupt@163.com

Abstract: The two-dimensional coupled map lattice (2D CML) is a spatiotemporal chaotic model with complex dynamic behavior and has high potential for designing stream cipher. We propose an offset 2D CML model by adding different offsets for each lattice. The offset 2D CML model has better chaotic properties, such as larger Lyapunov Exponent and more uniform chaotic sequence, than the original 2D CML model, which provides a good basis for constructing stream cipher. We combine the offset 2D CML model with the Partition Cellular Automaton (PCA), and propose a stream cipher algorithm. In our algorithm, the PCA is used to control the extraction of pseudo-random number from the offset 2D CML model, which effectively hides the orbit information of system and enhances the complexity of attacking chaotic sequences. Moreover, some fast nonlinear transform operations are specially introduced into our algorithm to improve the running speed. Theory analysis and simulation tests both confirm that the proposed stream cipher algorithm has excellent statistics performance, high security and efficiency. It has great potential for guaranteeing data security in the internet.

Keywords: Coupled map lattice, Partitioned cellular automaton, Steam cipher, Chaos-based cryptography

Speaker's biography: Zhuo Liu is an assistant professor with the School of Mathematics and Big Data, Guizhou Education University, Guiyang, China. She has received her PhD degree in 2022 from Chongqing University of Posts and Telecommunications, Chongqing, China. Her current research interests focus on the chaos-based cryptography fields of pseudo random number generation (PRNG), the image encryption and the dynamic behavior analysis in the higher-dimensional chaotic system, and she has published more than 6 refereed journal and conference articles in those fields.

Memristive DAE-GRU Network for Lithium-ion battery state of charge estimation

Jiayang Wang[1,A], Shiqi Zhou[1,B], Xiaofang Hu[2,C], Zhekang Dong[1,*]

[1] Hangzhou Dianzi University, School of Electronics & Information, Hangzhou, 310018, China

[2] Southwest University, College of Artificial Intelligence, Chongqing, 400715, China

[A]Email: w.jy@hdu.edu.cn, [B]Email: shiqizhou@hdu.edu.cn, [C]Email: huxf@swu.edu.cn

[*]Corresponding author: englishp@126.com

Abstract：Considering the state of charge (SOC) cannot be directly measured owing to the highly complex and nonlinear physical and electrochemical properties involved in the batteries, designing systems that can accurately estimate the SOC has become a key technology in battery management systems (BMS). Existing data-driven SOC estimation approaches still suffer from some limitations such as slower running speed and higher power consumption due to the large number of samples required for training. To this end, this paper proposes a compact denoising autoencoder and gated recurrent unit (DAE-GRU) hardware architecture via memristor circuits for fast and accurate Lithium-ion battery SOC estimation. Specifically, the DAE module is designed to extract useful feature representation by reducing noise and increasing the dimensionality of battery measurement data. Then, the GRU module is designed to learn the long-term dependency of the high-dimensional battery data (voltage, current, and temperature) and achieve accurate SOC estimation. The overall performance is evaluated by Root Mean Square Error (RMSE) at different ambient temperatures (i.e., 0°C, 25°C, and 45°C) and multiple operating conditions. The experimental results demonstrate that the entire scheme has good performance in accuracy, robustness, and operation cost (referring to time cost and power consumption), compared to existing state-of-the-art approaches.

Keywords：state of charge estimation, denoising autoencoder, gated recurrent unit, neural network, memristor

Speaker's biography: Jiayang Wang received the B.E degree in Electronic Information Science and Technology from China Jiliang University, Hangzhou, Zhejiang, in 2021. She is currently working toward the master's degree in Electronic Science and Technology at the Hangzhou Dianzi University. Her research interests cover memristor theory and artificial neural network.

A hierarchical protection scheme for intellectual property of semi-open source datasets based on double watermarking

Yang Lu[1,2], Zongwei Tang[1,A], Xiuli Chai[1,2,B,*], Mingxu Wang[1], Shiping Song[1]

[1]Institute 1, School of Artificial Intelligence, Henan Key Laboratory of Big Data Analysis and Processing, Henan University, Kaifeng 475004, China
[2]Institute 2, Henan Key Laboratory of Cyberspace Situation Awareness, Zhengzhou 450001, China
[A]Email: tzw@henu.edu.cn, [B]Email: chaixiuli@henu.edu.cn
[*]Corresponding author:chaixiuli@henu.edu.cn

Abstract：The high quality datasets are an important guarantee for the rapid development of deep learning, so the protection of datasets should be taken seriously. The semi-open source datasets are the datasets that are free for some users and used for academic communication and are charged for another part of users and generates commercial value. However, most of the existing datasets protection mechanisms are only a single passive copyright verification mechanism, which cannot protect semi-open source datasets well. Based on this situation, this paper proposes a hierarchical protection scheme for the intellectual property of semi-open source datasets based on double watermarking. The scheme adopts different protection schemes for datasets for the above mentioned user groups: internal users and purchased users, to achieve the purpose of hierarchical protection. The passive verification and active protection functions for semi-open source datasets are realized by embedding blind watermark and visual watermark, respectively. Finally, the paper conducts experiments on a number of underlying datasets to verify the imperceptibility, universality, harmlessness and effectiveness of the scheme.

Keywords：Double watermarking, Semi-open source datasets, Active protection , Passive verification

Speaker's biography: Zongwei Tang, M.S., received his B.S. in Engineering Automation from Donghua University of Technology in Nanchang, China, in 2017. He is now pursuing his master's degree at the School of Artificial Intelligence, Henan University, Zhengzhou, China. His inquiry interests include machine vision, image watermarking, etc.

A Global Self-Attention Neural Network for Image Restoration Based on Memristor Circuit Implementation

Wenhao Zhang[1,A]，Yue Zhou[1]，Shukai Duan[1,2,3]，Xiaofang Hu[1,2,3,*]

[1]College of Artificial Intelligence, Southwest University, Chongqing 400715, China
[2]Brain-inspired Computing & Intelligent Control of Chongqing Key Lab, Chongqing 400715, China
[3]Key Laboratory of Luminescence Analysis and Molecular Sensing (Southwest University), Ministry of Education
[A]Email: zwh981116@163.com
[*]Corresponding author: huxf@swu.edu.cn

Abstract：Convolutional neural networks are widely used in image restoration tasks, but they are limited by local operations and cannot be used to model long-range pixel dependencies. Recently, using the idea of non-local operations, various non-local networks and visual transformers have been proposed to address this problem of CNNs. However, the large number of parameters and complex operations make them unfavorable for end-side deployment. In this paper, we propose an efficient Global Self-Attention Neural Network (GSA-Net) for image restoration, and present a circuit design implementation scheme for GSA-Net based on memristor. Specifically, we design two global attention modules: the Global Spatial Attention Module (GSAM) and the Global Channel Attention Module (GCAM) to complete the modeling and inference of global relations. The GSAM is used to to models global spatial relations between the pixels of the feature maps, while the GCAM explore the global relations across the channels. In order to deal with image regions with complex textures, we also designed a multi-scale local information extraction module. Powered by these two designs, GSA-Net enjoys a high capability for capturing both local and global dependencies for image restoration. Finally, we provide a full-circuit implementation scheme of these three modules, using a modular design to complete the circuit design of the entire GSA-Net. The quantitative and qualitative results on synthetic and real datasets show that our proposed method outperforms state-of-the-art restoration approaches on image dehazing, deblurring, deraining and low-light enhancement benchmarks.

Keywords：Image Restoration, attention mechanisms, memristor circuit, non-local.

Speaker's biography: Wenhao Zhang received the B.E. degree in computer science and technology from Zhengzhou University, Zhengzhou, China, in 2020. He is currently working toward the M.E. degree with the College of Artificial Intelligence, Southwest University, Chongqing, China. His current research interests include image processing, computer vision, and deep learning.

On the security of chaos-based image encryption schemes（invited）

Junxin Chen[1]

[1]Dalian University of Technology, School of Software, Dalian, 116621, China
[*]Corresponding author: junxinchen@ieee.org

Abstract：
In recent decades, there has been considerable popularity in employing nonlinear dynamics and permutation-substitution structures for image encryption. Three procedures generally exist in such image encryption schemes: the key schedule module for producing encryption elements, permutation for image scrambling and substitution for pixel modification. This paper cryptanalyzes families of image encryption schemes that adopt pixel-level (bit-level) permutation and modular addition (bit-wise XOR) based substitution. The security analysis first reveals a common defect in the studied image encryption schemes. Specifically, the mapping from the differentials of the ciphertexts to those of the plaintexts is found to be linear and independent of the key schedules, permutation techniques and encryption rounds. On this theory basis, a universal chosen-ciphertext attack is further proposed. Experimental results demonstrate that the proposed attack can recover the plaintexts of the studied image encryption schemes without a security key or any encryption elements. Related cryptographic discussions are also given.

Keywords： Cryptanalysis, substitution and permutation, chosen-ciphertext attack

Speaker's biography: **Dr Junxin Chen** is currently a Professor at the School of Software, Dalian University of Technology, Dalian 116621, China. He received the B. Sc. Degree in Communications Engineering and M.Sc. and Ph.D degrees in Communications and Information System, all from Northeastern University in 2007, 2009, and 2016 respectively. From 2019 to 2020, he was a Postdoc Research Fellow in Department of Computer and Information Science, under the UM Macau Talent Programme (Class A), University of Macau. He worked as an Assistant Professor and Associate Professor in the College of Medicine and Biological Information Engineering, Northeastern University, Shenyang, China. Dr. Chen is currently working as a Full Professor at the School of Software, Dalian University of Technology. His research interests include internet of medical things, compressed sensing, artificial intelligence and information security. He has authored/co-authored over 60+ scientific papers in international peer-reviewed journals and conferences, such as, IEEE T-MM, T-CSVT, T-II, IoT, and IEEE Network, IEEE Photonics Journal, etc. He has an h-index of 27, and a total of 2100 citations. He is a topic Editor of Electronics, the Leading Guest Editor of IEEE Journal of Biomedical and Health Informatics, International Journal of Distributed Sensor Networks, etc., a Guest Editor of Signal Processing: Image Communication, etc. He is a regular reviewer of extensive top-tier field journals. He has received more than 10 awards from Mainland China and Macau. He has received about 1.5 million RMB funding from government and industry as PI. He has given more than 30 invited talks for universities and companies in China and Australia, such as University of Macau, Deakin University, etc. He is Senior Member of IEEE.

Design of Chaotic Systems with Robust Chaos（invited）

Zhongyun Hua

Harbin Institute of Technology, Shenzhen, School of Computer Science and Technology, Shenzhen, 518055, China
Email: huazyum@gmail.com;

Abstract： The robust chaotic behaviors indicate that a chaotic system has chaotic behaviors in the entire chaotic range, and no periodic windows exist. When chaotic systems are applied to many practical applications, they are required to have robust and complex hyperchaotic behaviors. In this talk, we introduce some chaotic map generation methods that can generate many chaotic maps with robust chaotic behaviors. The first method is constructed from *n* parametric polynomials with arbitrary orders, and its parameter matrix is configured using the preliminaries in linear algebra; the second method is built using the Pascal-matrix theory; and the third method utilizes existing one-dimensional chaotic maps as seed chaotic maps. Theoretical analysis proves that the proposed methods can produce high-dimensional hyperchaotic maps with multi positive Lyapunov exponents and thus exhibit robust hyperchaotic behaviors. To show the effects of the proposed methods, different dimensional hyperchaotic maps with robust hyperchaotic behaviors are generated using each generation method. Performance evaluations and comparisons demonstrate that the generated chaotic maps have more complex chaotic behaviors and better distribution of outputs compared with existing chaotic maps. A microcontroller-based hardware platform is developed to implement the generated hyperchaotic maps, and their chaotic sequences are tested to show high randomness. In addition, to demonstrate the applications of the generated hyperchaotic maps, we develop two chaos-based secure communication schemes. Simulation results show that the proposed chaotic maps with robustness have a stronger ability to resist channel noise than representative chaotic maps.

Keywords ： Chaotic system, Robust Chaos, Arnold Cat map, Hardware Implementation, Hyperchaotic Sequence, Secure Communication

Speaker's biography: Dr. Zhongyun Hua received the B.S. degree from Chongqing University, Chongqing, China, in 2011, and the M.S. and Ph.D. degrees from University of Macau, Macau, China, in 2013 and 2016, respectively, all in software engineering.

He is currently an Associate Professor with the School of Computer Science and Technology, Harbin Institute of Technology, Shenzhen, Shenzhen, China. His research interests include chaotic system, chaos-based applications, and multimedia security. He has published more than sixty papers on the subject, receiving more than 4100 citations, including mora then thirty IEEE Transactions papers. He is an Associate editor of International Journal of Bifurcation and Chaos.

A Simple Method for Constructing a Family of Hamiltonian Conservative Chaotic Systems

Musha Ji'e[1,A], Dengwei Yan[1,B], Shuqi Sun[1,C], Fengqing Zhang[2,D], Shukai Duan[1,E], Lidan Wang[1,*]

[1]Southwest University, College of Artificial Intelligence, Chongqing, 400715, China
[2] Southwest University, College of Electronic and Information Engineering, Chongqing, 400715, China
[A]Email: jemus10070301@163.com, [B]Email: 411354525@qq.com, [C]Email: shuqi_sun@163.com, [D]Email: zfqjessica@163.com, [E]Email: duansk@swu.edu.cn
[*]Corresponding author: ldwang@swu.edu.cn

Abstract: Conservative chaotic systems (CCSs) have unique advantages over dissipative chaotic systems (DCSs) in the fields of secure communication and pseudo-random number generators (PRNGs), etc. However, there are relatively fewer reports on CCSs than DCSs. To this end, this paper proposes an effective method for constructing a family of Hamiltonian conservative chaotic systems (HCCSs) by letting any three of the four sub-bodies denoted by 4D generalized Euler equations share a rotation axis. From theoretical analysis to experimental verification, one of the proposed HCCSs is studied thoroughly to demonstrate the effectiveness of this method. The example system has an infinite number of equilibrium points, which belong to either centers or saddles, resulting in hidden chaos. Besides, through the bifurcation diagram, parametric chaotic set, and Lyapunov exponent, richly dynamic behaviors related to parameters are displayed. Moreover, the 3D phase portraits verify that the Hamiltonian energy is conservative. Numerous energy-related coexisting orbits are discovered in this system, such as the coexistence of quasi-periodic orbits, chaotic orbits, and chaotic quasi-periodic orbits. Furthermore, the breadboard-based circuit is implemented to illustrate the HCCS's physical feasibility. Finally, the PRNG based on the HCCS has excellent randomness in terms of NIST and TESTU01 test results.

Keywords: Hamiltonian conservative chaotic system, Casimir power, hidden chaos, coexisting orbits, PRNGs and randomness tests, analog circuit

Speaker's biography: Mr. Musha Ji'e received the B.S. degree in physics from China West Normal University, Nanchong, China, in 2016, and the M.S. degree in computer science and technology from the Jiangxi University of Science and Technology, Ganzhou, China, in 2020. He is currently pursuing the Ph.D. degree in computer science and technology with Southwest University, Chongqing, China. His research interests include nonlinear chaotic systems and circuits, memristive systems, and chaos-based applications.

Exponential synchronization of uncertain delayed inertial neural networks with image encryption application

Zeyu Ruan[1,A], Lidan Wang[1,B], Shukai Duan[1,*]

[1] Southwest University, College of Artificial Intelligence, Chongqing, 400715, China
[A]Email: ruanzeyu123@163.com, [B]Email: ldwang@swu.edu.cn
[*]Corresponding author: duansk@swu.edu.cn

Abstract: In this paper, the exponential synchronization for uncertain delayed inertial neural networks is studied based on guaranteed cost intermittent control method. For the inertial neural network with second-order form, it is simplified into the form of first-order differential equations by variable substitution method. A new lemma is given to prove that the general system can achieve exponential stability through guaranteed cost intermittent control. Based on Lyapunov stability theory and intermittent control strategy, the sufficient conditions for the existence of guaranteed cost intermittent control are given. According to the new lemma, the exponential synchronization of uncertain delayed inertial neural networks is realized by guaranteed cost intermittent controller. In addition, the upper bound of the cost function is also obtained. In order to improve the control performance, The function fmincon is used to minimize the upper bound of the cost function, so as to obtain the control gain. Finally, the effectiveness and feasibility of the method are verified by a numerical simulation example, and the application of image encryption is verified according to the previous synchronization results.

Keywords: Guaranteed intermittent control; exponential stabilization; uncertain delayed inertial neural networks; image encryption.

Speaker's biography: Zeyu Ruan has received the B.S. degree in information and computing science and the M.S. degree in operational research and cybernetics from South-Central MinZu University, Wuhan, China, in 2018 and 2022, respectively. Now, she is currently pursuing the Ph.D. degree in computer science and technology at Southwest University, Chongqing, China. Her research interests include chaos, complex system, etc.

Memristive neural network circuit implementation of crossmodal associative learning between olfactory and visual

JinYing Liu[1,A], Yue Zhou[1], Shukai Duan[1,2], Xiaofang Hu[1,2,*]

[1]College of Artificial Intelligence, Southwest University, Chongqing 400715, China

[2]Brain-inspired Computing & Intelligent Control of Chongqing Key Lab, Chongqing 400715, China

[A]Email: jyliuu@163.com

[*]Corresponding author: huxf@swu.edu.cn

Abstract: Associative learning is an important branch of neuromorphic cognitive systems. Using biological behaviors to realize associative learning circuits in artificial neural systems has become a research hotspot in the field of brain-like intelligence and neuromorphic computing systems. In the process of associative learning, the neural system conducts comprehensive processing through a variety of sensory information, while most associative learning circuits based on artificial neural networks only discuss single-mode information processing, which can achieve a simple first-order conditional reflex process of associative learning. There are problems such as complex hardware circuit design and high-power consumption. Based on the information processing mechanism of drosophila crossmodal learning, this paper proposes a memristive neural network circuit of crossmodal associative learning between olfactory and visual, which simulates the information processing mechanism of single-mode and cross-modal associative memory of the brain. The circuit realizes the function of crossmodal cooperative memory, memory transfer, and the second-order conditional reflex of associative learning.

Keywords: Memristor, associative learning, circuit implementation, crossmodal memory.

Speaker's biography: Jinying Liu received the B.E. degree in computer science and technology from Shijiazhuang Tiedao University, Shijiazhuang, China, in 2019. She is currently working toward the M.E. degree with the College of Artificial Intelligence, Southwest University, Chongqing, China. Her current research interests include memritive neural network and circuit implementation.

Perceptron，the starting point of artificial intelligence

Fangyue Chen [1,A]，Wei Jin[1,B]，Qinbin He[2]

[1]School of Science and School of Computer Science & Technology, Hangzhou Dianzi University, Hangzhou 310018, Zhejiang, China
[2]School of Electronics and Information Engineering, Taizhou University, Taizhou 318000, Zhejiang,China
[A]Email: fychen@hdu.edu.cn, [B]Email: 492127285@qq.com, 2Email:heqinbin@126.com

Abstract: It was known that artificial intelligence originated from the perceptron proposed by Rosenblatt in 1957. So far, artificial intelligence has penetrated into every corner of our society and every field of science and technology. One of the basic problems of artificial intelligence is machine recognition, and perceptron is an important tool for machine recognition. In the binary case, the recognition problem boils down to the problem of perceptron realization of Boolean function or linear separability of Boolean function. Our work mainly includes: (1) the separability criterion of Boolean function; (2) Classification and enumeration of linear separable Boolean functions (LSBF); (3) Decomposition theorem and algorithms for non-linear separable Boolean functions (NLSBF).

Keywords: Artificial intelligence, perceptron, machine recognition, Boolean function, linear separability of Boolean function.

Desired number of coexisting chaotic attractors using quaternionic fractal

Xinyu Du[1,A], Dengwei Yan[1], Hang Shi[1], Shukai Duan[1], Lidan Wang[1,B,*]

[1] Southwest University, College of Artificial Intelligence, Chongqing 400715, China
[A]Email: 676786121@qq.com, [B]Email:ldwang@swu.edu.cn
[*]Corresponding author: ldwang@swu.edu.cn

Abstract: Multistability and multiscroll are two interesting phenomena in chaotic systems. When multiscroll attractors can be generated easily by some approaches, there is few generic method to construct desired number of coexisting chaotic attractors. To address this issue, the quaternionic fractal process inspired by quaternionic Julia sets iterative mapping is presented in this paper. The proposed methodology can not only apply to arbitrary existing continuous chaotic systems, but also generate any number of coexisting attractors based on the seed chaotic systems. Moreover, the design can be completed with simple variable substitution. In order to evaluate the performance of the quaternionic fractal process, we employ it to different types of 4D chaotic systems in a specific set of parameter regions. Moreover, the general form of quaternionic fractal process is presented so that other dimensional chaotic systems can be transformed. The dynamic behavior of fractal processed system is investigated by means of phase portraits, Lyapunov exponents, bifurcation diagrams, and basins of attraction. The result indicates that the quaternionic fractal process is applicable in different cases. Furthermore, a microcontroller-based hardware platform is developed to show its feasibility in industrial field. The experimental results imply that desired number of coexisting attractors are generated with preloading corresponding initial values.

Keywords: Quaternionic fractal; Chaotic systems; Coexisting attractors ; Dynamic analysis; Hardware implementation

Speaker's biography:

Xinyu Du received the B.S. degree in communication engineering from Southwest University, Chongqing, China. He is currently working toward the M.S. degree in nonlinear system analysis and measurement technology at College of Artificial Intelligence, Southwest University, Chongqing, China. His current research interests includes fractal and nonlinear circuits and systems.

Chaotic image encryption algorithm based on elliptic curve and adaptive DNA coding

Xiao Dinghan[1,A], Li Ying[1,B], Yu Simin[1], Wang Qianxue[1,*]

[1]College of Automation, Guangdong University of Technology, Guangzhou, 510006, China
[A]Email: xiao_dinghan@163.com, [B]Email: l2778839278@163.com
[*]Corresponding author: qianxue_wang@163.com

Abstract:

Most of the current chaotic image encryption algorithms adopt the symmetric encryption related to the plaintext, which has the problems such as key redundancy and one-time pad mode is difficult to realize. This paper proposes a new chaotic image encryption based on elliptic curve and adaptive DNA coding. This algorithm uses the elliptic curve public key cryptosystem to achieve key consensus, combined with the four-dimensional Lorenz hyperchaotic system to generate a key sequence for adaptive DNA encoding encryption, and a dynamic diffusion-adaptive permutation structure with intermediate ciphertext state feedback is embedded in the diffusion process of DNA coding and decoding to resist the segmentation attack and chosen plaintext attack. The ciphertext state of the encryption process can be adaptively synchronized at the decryption end without additional transmission. The simulation tests and comparative analysis show that the chaotic image encryption algorithm has extremely high practicability and security.

Keywords: image encryption; elliptic curve; hyperchaotic system; adaptive DNA coding; dynamic diffusion

Speaker's biography: Ying Li graduated from Jinan University in Shandong Province in 2022, and is now studying for a master's degree in control engineering at Guangdong University of Technology. Her research interests are digital domain chaos theory, FPGA, etc.

A chaotic image encryption method with global dynamic selection

Xin Chen[1,A]，Simin Yu[1,B] ，Qianxue Wang[1,*]

1College of Automation, Guangdong University of Technology, Guangzhou, 510006, China

[A]Email: chen0717xin@163.com, [B]Email: siminyu@163.com

[*]Corresponding author: qianxue_wang@163.com

Abstract：Due to the equivalent keys revealed by chosen-plaintext attack or chosen-ciphertext attack, most of the existing chaotic image encryption algorithms are demonstrated to be insecure. In order to improve the security performance, some scholars recently proposed the plaintext-related chaotic image encryption scheme. Despite of achieving the equivalent effect of one-time pad, another secure channel is needed to transmit the hash values and other parameters associated with the plaintext image before the ciphertext can be decrypted at the receiving end. Its main drawback is that an absolutely secure channel is needed to transmit the information associated with the plaintext, which is not feasible in practical applications. To further solve this problem, this paper proposes a chaotic image encryption scheme based on global dynamic selection of parallel structure. First, a chaotic sequence is employed to dynamically select DNA encoding rules. Secondly, the permutation operation with parallel structure is performed on the DNA-encoded matrix, and the DNA decoding rules are dynamically selected according to another chaotic sequence. Finally, the diffusion rules obtained by the ciphertext feedback mechanism are introduced to determine the dynamic diffusion operation. Compared with the existing single link or partial dynamic selection, the main advantage of this scheme is that it can achieve global dynamic selection. According to the research results of Lenstra et al., under the condition of limited years, the deciphering difficulty of this scheme is greater than that of the exhaustive attack, so the equivalent key cannot be deciphered. The proposed encryption mechanism can avoid transmitting additional information associated with the plaintext in the communication channel, which greatly simplify the key management. Theoretical analysis and numerical experiments demonstrate the feasibility of the method.

Keywords: Chaotic encryption, Equivalent key, Ciphertext feedback, Dynamic selection

Speaker's biography: Xin Chen is received the B.E. degree in mechanical engineering from Jinggangshan University , Jian, China, in 2021.He is currently pursuing the M.S. degree in the School of Automation, Guangdong University of Technology, China. His research interests include chaotic cryptanalysis and design.

Security analysis of image encryption algorithm based on two-dimensional infinite folding map

Guanwen Shi [1,A], Yiyang Huang [1,B], Simin Yu[1,C], Qianxue Wang [1,*]

1College of Automation, Guangdong University of Technology, Guangzhou, 510006, China

[A]Email: sgwxuexi@126.com, [B]Email: huangyiyang_21@163.com, [C]Email: siminyu@163.com

[*]Corresponding author: qianxue_wang@163.com

Abstract:

This paper analyzes the security of the image encryption algorithm based on a two dimensional(2D) infinite collapse map. The encryption algorithm adopts a permutation–diffusion structure and can perform two or more rounds to achieve a higher level of security. By cryptanalysis, it is found that the original diffusion process can be split into a permutation-diffusion structure, which comes after the original permutation, so these two permutations can be merged into one. Then, some theorems about round-down operation are summarized, and the encryption and decryption equations in the diffusion process are deduced and simplified accordingly. Since the chaotic sequences used in encryption algorithm are independent of the plaintext and ciphertext, there are equivalent keys. The original encryption algorithm with single-round, two-round, and multi-round of permutation–diffusion processes is cracked, and the data complexity of the cryptanalysis attacks is analyzed. Numerical simulation is carried out by MATLAB, and the experimental results and theoretical analysis show the effectiveness of the cryptanalysis attacks. Finally, some suggestions for improvement are given to overcome the shortcomings of the original encryption algorithm.

Keywords: Chaotic encryption, Equivalent key, Ciphertext feedback, Dynamic selection

Speaker's biography: Yiyang Huang is currently studying for a master's degree at College of Automation, Guangdong University of Technology in Guangzhou, China

.

A cryptanalysis based on a two-dimensional hyperchaotic mapping image encryption algorithm

Qinmao Jiang[1,A]，Simin Yu[1,B]，Qianxue Wang[1,*]

1College of Automation , Guangdong University of Technology, Guangzhou, 510006, China

[A]Email: qinmao_jiang@163.com, [B]Email: siminyu@163.com

[*]Corresponding author: qianxue_wang@163.com

Abstract：This paper analyzes the security of an image encryption algorithm based on two-dimensional hyperchaotic map. This encryption algorithm generates chaotic sequences through a combination of two one-dimension chaotic maps, and uses them to generate permutation keys and diffusion keys. Then, the image is encrypted using the structure of row-column permutation, forward-diffusion and backward-diffusion. The proposer claims that the above algorithm has good reliability and security through theoretical analysis and experimental test results. However, it is found through cryptanalysis that the algorithm can not resist the chosen plaintext attack. Although the forward-diffusion and backward-diffusion of the original algorithm use two different diffusion keys, and there is a ciphertext feedback mechanism, the iterative analysis of the diffusion formula shows that it can be equivalent to one global diffusion. In addition, the generation of chaotic sequences in the encryption process is independent of plaintext images, so the method of chosen plaintext attacks can be used to obtain the equivalent diffusion keys and equivalent permutation keys. In view of the security loopholes in the algorithm, the theoretical analysis and numerical simulation results show the validity of the analysis method proposed in this paper and give suggestions for improvement.

Keywords：Image encryption, Ultra Chaotic Systems, Select plaintext attack, Cryptanalysis.

Speaker's biography: Qinmao Jiang received his bachelor's degree in mechanical and electronic engineering from East China Jiaotong University, Nanchang, China, in 2021. He is currently studying for a master's degree at Guangdong University of Technology in Guangzhou, China, and his research direction is chaotic system.

Construction and application of high-dimensional digital chaotic system

Dongsheng Kuang [1,A], Qianxue Wang [1,B],

[1] School of Automation, Guangdong University of Technology, Guangzhou, 510006, China

[A]Email: dongsheng_kuang@163.com, [B] qianxuewang@163.com

[*]Corresponding author: qianxuewang@163.com

Abstract：Generating digital chaotic system on finite state machine with theoretically proving is a hot topic in recent years. This paper put forward a general design method to solve the construction problem of high-dimensional digital chaotic systems (HDDCS). The construction of the iterative function uncontrolled by random sequences via simple bitwise operations is the starting point of this research, then the chaotic behavior of the new designed HDDCS is mathematically proven to remain unchanged as finite precision changes according to Devaney's definition of chaos, and several examples illustrate the effectiveness and feasibility of this method. In the aspect of application research, the designed HDDCS has be used to improve the particle swarm optimization algorithm to solve numerical optimization problems. This paper aims to refine and expand the theoretical and application framework of higher-dimensional digital chaotic system.

Keywords：high-dimensional digital chaotic system, iterative function, state transition diagram, particle swarm optimization algorithm.

Speaker's biography: Kuang Dongsheng received the B.S. degree in automation from JiangXi University of Science and Technology, Ganzhou, China, in 2021. He is now a postgraduate in the School of Automation of Guangdong University of Technology, and his research direction is chaotic systems.

Design and Application of a New Echo State Network Based on Chebyshev Map and Chaotic System in Digital Domain

Minzhi Xie[1,A], Simin Yu [1,B], Qianxue Wang [1,*],

[1]College of Automation, Guangdong University of Technology, Guangzhou,510006, China
[A]Email: 13517968892@163.com, [B]Email: siminyu@163.com
[*]Corresponding author: qianxue_wang@163.com

Abstract: Echo state network (ESN) is a good predictive model of chaotic time series, but the randomness of input weight matrix and reserve pool of traditional echo state network leads to low prediction accuracy and unstable prediction performance. To improve the prediction performance, a novel prediction model Ch-SC-ESN is proposed. Firstly, the input weight matrix generated by Chebyshev map is used, and secondly, the topology structure of the reserve pool is optimized by using the higher-dimensional digital chaotic system. In order to verify the effectiveness of the new prdiction model proposed in this paper, Mackey-Glass time series, Lorenz time series, Rossler time series and other time series are predicted separately. Compared with other models, The Ch-SC-ESN proposed in this paper has significant advantages in terms of prediction accuracy and prediction stability.

Keywords: echo state network , time series prediction , Chebyshev map , higher-dimensional digital chaotic system

Speaker's biography: Minzhi Xie received the B.S. degree in mechanical engineering and automation from Nanchang Institute of Technology, Nanchang, China, in 2021. He is now a postgraduate majoring in control engineering in the Automation College of Guangdong University of Technology.

Memristor-based time-delay chaotic system with coexisting hidden attractors and pseudo-random sequence generator

Shuqi Sun[1,A], Dengwei Yan[1,B], Musha Ji'e[1,C], Xinyu Du[1,D], Lidan Wang[1,E,*], and Shukai Duan[1,F]

[1]School of Artificial Intelligence, Southwest University, Chongqing, 400715, China

[A]Email: shuqi_sun@163.com, [B]Email: 411354525@qq.com, [C]Email: jemus10070301@163.com, [D]Email: 676786121@qq.com, [E]Email:ldwang@swu.edu.cn, [F]Email: duansk@swu.edu.cn

[*]Corresponding author: ldwang@swu.edu.cn

Abstract: Memristor, as a controllable nonlinear element, can easily generate chaotic signals. At present, more and more attentions have been paid to the memristor-based chaotic system, but the memristor-based time-delay (MBTD) chaotic system with coexisting hidden attractors is rarely involved. Therefore, a novel 3-D MBTD chaotic system with abundant coexisting hidden attractors and line equilibrium points is proposed in this work. Firstly, by applying both dynamic analysis and numerical simulation, basic behaviors of the system are employed to illustrate the superiority of the system. Then, some special nonlinear phenomena such as hidden extreme multi-stability, coexisting hidden attractors of periodic and chaotic, coexisting multi-scroll hidden attractors, coexisting single-scroll hidden attractors and coexisting periodic attractors are observed, which indicate complex dynamic behaviors of this system. Moreover, the system which has good autocorrelation and cross-correlation is applied to generate the chaotic pseudo-random sequence. Finally, the approximate entropy of the chaotic pseudo-random sequence is larger than that of other time-delay chaotic systems. The above manifest that the MBTD chaotic system with coexisting hidden attractors possesses abundant dynamics and good randomness. Hence this system owns latent force in the application of memristor.

Keywords: memristor; time-delay chaotic system; coexisting hidden attractors; pseudo-random sequence generator

Speaker's biography: Shuqi Sun received the B.E. degree in electronic information science and technology from China West Normal University, Nanchong, China, in 2020. She is currently pursuing the M.E. degree in information and communication engineering with the College of Artificial Intelligence, Southwest University, Chongqing, China.Her current research interest includes time-delay nonlinear circuits and systems.

Multi-Scale Attentive Neural Network for Image Restoration

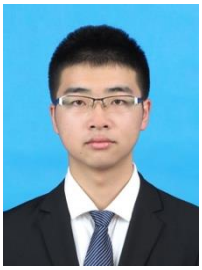
Peng He[1,A]，Yue Zhou[1]，Shukai Duan[1,2]，Xiaofang Hu[1,2,*]

[1]College of Artificial Intelligence, Southwest University, Chongqing 400715, China
[2]Brain-inspired Computing & Intelligent Control of Chongqing Key Lab, Chongqing 400715, China
[A]Email: 17693352913@163.com
[*]Corresponding author: huxf@swu.edu.cn

Abstract： Images taken in rainy, hazy, and low-light environments severely hinder the performance of outdoor computer vision systems. Most data-driven image restoration methods are task-specific and computationally intensive, whereas the capture and processing of degraded images occur largely in end-side devices with limited computing resources. Motivated by addressing the above issues, a novel software and hardware co-designed image restoration method named multi-scale neural network is proposed in this paper, which combines the deep learning algorithm and the nanoscale device memristor. First, the multi-scale complementary spatial contextual information is exploited by the multi-flow aggregation block. Then, the dense connection design is adopted to enhance the transfer of feature maps in the deep network and alleviate gradient disappearance. Next, a dual-attention mechanism is constructed to concentrate and enhance critical features autonomously. Finally, the memristive hardware implementation scheme is designed to provide low energy consumption solutions for embedded applications. Extensive experiments in image deraining, image dehazing, image denosing and low-light image enhancement have shown that the proposed method is highly competitive with over 20 state-of-the-art methods.

Keywords： Image restoration, Memristor, Deep learning, Attention mechanisms, Dual attention, Nanoscale device.

Speaker's biography: Peng He is studying for the M.S. degree with the College of Artificial Intelligence, Southwest University, Chongqing, China. His research interests include artificial neural networks, memristive systems, and image processing.



BSSCN-Net: Binary Neural Networks with Spatial Separable Convolutions and Spectral Normalization

Tongtong Gao[1,A]，Xiaofang Hu[1,2,3,*]

[1]College of Artificial Intelligence, Southwest University, Chongqing 400715, China
[2]Brain-inspired Computing & Intelligent Control of Chongqing Key Lab, Chongqing 400715, China
[3]Key Laboratory of Luminescence Analysis and Molecular Sensing (Southwest University), Ministry of Education
[A]Email:gtt1025@email.swu.edu.cn
[*]Corresponding author: huxf@swu.edu.cn

Abstract：The binary neural networks (BNNs) quantify the weights and activations to +1 or -1, which greatly reduces the storage space and computing resources required in the convolution calculation process, and alleviates the contradiction between the enormous computation of deep convolutional neural networks (DCNNs) and the limited computational units of end-side devices. However, the dramatic reduction in computation results in a performance gap between BNNs and full-precision neural networks (FNNs). Moreover, the massive convolution kernel parameters in binarized DCNNs remain an obstacle for end-to-end deployment. In this paper, a lightweight BNN called BSSCN-Net is proposed, which applies binary spatial separable convolution to reduce the parameters of the binary convolution kernels. Furthermore, a BNN training framework is designed to improve the performance of BSSCN-Net, which consists of a full-precision model, a BSSCN-Net, and a discriminator with spectral normalization layers. In this framework, our proposed BSSCN-Net can improve the ability to learn feature distributions by simultaneously performing distillation and adversarial training. A series of experimental results validate that our proposed methods can significantly enhance the performance and effectiveness of binary neural networks.

Keywords：Binary Neural Networks, Convolutional Neural Networks, Saptial Separable Convolutions，Spectral Normalization

Speaker's biography: Tongtong Gao received the B.S. degree from the College of Computer & Information Science, Wuhan University of Technology, Wuhan, China, in 2018. Currently, he is studying for the M.S. degree with the School of Artificial Intelligence, Southwest University, Chongqing, China.

His research interests include binary neural networks, image processing, deep learning, and memristive system.

Design of pseudorandom number generator for controllable multidouble-scroll chaotic system

Hongxin Peng[1,A], Musha Ji'e, Xingyu Du, Shukai Duan and Lidan Wang[*]

College of Artificial Intelligence, Southwest University, Chongqing 400700, China,
[A]Email: phx123025@163.com,
[*]Corresponding author: ldwang@swu.edu.cn

Abstract: The generation, implementation and application of multi-scroll chaotic system have been extensively studied due to their complex dynamic behavior. This article introduces a new controlled multi-doublescroll chaotic system and the associated implementation of a digital platform—Field Programmable Gate Array (FPGA). This chaotic system can generate 2N+1 or 2N+2 numbers of double-scroll attractors. In particular, the proposed system has controllable multistability and multi-scroll complete amplitude control characteristic. Mathematical analyses such as Lyapunov exponents, bifurcation diagram, phase diagrams, basin of attraction, etc. are presented to show the complex dynamic properties of the system. A new pseudo-random number generator(PRNG) design based on the multi-doublescroll system is proposed. A post processing circuit is designed to improve the performance of the generator. The PRNG achieves extremely low resource utilization while having excellent performance. The proposed PRNG uses less than 1% of the resources of the target FPGA. The bits throughput is up to 7.2 Gbps. To our best knowledge, it reaches the highest data throughput of PRNG designs based on continuous systems. The evaluation sequences are tested using the generic randomness tests NIST SP800-22 and TestU01. The experimental results show that the generated pseudo-random sequences have passed all the test items.

Keywords： Multiscroll chaotic system, control of the multistability, field programmable gate array (FPGA), pseudorandom number generator.

Speaker's biography: Peng hongxin received the B.E. degree in electronic information engineering from Nanyang Institute of Technology, Henan, China, in 2017. He is currently studying for a master's degree in the School of Artificial Intelligence, Southwest University, Chongqing, China. His research interests include multi-scroll chaotic system, non-linear system and digital circuit designs.

Application of Reservoir Computing Based on a 2D Discrete Memristive Map in Efficient Time Signal Processing

Shengjie Xu[1]，Jing Ren[1]，Musha Ji'e[1]，Lidan Wang[1]，Shukai Duan[1]

College of Artificial Intelligence, Southwest University, Chongqing 400715, China

Email: ldwang@swu.edu.cn

Abstract： The analysis of time series is essential in many fields, and neural networks can efficiently process features in temporal time and are advantageous for handling such tasks. In particular, reservoir computing can provide effective temporal processing of recurrent neural networks at a low training cost and is therefore well suited for time series analysis and prediction tasks. Here, we report a reservoir computing system based on a two-dimensional discrete memristive map based on a sine transform that can efficiently process temporal data. The proposed STM-RC model can handle temporal data efficiently and the map in the model have rich dynamical properties that satisfy the criterion of rich states inside the reservoir. We tested three real-world time series prediction tasks using the proposed STM-RC model, which outperformed most existing software-based reservoir computing systems as well as memristor-based reservoir computing systems. Our work shows that memristor-based maps can also be used as reservoirs and have high performance on time series prediction tasks, and is expected to handle more complex temporal tasks as well as hardware implementations in the future.

Keywords： reservoir computing, discrete memristor, time series prediction, chaotic map

Memristor's characteristics: From non-ideal to ideal

Fan Sun[1,A], Jing Su [1], Jie Li [1], Shukai Duan[1,2], Xiaofang Hu[1,2,*]

[1]College of Artificial Intelligence, Southwest University, Chongqing 400715, China
[2]Brain-inspired Computing & Intelligent Control of Chongqing Key Lab, Chongqing 400715, China
[A]Email: sunfan@email.swu.edu.cn
[*]Corresponding author: huxf@swu.edu.cn

Abstract: Memristor has been widely studied in the field of neuromorphic computing and is considered to be a strong candidate to break the von Neumann bottleneck. However, the non-ideal characteristics of memristor seriously limit its practical application. There are two sides to everything, and memristors are no exception. The non-ideal characteristics of memristors may become ideal in some applications. Genetic Algorithm (GA) is a method to search for the optimal solution by simulating the process of biological evolution. It is widely used in the fields of machine learning, combinatorial optimization, and signal processing. In this paper, we simulate the biological evolutionary behavior in GA by using the non-ideal characteristics of memristors, based on which we design peripheral circuits and path planning algorithms based on memristor networks. The experimental results show that the non-ideal characteristics of memristor can well simulate the biological evolution behavior in GA.

Keywords: Memristor, Non-ideal Characteristic, Genetic Algorithm, Path Planning.

Speaker's biography: Fan Sun received the B.S. degree in Internet of Things Engineering from the Xuchang University, Xuchang, China. He is currently pursuing the M.S. degree in electronic information with Southwest University. His research interests include memristor and memristive systems, neuromorphic computing systems, machine learning, and intelligent signal processing in electronic nose.

Network Compression by Maintaining Channel Stability

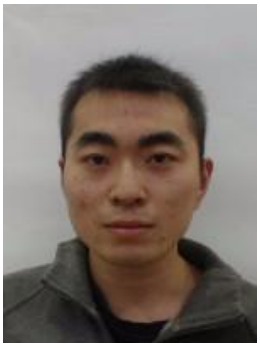
Yuanzhi Duan[1,A]，Xiaofang Hu[1,2,*]

[1]College of Artificial Intelligence, Southwest University, Chongqing 400715, China
[2]Brain-inspired Computing & Intelligent Control of Chongqing Key Lab, Chongqing 400715, China
[A]Email:swuyzhid@email.swu.edu.cn
[*]Corresponding author: huxf@swu.edu.cn

Abstract：Channel pruning is widely used for compressing convolutional neural networks (CNNs), which lies in the design or use of a pruning criterion to discard the redundant filters/channels. However, the correctness of the existing criteria is questionable. Recent studies have shown that some prevalent criteria do not work as well as expected in some situations. Two issues need to be addressed: (1) Few criteria consider the impact of interactions between channels, which results in inaccurate importance scores. (2) The pruning criteria are only valid locally, e.g., the filters considered important contribute little to the next layer. In this paper, we propose a novel criterion that solves the two issues. Specifically, we first reveal that feature information is partially lost in the forward process due to the interaction. Based on this phenomenon, we present a method to measure the importance of a channel by its true contribution to the next layer. Besides, we investigate the applicability of our method. Extensive and targeted experiments are designed to demonstrate the effectiveness of the proposed criterion. The results show that the proposed method achieves state-of-the-art pruning performance on several benchmark networks and datasets.

Keywords：Convolutional Neural Network, Network Compression, Channel Pruning

Speaker's biography: **Yuanzhi Duan** is a master student in the College of Artificial Intelligence at Southwest University, Chongqing, China. He received his B.E. degree in Hefei University of Technology in 2017. Her research interests are neural network compression, deep learning, optimization methods.



Track 4: Chaotic communications, chaotic cryptography, optics chaos, etc

Time	Speaker	Affiliation	Title
Session 01-T4——Presider: Nianqiang Li, Lin Jiang Time: Nov 26, 14:00-16:00 | (Tencent ID: 492-560-852)			
14:00-14:18	**Dongzhou Zhong (invited)**	Wuyi University	Four-channels optical chaos secure communications with the rate of 400Gb/s using optical reservoir computing based on two quantum dot spin-VCSELs
14:18-14:36	**Lin Jiang (invited)**	Southwest Jiaotong University	Chaotic optical communications over long-distance optical fiber driven by an AI chaos generation model
14:36-14:48	Zhiwei Jia	Taiyuan University of Technology	Parallel Generation of Multi-channel Low-correlation Broadband Optical Chaos Based on Long-cavity FP Laser with Optical Feedback
14:48-15:00	Weidong Shao	Huazhong University of Science and Technology	Stable and high-speed secure key distribution based on reciprocal optical fibers and chaotic sources
15:00-15:12	Xiaoxin Mao	Taiyuan University of Technology	Optical chaos communication at 60-Gb/s bit rates over 100-km fiber transmission using semiconductor lasers
15:12-15:24	Yuhe Zhang	Guangdong University of Technology	Effect of intensity noise and phase noise on common-signal-induced synchronization in distributed feedback lasers
15:24-15:36	Xiaojing Wei	Taiyuan University of Technology	Generation of broadband chaotic laser subject to active optical feedback
15:36-15:48	Xin-hui Zhang	Guangdong University of Technology	Chaos synchronization of vertical-cavity surface-emitting lasers with common injection of polarization-random light
15:48-16:00	Shuangquan Gu	Soochow University	Phase stability diagram, self-organized structures, and multistability in a free-running VCSEL

Coffee Break			
Session 02-T4——Presider: Xiangming Cai Time: Nov 26, 16:05-18:05 | (Tencent ID: 492-560-852)			
16:05-16:23	**Xiangming Cai (invited)**	Xiamen University	Differential Chaos Shift Keying for Underwater Acoustic Communications
16:23-16:41	**Chunlei Fan (invited)**	Heilongjiang University	A universal method for constructing non-degenerate hyperchaotic systems with any desired number of positive Lyapunov exponents（invited topic）
16:41-16:53	Zhuwen Yang	Guangdong University of Technology	Paper Title: Design of a New Non-Coherent Cross-QAM-Based M-ary DCSK Communication System
16:53-17:05	Zhuozhao Chen	Guangdong Ocean University	An asymmetric image encryption scheme based on hash SHA-3, RSA and compressive sensing
17:05-17:17	Simin Du	Guangdong Ocean University	IWT and RSA based asymmetric image encryption algorithm
17:17-17:29	Tingting Huang	Huaqiao University	Chaotic Transmitted Reference Modulation: A Robust Method of Communicating with Chaos
17:29-17:41	Mengxuan Zhang	Guizhou Normal University	Generalized Carrier Index Differential Chaos Shift Keying Based SWIPT with Conversion Noise and Path Loss-Effect
17:41-17:53	Meiyuan Miao	Nanjing University of Posts and Telecommunications	Signal design of MDCSK and Coded Modulation for Impulsive Noise in PLC
17:53-18:05	Haoyu Chen	Fuzhou University	Parallel Differential Chaotic Shift Keying with Code Index Modulation for Wireless Communication
Session 03-T4——Presider: Haipeng Ren Time: Nov 27, 9:20-11:20 | (Tencent ID: 492-560-852)			
9:20-9:38	**Haipeng Ren (invited)**	Xi'an Modern Control Technology Research Institute	New characteristics of chaos and its application in wireless communication
9:38-9:56	**Lin Zhang (invited)**	Sun Yat-sen University	Intelligent Chaotic Communication Technology Based on Deep Learning
9:56-10:08	Jian Zeng	Heilongjiang University	Based on 5-D Hyperchaotic System and DNA Sequence
10:08-10:20	Pengteng Guo	Heilongjiang University	Application of GRU Neural Network in Chaotic Sequence Prediction

10:20-10:32	Chao Duan	Guangdong University of Technology	Deep Learning-Based Sparse Codebook Multiple Access for Multi-carrier Differential Chaos Shift Keying System
10:32-10:44	Hua Yang	Nanjing University of Posts and Telecommunications	Group-based Index Modulation for Differential Chaos Shift Keying
10:44-10:56	Ruipeng Yang	Guangdong University of Technology	Design of A New CIM-DCSK-Based Ambient Backscatter Communication System
10:56-11:08	Zijing Jiang	Heilongjiang University	SM4 Chaotic Masking Scheme Against Power Analysis Based on FPGA
11:08-11:20	Yanan Wu	Heilongjiang University	A Novel Color Image Encryption Scheme Based on Hyperchaos and Hopfield Chaotic Neural Network
Coffee Break			
Session 04-T4——Presider: Longsheng Wang Time: Nov 27, 11:25-12:00 | (Tencent ID: 492-560-852)			
11:25-11:43	**Jiagui Wu (invited)**	Southwest University	Chaotic secure communication based on convolutional neural networks and silicon photonic microcavity
11:43-12:00	**Hongxiang Wang (invited)**	Beijing University of Posts and Telecommunications	Chaotic fingerprint for transmitter identification in physical layer security of optical network
Launch Break			
Session 05-T4——Presider: Dongzhou Zhong, Hongxiang Wang Time: Nov 27, 14:00-16:18 | (Tencent ID: 492-560-852)			
14:00-14:18	**Nianqiang Li (invited)**	Soochow University	Nonlinear dynamics and broadband chaos generation in spin-VCSELs
14:18-14:36	**Longsheng Wang (invited)**	Taiyuan University of Technology	Coherent optical chaos communication with probabilistic shaping
14:36-14:54	**Xiaozhou Li (invited)**	Dalian University of Technology	Studying the dynamical behaviors of chaotic optically injected semiconductor lasers
14:54-15:06	Qiang Cai	Taiyuan University of Technology	Fast physical random bit generation with a photonic integrated chaotic semiconductor laser
15:06-15:18	Haifeng Li	Taiyuan University of Technology	Chaotic time-delay signature suppression using quantum noise

15:18-15:30	Chao Kai	Taiyuan University of Technology	Video Recognition based on Photonic Reservoir Computing
15:30-15:42	Jiayi Li	Taiyuan University of Technology	Handwritten digit recognition based on a single dynamical node-based optical reservoir computing
15:42-15:54	Xueting Zhang	Yantai University	The Research of Chaotic System Based Four-Wave Mixing
15:54-16:06	Zhang Jing	Heilongjiang University	Research on Discrete Chaotic Synchronization Methods And Applications
16:06-16:18	Meng Xing	Northeastern University	A High-Resolution Image Encryption Algorithm Using a Dynamic S-box Based on Chaotic Map
Coffee Break			
Session 06-T4——Presider: Chunlei Fan Time: Nov 27, 16:25-17:50 | (Tencent ID: 492-560-852)			
16:25-16:37	Dongyang Peng	Guangdong University of Technology	Neural Network-aided Detection Scheme For Index-Modulation DCSK System
16:37-16:49	Xinkang Liu	Central South University	A novel image encryption scheme based on 2D SILM and improved permutation-confusion-diffusion operations
16:49-17:01	Wenhao Yan	Heilongjiang university	A Class of Polynomial Chaotic Map With Image Encryption
17:01-17:13	Mengdi Zhao	University of Jinan	A non-degenerate n-dimensional integer domain chaotic map model with application to PRNG
17:13-17:25	Guoqiang Long	Henan University	Verifiable visually meaningful image encryption based on compressed sensing (CS) and improved game of life (IGOL)
17:25-17:37	Ruoran Liu	University of Jinan	Cryptanalysis and construction of keyed strong S-Box based on random affine transformation matrix and 2D hyper chaotic map
17:37-17:50	Zhe Lin	University of Jinan	Irreversible and parallel key expansion algorithm based on a 2D discrete hyper chaotic map with memristor

Four-channels optical chaos secure communications with the rate of 400Gb/s using optical reservoir computing based on two quantum dot spin-VCSELs（invited）

DONG ZHOU ZHONG[1,*], KE KE ZHAO[1], YA LAN HU[1], JIN BO ZHANG[1], WAN AN DENG[1], PENG HOU[1]

[1]Intelligent Manufacturing Faculty, Wuyi University, Jiangmen 529020, China
[*]Corresponding author: dream_yu2002@126.com

Abstract：In this work, we utilize four parallel reservoirs to model the chaotic dynamics of the output four polarization components (PCs) from a driving QD spin-VCSEL. Here, the four parallel reservoirs are implemented using the four PCs of a reservoir QD spin-VCSEL. High-quality chaos synchronizations of four pairs of PCs can be realized by using the four parallel reservoirs based on a reservoir QD spin-VCSEL. Under these high-quality synchronizations, we successfully implement four-channel secure communications with 4×100Gb/s 16 QAM messages under guaranteeing. We further discuss the performances of the bit error ratios (BERs) for four decoding messages under different parameters. We show that all BERs via different parameters are less than 7×10^{-3}, denoting that high-quality data-transmissions can be potentially obtained in the system. Moreover, we prove that our proposed multi-channel optical chaotic communication scheme has the same level of security as the traditional schemes. Our findings show that the delay-based optical reservoir computing based on a QD spin-VCSEL provides an effective method for realization of multi-channel optical secure communication.

Keywords：Quantum-dot (QD) spin-vertical-cavity surface-emitting laser, Reservoir Computing, Optical chaos secure communication, Chaos synchronization

钟东洲：男，1977 年生，光学专业博士，教授，博士生导师。于 2002.09-2005.06 年期间在西南大学“非线性光纤光学”重庆市重点实验室攻读光学专业硕士学位，于 2005 年 5 月获得光学专业理学硕士学位，于 2008.09-2012.06 年期间在中山大学“光电材料与技术”国家重点实验室攻读光学专业博士学位，于 2012.06 获得光学专业理学博士学位，于 2014.09-2015.06 期间在北京大学龚祺煌院士主持的“人工微结构和介观物理国家重点实验室”从事微结构半导体激光器的非线性效应研究。

研究方向：主要研究方向为激光混沌逻辑计算，激光混沌雷达测距，光子储备池计算。在激光混沌时序触发逻辑计算，激光混沌数据选择逻辑计算，激光混沌逻辑计算可重构，同步混沌激光混沌雷达测距，相关混沌雷达多目标测距，激光混沌光学储备池计算取得了突破性创新成果，推动了激光混沌的应用发展，在国内外有一定的影响力。今后全力推动激光混沌雷达测距产业化，深入探索光子深度储备池计算及其在激光成像和测距中的应用，在“压缩超快激光多维成像”取得突破性进展。主持和完成国家自然科学基金面上项目 2 项，参与完成国家自然科学基金项目 3 项。主持和完成 2 项广东省自然科学基金面上项目，主持和完成两项广东省教育厅重大专项项目 2 项，主持广东省教育厅特色创新项目 1 项，参与广东省教育厅团队项目 1 项。在国内外权威核心期刊（如 Optics Express，物理学报，Optics Communication 等）发表高水平论文 50 篇，其中中科院 SCI 二区论文 12 篇。获得国家发明专利授权 12 项，美国发明专利 1 项。完成广东省科技成果登记 1 项《激光混沌同步及应用》，其成果鉴定达到国际先进水平。目前担任《国家自然科学基金项目》评审专家，《广东省科技项目》评审专家，《江门市科技项目》评审专家。担任《Optics Express》，《Opt. Letter 》，《Chin. Opt. Lett》等国际权威核心期刊审稿人。

Chaotic optical communications over long-distance optical fiber driven by an AI chaos generation model （invited）

Lin Jiang[1,2,*]，Jiacheng Feng[1]，Anlin Yi[1]，Lianshan Yan[1,2]

[1]Center for Information Photonics & Communications, Southwest Jiaotong University, Chengdu 611756, Sichuan, China;
[2]Peng Cheng Laboratory, Shenzhen, 518000, Guangdong, China;
*Corresponding author: linjiang@swjtu.edu.cn

Abstract：We have proposed a model construction scheme of chaotic optoelectronic oscillator (OEO) based on Fourier neural operator (FNO). The proposed scheme can obtain a multi-parameter chaotic OEO model without any prior knowledge in advance, which is trained from chaotic time series generated by the chaotic OEO (actual components) with different feedback gains and time delays. We introduce the maximal Lyapunov exponent λ_{max} and the Pearson correlation coefficient (PCC) to evaluate the chaotic state of time series and the nonlinear mapping ability of FNO, respectively. Both numerical and experimental results show that the PCC can be greater than 0.99 in the case of low feedback gain, and the λ_{max} of time series generated by chaotic OEO (actual components) and FNO are both positive. Meanwhile, the generalization ability of FNO is analyzed, and the results show that FNO is more robust than LSTM. Besides, the generalization ability of FNO is analyzed, and the results show that FNO is more robust than LSTM. Finally, the proposed scheme has been experimentally verified in chaotic-encrypted 200-Gbit/s 16QAM systems over 1000-km.

Keywords：optoelectronic oscillator; Fourier neural operator; Chaotic optical communications;

Speaker's biography: Dr. Lin Jiang received the Ph.D. degree from Southwest Jiaotong University, Chengdu, China, in 2020. Since June 2020, he has been an associate Professor with the Center for Information Photonics and Communications of Southwest Jiaotong University, Chengdu, China. He has authored or co-authored more than 40 research papers. His current research interests include optical performance monitoring, high-speed long-haul transoceanic transmission and secure optical communication. He is a Member of the IEEE and the Chinese Optical Society.

Parallel Generation of Multi-channel Low-correlation Broadband Optical Chaos Based on Long-cavity FP Laser with Optical Feedback

Zhiwei Jia[1,A], Xinhong Zhong[1], Qingtian Li[1], Anbang Wang[1,2,3,*], Yuncai Wang[2,3]

[1]Key Lab of Advanced Transducers and Intelligent Control System, Ministry of Education and Shanxi Province, Taiyuan University of Technology, Taiyuan, 030024, China

[2] School of Information Engineering, Guangdong University of Technology, Guangzhou, 510006, China

[3] Guangdong Provincial Key Laboratory of Photonics Information Technology, Guangzhou, 510006, China

[A]jiazhiwei@tyut.edu.cn

[*]Corresponding author: wanganbang@tyut.edu.cn

Abstract：Semiconductor-laser-based optical chaos has been widely used in various applications such as random number generator (RNG) and chaos secure communication. To achieve high-speed RNG or improve the transmission rate of chaos communication, broadband optical chaos is very desired. However, the bandwidth of optical chaos is limited by the intrinsic relaxation oscillation. In this work, we demonstrate the broadband chaos generation by a long-cavity Fabry-Perot (LC-FP) semiconductor laser with simple mirror feedback. The chaos bandwidth is significantly enhanced to more than 33 GHz by multi-mode beating effect. The optical spectrum of LC-FP laser consists of a series of mode peaks with the internal of about 28.3 GHz. Under strong optical feedback, every mode peak is widened and overlap with each other, and a very wide-spectrum optical chaos is obtained. Moreover, by multi-channel optical filtering, parallel generation of multi-channel optical chaos is realized. By optimizing the linewidth and channel internal of multi-channel optical filtering, 8-channel broadband optical chaos with the bandwidth above 27 GHz are simultaneously generated, and the cross correlation between different channels is always lower than 0.1. This work provides a very simple scheme for multi-channel optical chaos generation.

Keywords：multi-channel optical chaos, long cavity FP laser, low correlation

Speaker's biography: Zhiwei Jia received his Ph.D. degree from Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China, in 2017. Since September 2017, he has been working as a lecturer in Taiyuan University of Technology, Taiyuan, China. His research interests include the generation of broadband laser chaos and dynamics of semiconductor laser, mid-infrared quantum cascade lasers.

Stable and high-speed secure key distribution based on reciprocal optical fibers and chaotic sources

Weidong Shao[1,2], Taihang Qiu[1,2], Lei Deng[1,2], Qi Yang[1,2], Xiaoxiao Dai[1,2], Deming Liu[1,2], and Mengfan Cheng[1,2,*]

[1]Huazhong University of Science and Technology, Wuhan, 430074, China
[2]Shenzhen Huazhong University of Science and Technology Research Institute, Shenzhen, 518000, China
[*]Corresponding author: chengmf@mail.hust.edu.cn

Abstract: Secure key distribution (SKD) is a great important component in optical secure communication. It provides consistent secure keys for symmetric optical cryptography. More recent attention has focused on the SKD strategy based on characteristics of reciprocal optical channels, because of its high efficiency in key exchanging and no need for pre-sharing. A primary concern is the distribution rate limitation from the slow variation of optical fiber links. We established a joint source-channel model to boost the rate of SKD with chaotic systems. The wideband frequency spectrum and complex dynamics of chaotic systems enable a high-speed SKD with a rate of several Gbit/s. However, we noticed the instability originating from the restricted span of polarization states. Here, we report a stable and high-speed SKD scheme via orthogonal polarizations. Correlated orthogonal polarization sources are constructed under the frame of bi-directional transmission. The fiber channel between two nodes functions as a reciprocal medium and offers shared nonlinearity. A 10-km fiber channel, error-free SKD with a rate of 2.07 Gbit/s is experimentally realized. The peak performance can maintain at a high level within a time scale of 30 minutes. The proposal is a competitive alternative with long-term stability and provides a conceivable way for practical applications.

Keywords: Optical secure communication, secure key distribution, reciprocity, chaotic system.

Speaker's biography: Weidong Shao is a Ph.D. student at Hubei Key Laboratory of Distributed System Security, Hubei Engineering Research Center on Big Data Security, and School of Cyber Science and Engineering at Huazhong University of Science and Technology (HUST). He received a B.S. degree in optoelectronics information science and engineering from Soochow University, Suzhou, China, in 2018. His research interests include optical secure communication, optical cryptography, and information processing.

Optical chaos communication at 60-Gb/s bit rates over 100-km fiber transmission using semiconductor lasers

Xiaoxin Mao[1,2A], Xiaoqi Fan[1,2B], Longsheng Wang[1,2C], Anbang Wang[1,2,3,4*], Yuncai Wang[3,4D]

[1]Key Lab of Advanced Transducers and Intelligent Control System, Ministry of Education and Shanxi Province, Taiyuan, 030024, China
[2]College of Physics and Optoelectronics, Taiyuan University of Technology, Taiyuan, 030024, China
[3]School of Information Engineering, Guangdong University of Technology, Guangzhou, 510006, China
[4]Guangdong Provincial Key Laboratory of Photonics Information Technology, Guangzhou, 510006, China
[A]Email: maoxiaoxin0829@link.tyut.edu.cn, [B]Email: fanxiaoqi1251@link.tyut.edu.cn,
[C]Email: wanglongsheng@tyut.edu.cn, [D]Email: wangyc@gdut.edu.cn
[*]Corresponding author: wanganbang@tyut.edu.cn

Abstract:

In the past decades, high bit rate data transmission is an untiring pursuit of optical chaos communication. Here, we experimentally demonstrate a 60-Gb/s chaos communication over 100-km fiber transmission based on broadband chaos synchronization in semiconductor lasers. In the scheme, a pair of semiconductor lasers are used as transmitter and receiver, in which chaotic synchronization are achieved by common chaotic optical injection generated by a driving laser with optical feedback from a chirped fiber Bragg grating. In the transmitting end, after photovoltaic conversion, chaotic carrier with bandwidth of 30GHz is used to encrypted data. Modulating a continuous wave, the encrypted data is transmitted to receiving end via WDM technology as well as driving signal. The data is decrypted by subtracting synchronized chaotic carriers recovered by receiver and digital signal processing. Finally, a secure transmission of 60-Gb/s probabilistic-shaping pulse-amplitude-modulation data with bit error ratio (BER) below soft decision forward error correction threshold is demonstrated. The system performances are evaluated by analyzing BERs with different masking coefficients, synchronization coefficients, and parameter mismatches. We hope that the proposed scheme can become a possible way to satisfy the needs of secure and high-speed optical communications in modern society.

Keywords: Chaos, Chaos communication, Semiconductor lasers, Pulse amplitude modulation

Speaker's biography: Xiaoxin Mao was born in Jinzhong, China, in 1994. He received the B.S. degree in 2017 from the Taiyuan University of Technology, Taiyuan, China, where he is currently working toward the Ph.D. degree. His research interests include chaotic laser and high-speed chaos communication.

Effect of intensity noise and phase noise on common-siganl-induced synchronization in distributed feedback lasers

Yuhe Zhang[1,A], Yuncai Wang[1,*], Anbang Wang[2], Laihong Mo[3], Junpei Xun[3], Cunyou Guo[3]

School of Guangdong University of Technology, Guangzhou, 510006, China
[A]Email: 2112103019@mail2.gdut.edu.cn
[*]Corresponding author: wangyc@gdut.edu.cn

Abstract: The generation of laser optical chaos depends on the nonlinear effect of laser itself. The nonlinear system is very sensitive to external conditions. Under different injection conditions, the nonlinear system will produce different results. Therefore, in order to explore the influence of the driving source on the nonlinearity in the laser system, we modulate the noise on a continuous light through phase modulation and intensity modulation to form phase noise and intensity noise. From the perspective of system security, we numerically compare the effect of phase noise and intensity noise on common-siganl-induced synchronization in distributed feedback lasers. And the simulation results show that phase noise has more advantages than intensity noise from the perspective of the system security.

Keywords: Intensity noise; Phase noise ; System security; Distributed feedback lasers

Speaker's biography:
Yu-he Zhang obtained an undergraduate degree from Guangdong University of Technology in 2021. He is now a graduate student at Guangdong University of Technology. His research interests include chaos, complex system, etc.

Generation of broadband chaotic laser subject to active optical feedback

Wei Xiaojing[1,2,A], Qiao Lijun[1,B], Zhang Mingjiang[1,*]

[1] Key Laboratory of Advanced Transducers and Intelligent Control System, Ministry of Education, Shanxi Province, Taiyuan University of Technology, Taiyuan 030024, China
[2] College of Physics and Optoelectronics, Taiyuan University of Technology, Taiyuan 030024, China
[A]Email: weixiaojing0163@link.tyut.edu.cn, [B]Email: qiaolijun@tyut.edu.cn
[*]Corresponding author: zhangmingjiang@tyut.edu.cn

Abstract: Chaotic laser, known for the characteristics of noise-like, large amplitude and wide spectrum, is a typical unstable output form of laser diodes. It has been widely used in secure optical communication, high-speed random number generation, optical sensing and artificial intelligence calculation. Due to the advantages of small size, low cost, long life and unstable behaviors with external disturbances, semiconductor lasers have become the main light source for the generation of chaotic laser. The chaotic laser can be generated by perturbing the semiconductor laser with optical feedback, optical injection, and photoelectric feedback. Among the above three methods, optical feedback has been widely used for its simple structure and rich modes of external cavity. However, since the main energy of the laser output is concentrated near the relaxation oscillation frequency, the bandwidth of chaos generated by conventional optical feedback is only a few GHz and the power spectrum is uneven, which extremely limits the practical applications of chaotic laser. Aiming at the issues mentioned above, we proposed the method of active optical feedback by using a semiconductor laser. The generation of flat broadband chaotic laser can be achieved by changing the structure of optical feedback. Firstly, we proposed a method to generate flat broadband chaotic laser by using active optical feedback with a high nonlinear fiber. Through the four-wave mixing effect between the modes generated by the laser and the multi-longitudinal modes inherent in the loop long cavity, a large number of different frequency components are excited. A flat broadband chaotic signal with the standard bandwidth of 38.9 GHz and the spectrum flatness of 4.2 dB is generated experimentally. The bandwidth of the chaotic laser generated by the proposed method is enhanced to approximately 4.5 times that of the conventional optical feedback. Furthermore, the effects of the feedback strength and the injected optical power of the high nonlinear fiber on the bandwidth and spectrum flatness of the chaotic laser is investigated experimentally. The results show that the chaos bandwidth is continuously enhanced and the flatness is optimized by increasing the feedback strength and the injected optical power. Then, a method for generating flat broadband chaotic laser with an asymmetric dual-path structure based on filtered active optical feedback is proposed and demonstrated experimentally. Through the beating frequency effect between the filtered mode generated by filtered path and the chaos mode generated by non-filtered path, the high frequency oscillation is generated. The nonlinear mixing effect between the high frequency oscillation and the laser relaxation oscillation produces many new frequency components, resulting in the generation of flat broadband chaotic signal with the standard bandwidth of 36.1 GHz and the spectrum flatness of 5.8 dB. Furthermore, the effects of filter frequency detuning, filter bandwidth and filter feedback strength on the bandwidth and spectrum flatness of chaos are investigated. The results show that the bandwidth enhancement and the flat spectrum can be achieved simultaneously in a wide range of operating parameters. The proposed methods of active optical feedback realize the bandwidth enhancement and spectrum flatness of chaotic laser, which further promote the application of chaotic laser in the field of information.

Keywords：Active optical feedback; broadband chaotic laser; flat spectrum; high nonlinear optical fiber; dual-path optical feedback

Speaker's biography: Xiaojing Wei received the B.S. degree in 2019 in applied physics from the College of Physics and Optoelectronics, Taiyuan University of Technology, Taiyuan, China. She is currently working toward the Ph.D. degree in optics engineering. Her current research focuses on nonlinear dynamics of semiconductor lasers.

Chaos synchronization of vertical-cavity surface-emitting lasers with common injection of polarization-random light

Xin-hui Zhang[1,2]，An-bang Wang[1,2]，Yue-hui Sun[1,2], Jun-pei Xu[1,2]， Lai-hong Mo[1,2], Cun-you Guo[1,2], Fei-fan Zhang[1,2], Min Zhou[1,2], Yuan Zhao[1,2]，Xing-yu Tao， Yun-cai Wang[1,2,*]

[1]School of information Engineering, Guangdong University of Technology, Guangzhou 510006, China
[2]Guangdong Provincial Key Laboratory of Photonics Information Technology, Guangzhou 510006, China
[*]Corresponding author: wangyc@gdut.edu.cn

Abstract： We propose and numerically demonstrate common-signal-induced synchronization between two vertical-cavity surface-emitting lasers (VCSELs) driven by common light with randomly polarization varying. The results show that the correlation coefficient between the intensity oscillations of the two response lasers is lower than 0.9 when the setting angle detuning between the two half wave plates is larger than 10°. The master-slave correlation, the correlation between the XP(YP) mode of injected light and the XP(YP) mode of VCSELs, is mainly concentrated in 0.2-0.4, which ensures the privacy of the key. Based on the above two points, this secure is enhanced due to the polarization direction of laser cannot be acquired by Eve. Furthermore, the correlation between two orthogonal LP modes is very small so that this framework can generate two sets of keys in parallel.

Keywords：chaos synchronization; constant-amplitude and polarization time-varying; common injection; VCSEL

Speaker's biography:

Xin-hui Zhang received the B.S. degree in applied physics from the Taiyuan University of Technology, China, in 2021. She is currently pursuing the M.S. degree in Guangdong University of Technology. Her research interests include chaos synchronization, key distribution. Phase stability diagram, self-organized structures, and multistability in a free-running VCSEL.

Phase stability diagram, self-organized structures, and multistability in a free-running VCSEL

Shuangquan Gu[1, 2, A], Pei Zhou[1,2, B], Nianqiang Li[1,2,*]

[1] School of Optoelectronic Science and Engineering, Soochow University, Suzhou, 215006, China
[2] Key Laboratory of Modern Optical Technologies of Education Ministry of China, Soochow University, 215006, China
[A]Email: gsq_1995@126.com, [B]Email: peizhou@suda.edu.cn
[*]Corresponding author: *nli@suda.edu.cn*

Abstract:
To obtain a global understanding of the stability of the parameter space in a free-running vertical-cavity surface-emitting laser (VCSEL), in this paper, we systematically investigate the stability of the model of VCSEL, spin-flip model (SFM), with a small misalignment between the phase and amplitude anisotropies under different parameter combinations. With the help of the high-resolution stability phase diagrams and temporal evolution diagram, the occurrence of infinite families of periodic Arnold tongue and self-similar shrimp-shaped structures embedded in quasiperiodic and chaotic regions, respectively, is revealed. Of interest is that we first witness the Arnold tongue cascades covered by multiple distinct numbers of peaks in several parameter combinations. Furthermore, the multistability is investigated in detail through the basin of the attraction. The eyes of anti-chaos and periodicity characterized by fractal are also discovered. The findings bring a new sight of the polarization dynamics in the VCSELs and also open the possibility to detect the structures experimentally and discover underly interesting novel applications.

Keywords: vertical-cavity surface-emitting lasers, spin-flip model, phase stability diagram, self-organizations, codimension-2 bifurcation, multistability

Shuangquan Gu: Mr. Shuangquan Gu received the B.S. degree in electronics and information engineering and the M.S. degree in information and communication engineering from Anshun University and Heilongjiang University, China, in 2018 and 2021, respectively. He is currently pursuing the Ph. D. degree with Soochow University, China. His research interests include chaos, the vertical surface-emitting laser, nonlinear laser dynamics, bifurcation theory, etc.

Differential Chaos Shift Keying for Underwater Acoustic Communications（invited）

Xiangming Cai, Wekai Xu，Lin Wang

Department of Information and Communication Engineering, Xiamen University, Xiamen, 361005, China
Email: Samson0102@qq.com, xweikai@xmu.edu.cn, wanglin@xmu.edu.cn
*Corresponding author: xweikai@xmu.edu.cn

Abstract：Underwater acoustic (UWA) channel is a typical harsh and complex environment for information transmission. The performance of UWA communications is affected significantly by low propagation speed, large propagation delays, variation of the channel impulse response and so on. The multipath transmission combined with lager propagation delays of UWA channels cause serious inter-symbol-interference (ISI) which may influence dozens of symbols. Variation of the channel impulse response results in severe Doppler spread. Therefore, how to design transmission signal is an essential issue for physical layer of underwater acoustic communication systems.

In this paper, we present a chaos-based communication scheme for underwater acoustic communications. The proposed scheme combines code-shifted differential chaos shift keying (CS-DCSK) with orthogonal frequency division multiplexing (OFDM), namely MC-CS-DCSK. The proposed scheme firstly utilizes the orthogonal characteristic of the orthogonal codes (such as Walsh code) to make the chaotic reference chips and the information bearing chips superimposed in time/frequency domain. Then the chips from CS-DCSK modulators, which form a multiple carrier symbol, are shifted by a cyclic-shift interleaver. Then, the shifted chips are loaded onto different sub-carriers by the use of inverse discrete Fourier transform (IDFT). Furthermore, we designed index modulated chaotic communication system for underwater acoustic communication. It enhances the data rate of chaos-based system. Simulated results and field experiment results show that the proposed systems have robust performance over doubly selective fading channel and underwater acoustic channels.

Keywords：differential chaos shift keying，underwater acoustic communication，index modulation

Speaker's biography: Weikai Xu is currently an associate professor with the Department of Information and Communication Engineering, Xiamen University. He received the Ph.D. degree in electronic circuit and system from Xiamen University, Xiamen, China, in 2011. His research interests include chaotic communications and underwater acoustic communications.

A universal method for constructing non-degenerate hyperchaotic systems with any desired number of positive Lyapunov exponents（invited）

Chunlei Fan*，Qun Ding[A]

Electrical Engineering College, Heilongjiang University, Harbin, 150080, China
[A]Email: 1984008@ hlju.edu.cn
*Corresponding author: 2020021@hlju.edu.cn

Abstract：Due to the limited machine word length of hardware devices, the dynamics of digital chaotic systems will degenerate. To combat this issue, we proposed a universal method that is based on singular value decomposition (SVD), which can reversely construct non-degenerate hyperchaotic systems with any desired number of positive Lyapunov exponents by controlling pre-specified singular values. To assess the practicability and effectiveness of the method, we construct a 6-dimensional non-degenerate hyperchaotic system as an example. Furthermore, based on the hyperchaotic system, a pseudorandom number generator (PRNG) with desirable statistical characteristics is designed for image encryption. Numerical simulations were performed to evaluate the security of the image encryption algorithm in terms of histogram, information entropy, differential attack test, etc. The proposed non-degenerate hyperchaotic system can be effectively applied in the field of multimedia data encryption and information security.

Keywords：Hyperchaotic system; Lyapunov exponent; PRNG; image encryption

Speaker's biography: C.L. Fan received the Ph.D. degree in microelectronics and solid-state electronics from the Electrical Engineering College, Heilongjiang University, China, in 2020. During this period, he worked as a Research Assistant at the Hong Kong Polytechnic University from 2018 to 2019. Since 2020, he has been with the Electrical Engineering College, Heilongjiang University, China, as a Full Associate Professor. His current research interests mainly focus on chaos theory, secure communications, and hardware encryption.

Paper Title: Design of a New Non-Coherent Cross-QAM-Based *M*-ary DCSK Communication System

Zhuwen Yang[1,A], Guofa Cai[1,B]

[1]College of Information Engineering, Guangdong University of Technology, Guangzhou, 510000, China

[A]Email: zhuwenyang2022@126.com, [B]Email: caiguofa2006@gdut.edu.cn

[*]Corresponding author: caiguofa2006@gdut.edu.cn

Abstract: In this paper, a new non-coherent cross-quadrature amplitude modulation (XQAM)-based *M*-ary differential chaos shift keying (XQAM-*M*DCSK) system is proposed. In such a system, an autocorrelator is adopted at the receiver to obtain the channel compensation value. This framework can be extended to various amplitude phase shift keying-based *M*DCSK systems, such as star QAMbased *M*DCSK (star QAM-*M*DCSK) and square QAM-based *M*DCSK (SQAM-*M*DCSK) systems. Moreover, the bit error rate (BER) expression of the proposed XQAM-*M*DCSK system is derived over a multipath Rayleigh fading channel. Results show that the proposed XQAM-*M*DCSK system can achieve better BER performance and a lower peak-to-average power ratio (PAPR) compared to the star QAM-*M*DCSK system. Furthermore, we also show that the performance of the proposed system can be close to that of a system with perfect channel state information (CSI).

Keywords: Cross QAM based *M*-ary differential chaos shift keying; Bit error rate; Multipath Rayleigh fading channel.

Speaker's biography:

Zhuwen Yang received the B.S. degree in communication engineering from Beijing Institute of Technology, Zhuhai, China, in 2021. He is currently pursuing the M.S. degree in the School of Information Engineering, Guangdong University of Technology, China. His primary research interests include chaos-based communications.

An asymmetric image encryption scheme based on hash SHA-3, RSA and compressive sensing

An asymmetric image encryption scheme based on hash SHA-3, RSA and compressive sensing

Zhuozhao Chen[1,A], Guodong Ye[1,2,B,*]

[1]Faculty of Mathematics and Computer Science, Guangdong Ocean University, Zhanjiang, 524088, China
[2]Guangdong Provincial Engineering and Technology Research Center of Far Sea Fisheries Management and Fishing of South China Sea, Zhanjiang, 524088, China
[A]Email: chenzhuozhao2021@163.com, [B]Email: guodongye@hotmail.com
[*]Corresponding author: guodongye@hotmail.com

Abstract: Objective: In order to avoid the unauthorized access to private images and make a secure communication, an asymmetric image encryption algorithm based on SHA-3 and compressive sensing is proposed.

Methods: Firstly, a random matrix is generated and a modular-addition operation is performed between it with the plain image, obtaining a preprocessed image. Then, hash values of the preprocessed image are computed by secure hash algorithm in the third generation (SHA-3), and are grouped and summed to get three plaintext keys. Using Rivest-Shamir-Adleman (RSA), three ciphertext keys can be obtained correspondingly. Secondly, a new mathematical transformation model (MTM) is designed to transform all keys into initial values for chaotic system. Then, keystream is calculated accordingly. Thirdly, the plain image is compressed by compressive sensing (CS), and further confused by random sequences. Then, applying discrete wavelet transformation (DWT) to the confused image and generating four components of high and low frequencies. Chaotic sequences are used again to confuse the low frequency components, and then all components are recombined again into a matrix. Thereafter, perform inverse DWT (IDWT) to get a middle cipher image (MCI). Finally, another random matrix is generated by chaotic sequences, and the final cipher image is obtained by a modular-addition operation again to the MCI.

Results: Experiments show that the proposed scheme can reconstruct the plain image with a high quality. In particular, the proposed method can resist known plaintext attack and chosen plaintext attack because the keystreams are related to the plain image and with no extra transmission.

Keywords: Image encryption, Chaotic system, Asymmetric encryption, SHA-3, Compressive sensing

Speaker's biography: Zhuozhao Chen received the B.S. degree in electronic information engineering from Guangdong Pharmaceutical University, Guangzhou, China, in 2021. He is currently pursuing the M.S. degree in computer science and technology at Guangdong Ocean University. His research interests include information security and image encryption.

IWT and RSA based asymmetric image encryption algorithm

Simin Du[1,A], Guodong Ye[1,2,B,*]

[1]Faculty of Mathematics and Computer Science, Guangdong Ocean University, Zhanjiang, 524088, China
[2]Guangdong Provincial Engineering and Technology Research Center of Far Sea Fisheries Management and Fishing of South China Sea, Zhanjiang, 524088, China
[A]Email:dusimin1999@163.com, [B]Email: guodongye@hotmail.com
[*]Corresponding author: guodongye@hotmail.com

Abstract：An asymmetric image encryption algorithm based on integer wavelet transformation (IWT) and Rivest-Shamir-Adleman (RSA) algorithm is proposed. Firstly, two plain characteristic parameters (PCP) of the plain image are extracted and two random numbers are chosen. Then, a new parameter transformation model (PTM) is constructed to do nonlinear processing for them, and three cipher characteristic parameters (CCP) are got. After applying RSA operation for CCP (seen as plain messages), three cipher messages are obtained. Secondly, a new initial value obtaining model (IOM) for all plain messages and cipher messages is established, by which initial values of 3D chaotic system are produced. Then, three chaotic sequences can be generated. Thirdly, chaotic sequences are used to confuse the plain image by a way of row-column cycle. Then, IWT operation is carried out and the above chaotic sequences are employed to confuse again the wavelet coefficients. Thereafter, inverse IWT is applied to get the confused image, realizing double confusion operations on both spatial domain and frequency domain. Finally, the confused image is diffused as a whole to get the cipher image. Experiment results explain that the proposed algorithm can realize the encryption in short time, and resist effectively against brute-force attack and noise attack.

Keywords：Asymmetric image encryption; IOM; PTM; RSA; IWT

Speaker's biography: Simin Du received the B.S. degree in medical information engineering from Jiangxi University of Chinese Medicine, Nanchang, China, in 2021. He is currently pursuing the M.S. degree in computer science and technology at Guangdong Ocean University. His research interests include information security and image encryption.

Chaotic Transmitted Reference Modulation: A Robust Method of Communicating with Chaos

Tingting Huang[1,*]，Lin Wang[2,A]，Weikai Xu[2,B]，Jianeng Tang[1,C]

[1]Institute 1, School of Huaqiao University, Quanzhou, 362000, China
[2]Institute 2, School of Xiamen University, Xiamen, 362000, China
[A]Email:wanglin@xmu.edu.cn , [B]Email:xweikai@xmu.edu.cn ,
[C]Email:tangjianeng@sina.com
[*]Corresponding author: tthuang@hqu.edu.cn

Abstract： The different chaotic shift keying (DCSK) modulation avoids the receiver from generating a copy of the chaotic basis function through the chaotic synchronization circuit by transmitting a reference signal at the transmitter. However, this method also leads to low energy and bandwidth efficiency. In order to solve the above problems, a chaotic transmitted reference(CTR) system has been proposed. In this system, the reference signal does not need to be sent by at the transmitter any more, but has been placed in the receiver in advance. What calls for special attention is that the reference signal is a binary sequence consisting of (1, -1), which is converted by chaotic non-binary information sequence. When receiving the chaotic information sequence, it has been converted to a information binary sequence by employing the same non-binary to binary conversion policy. Finally, the correlation operation between the binary reference sequence and the binary information sequence has been utilized. Obviously, if received and stored sequences are similar, the correlation coefficient will be large whereas if sequences are different, the correlation coefficient will be close to zero. The simulation results show that compared with the DCSK communication technology, the proposed method can not only increase the energy and bandwidth efficiency exponentially, but also achieve a considerable performance gain when the spread factor is larger than 60. Specially, the performance gain is about 5dB at ber=10^-5 when the spread factor is 240 in AWGN channel.

Keywords： Chaotic Transmitted Reference Modulation, DCSK, Robust

Speaker's biography: Tingting Huang received her Ph.D. degree in 2017 from Xiamen University, Xiamen, China. Currently, she is a lecturer at the engineering college in Huaqiao University, Quanzhou, China. Her research interests include chaotic digital communication, chaotic encryption, and ultra-wideband communications.

Generalized Carrier Index Differential Chaos Shift Keying Based SWIPT with Conversion Noise and Path Loss-Effect

Guixian Cheng[1,A*]， Mengxuan Zhang[1,B]

[1]Guizhou Normal University, School of Physics and Electronic Science, Guiyang , 550001, China

[A]Email: chgx86@126.com, [B]Email: 20010070245@gznu.edu.cn

[*]Corresponding author: chgx86@126.com

Abstract： A generalized carrier index differential chaos shift keying with simultaneous wireless information and power transfer (GCI-DCSK SWIPT) scheme, is proposed, which is an improved scheme for CI-DCSK SWIPT. Compared to CI-DCSK SWIPT, GCI-DCSK SWIPT is not only more flexible in selecting both index bit number and index carriers number, but also is more practical by considering both path loss and the conversion noise generated by radio frequency (RF) band to baseband. The proposed scheme applied a time switching manner to harvest the energy carried by the inactive carriers. Theoretical bit error rate (BER) expressions of the scheme over AWGN and multipath Rayleigh fading channels are derived, and the ratio of harvested energy to transmitted energy is derived to desecribe the probability of self-suffieieney on power supply. Besides, the frame-derived factor and the energy carried by inactive carriers are optimized to obtain better BER performance. Simulation results show that taking both path loss and conversion noise into consideration, the scheme is still self-sufficient with good BER performance. Furthermore, by adjusting the number of active carriers of GCI-DCSK SWIPT, some cases of GCI-DCSK SWIPT outperform conversion noise-aware CI-DCSK SWIPT in BER.

Keywords：DCSK; index modulation; SWIPT; path loss; conversion noise

Signal design of MDCSK and Coded Modulation for Impulsive Noise in PLC

Meiyuan Miao[1,A]，Lin Wang[1,B]

[1] Nanjing University of Posts and Telecommunications, School of Communication and Information Engineering, Nanjing, 210003 China
[2]Xiamen University, School of Information , Xiamen, 365001, China

[A]Email:meiyuanmiao@foxmail.com, [B]Email:wanglin@xmu.edu.cn)

Abstract：The previous work for mitigate the influence of impulsive noise for PLC. However, it also has a error floor of BER. To further mitigate the BER error floor of M-ary differential chaos shift keying (MDCSK) modulation for impulsive noise, a low-cost high-reliability coded modulation scheme without equalizations is desirable for impulsive noise. In this paper, a protograph-based low-density parity-check coded MDCSK-based bit-interleaved coded modulation (MDCSK-BICM) scheme is proposed for the scenario with impulsive noise obeying BernoulliLaplace distribution. Considering the Gaussian distribution of protograph extrinsic information transfer (PEXIT) and the benchmark of coding design, the U-shaped non-coherent capacity is derived with optimal code rate for square MDCSK, showing that the code rates are stable with Eb/N0 increasing but still much lower than that of DS-16DQAM at code rate >0.145. The derived joint probability density function can be considered as approximately a Gaussian distribution, which is used to improve the impulsive noise fitted PEXIT. Finally, a new code under a novel principle is designed for better bit error rate performance based on the improved PEXIT analysis. Both PEXIT analysis and simulation results demonstrate that the proposed scheme achieves a better BER than that with a traditional scheme, and suggesting a research approach based on simple methods. This basic research work provides a guide to establish a framework and optimize the performance of transmission systems over practical power line communication.

Keywords：MDCSK，Coded Modulation，impulsive noise， PLC，LDPC

Speaker's biography: Dr. Meiyuan Miao received the B.Sc. degree in Communication engineering, the M.Sc. degree in Optics engineering from Dalian Polytechnic University, Dalian, China, in 2014 and 2017, and the Ph.D. degree in Communication and information system from Xiamen University, Xiamen, China, in 2022. She was a Foreign Co-Researcher with the Department of Institute of Materials and Systems for Sustainability, Nagoya University, Nagoya, Japan. She is currently a Lecturer with the Nanjing University of Posts and Telecommunications. Her research interests include chaotic communications, PLC, multi-access, and coded modulations.

Parallel Differential Chaotic Shift Keying with Code Index Modulation for Wireless Communication

Haoyu Chen， Pingping Chen

[1,2,*]School of Advanced Manufacturing, Fuzhou University, Jinjiang, 362251, China
[1]Email: kevininfzu@gmail.com

Abstract： The differential chaos shift keying with code index modulation (CIM-DCSK) using Walsh codes can increase the data rate, but bit error rate (BER) performance degrades over the practical multipath channel with high delay spread. To tackle this drawback, this paper proposes a parallel CIM-DCSK (PT-CIM-DCSK), where the information sequence is generated by adding modulated sequences together and transmitted parallelly after the reference sequence. By exploiting the quasi-orthogonal characteristics of permuted chaotic signals, the interference between added sequences can be remarkably suppressed. The parallel transmission concept enables the proposed design to improve both the data throughput and the BER performance. The performance of the PT-CIM-DCSK is analytically studied and BER expressions are derived over multipath Rayleigh fading channels. Simulations are carried out to confirm the derived analytical results. In the high-delay scheme, the proposed scheme outperforms CIM-DCSK by more than 5 dB at a BER of 10^{-4}. Besides, the PT-CIM-DCSK has been further extended to the frequency-modulated (FM) form. The results show that the proposed scheme can achieve significant performance gains compared with its rivals for various modulation orders over ultra-wideband (UWB) channel. Thus, PT-CIM-DCSK is an alternative for low-cost and low-complexity wireless communication applications.

Keywords： Chaotic communication, differential chaos shift keying (DCSK), code index modulation (CIM), ultra-wideband (UWB).

Speaker's biography: Haoyu Chen received the B.Eng. degree in electronic information engineering from Fuzhou University, Fujian, China, in 2020. He is currently pursuing the M.Sc. degree with the Department of Electronic Information Engineering, Fuzhou University, Fujian, China. His research interests include chaos-based communications, index modulation and their applications to wireless communications.

混沌的新特性及其在无线通信中的应用（invited）

Hai-Peng Ren[1]，

[1] Xi'an Modern Control Technology Research Institute, Xi'an 710065, China

*Corresponding author: renhaipeng@xaut.edu.cn

Abstract：

介绍了近年来发现的混沌的新特性包括李亚谱诺夫指数不变性、自相关函数不变性及其在混沌基带通信和扩频通信中的应用。给出了这些特性为无线通信系统性能提升带来的契机，包括理论上完全消除多径干扰的影响、信道盲辨识新方法、扩频通信质量和速率的提升，同时介绍了应用人工智能方法提升混沌基带无线通信系统性能的一些有益探索。

Keywords：李亚谱诺夫指数不变性，自相关函数不变性，混沌通信

Speaker'sbiography:

任海鹏，博士，教授，研究领域为：复杂系统控制与智能信息处理。发表论文 100 多篇，授权发明专利超过 50 项，出版专著 2 部。

基于深度学习的智能混沌通信技术
（invited）

中山大学电子与信息工程学院 张琳（Email:isszl@mail.sysu.edu.cn）
广州市外环东路 132 号，510006

摘要:为了进一步提升混沌通信系统的信息传输性能，本文将深度学习用于混沌通信，研究基于深度学习的智能混沌信息传输技术，以提升其可靠性。在接收端，构建神经网络结构，利用全连接层对接收到的混沌扩散调制序列进行联合解沃尔什码扩散和混沌解调；同时利用长短期记忆（Long Short-Term Memory，LSTM）单元提取混沌序列之间的相关性，进一步提高系统恢复信息的准确度。实验结果表明，本文提出的智能联合解扩和解调方案可以达到比传统混沌通信系统更好的误比特率性能。此外，本文还添加残差网络（Residual Network，ResNet）结构对神经网络进行了改进。实验结果表明，基于 ResNet 结构的改进神经网络具备更好的收敛性能，进一步提升了智能混沌信息传输系统的可靠性。

Designing A Novel Color Image Encryption Scheme Based on 5-D Hyperchaotic System and DNA Sequence

Jian Zeng[1,A], Ziheng Yang[1,B], Qun Ding[2,*]

[1,2]School of Electronic Engineering, Heilongjiang University, Harbin, 150000, China
[A]Email: 2211790@s.hlju.edu.cn, [B]Email: yzh@hlju.edu.cn
[*]Corresponding author: qunding@aliyun.com

Abstract: Nowadays, it is more and more necessary to improve the encryption performance of images and the secure transmission performance of images. Therefore, in this paper, a bit-level scrambling algorithm based on hyperchaos is proposed, with a newly constructed five-bit hyperchaotic system combined with DNA sequence encryption to achieve bit-wide scrambling of plaintexts. The proposed five-dimensional hyperchaotic system has good chaotic dynamics, combining hyper-chaotic sequence with bit-level dislocation to enhance the pseudo-randomness of the plaintext image. We adopt the scheme of decomposing the plaintext color image into three matrices of R, G, and B, and performing block operations on them. The block matrix is DNA encoded, operated and decoded. The DNA operation is also determined by the hyperchaotic sequence, and finally gen-erated ciphertext image. The results of the various security analyses prove that the ciphertext images generated by the algorithm have good distribution characteristics, which can not only resist differential attacks, but also have the advantages of large cryptographic space.

Keywords: 5-D hyperchaotic system; color image encryption; bit-level permutation; DNA encoding

Speaker's biography: Jian Zeng graduated from Harbin University of Science and Technology with a Bachelor's degree in Electronic Science and Technology. Currently, she is a master's student in Electronic Communication and Engineering at Heilongjiang University. Her main research interests are chaotic systems, nonlinear circuits, modelling and control of systems and Hardware secure communication systems.

Application of GRU Neural Network in Chaotic Sequence Prediction

Pengteng Guo[1,A], Jing Zhan[1,B], Qun Ding[*]

Heilongjiang University, School of Electronic Engineering, Harbin, 150000, China
[A]Email: 2211744@s.hlju.edu.cn, [B]Email: 2211783@s.hlju.edu.cn
[*]Corresponding author: qunding@aliyun.com

Abstract: Due to the practical problems of achieving complete synchronization of chaotic systems, but in many application, only a limited number of steps ahead of the prediction is needed to achieve some degree of equivalence with synchronization, so there are great prospects for fast and accurate prediction of chaotic sequences for applications such as clean energy utilization and public health events. In this paper, the classical chaotic system, Chen and Lorenz, is used as the object of study. The GRU (grated recurrent unit) model, which has the advantage of capturing long-term dependencies, is selected, and single-step prediction and multi-step prediction are performed for Lorenz and Chen chaotic systems. The experimental results on the Lorenz and Chen chaotic systems show that: under the same conditions, the GRU model has a certain improvement effect on the prediction error than LSTM and RNN ; in terms of convergence efficiency: it has a higher convergence efficiency than the other two models.

Keywords: chaotic sequence, neural network, GRU and prediction

Speaker's biography: Pengteng Guo received his B.E. degree in Measurement and Control Technology and Instrumentation from Taiyuan Institute of Technology in 2019, and is currently pursuing his M.S. degree in Information and Communication Engineering in the School of Electronic Engineering at Heilongjiang University, with his main research areas: chaos synchronization, machine learning. Deep Learning-Based Sparse Codebook Multiple Access for Multi-carrier Differential Chaos Shift Keying System.

Deep Learning-Based Sparse Codebook Multiple Access for Multi-carrier Differential Chaos Shift Keying System

Chao Duan[1,A], Yi Fang[1,*]

[1]School of Information Engineering, Guangdong University of Technology, Guangzhou, 510006, China

[A]Email: duanchao@gzgs.edu.cn, [*]Corresponding author: fangyi@gdut.edu.cn

Abstract: This paper proposes a deep learning-based sparse codebook multiple access (SCMA) for multi-carrier differential chaos shift keying (MCDCSK), named DL-S-MCDCSK. For the sake of improving the spectrum efficiency, we introduce the SCMA technology, which encodes information bits to multi-dimension complex codewords, to the MCDCSK. The complex codewords could overlap on sub-carrier resources in a non-orthogonal way. Unlike the conventional hand-craft codebook and Message Passing Algorithm (MPA) decoding method, the proposed scheme adopts deep neural network (DNN) as encoder and decoder of SCMA, respectively, in transmitter and receiver. As the codewords generated by encoder are complex value, the corresponding real and imaginary part are modulated by the chaotic signal and its Hilbert transformation version respectively, then the modulated signal is sent to the receiver after multi-carrier modulation. At the receiver, the resultant codewords will be recovered by the process of demodulation, and be input to the decoder for training. We regard the decoding process as a classification problem aiming to optimize the codebooks by backforward propagation. The codebooks are randomly generated and trained in the proposed DL-S-MCDCSK system. In the proposed scheme, the complicated design of codebooks and conventional decoding algorithm are replaced with DNN, which can improve the spectrum efficiency of MCDCSK as well as enhance the anti-fading ability. Simulation results demonstrate that our proposed scheme can achieve desirable BER performance over both AWGN and Rayleigh fading channels.

Keywords: Wireless communications, multi-carrier differential chaos shift keying, deep neural network, sparse codebook multiple access.

Speaker's biography: Chao Duan received the B.S. degree in information engineering from National University of Defence Technology, and the M.S. degree from Northwestern Polytechnical University in 2016. He is currently pursuing Ph.D. degree with the School of Information Engineering, Guangdong University of Technology. His research interests include wireless communication, deep learning and internet of things.

Group-based Index Modulation for Differential Chaos Shift Keying

Hua Yang[1,*]，Zhu Meng[1,A]，ShouYi Li[1,B], Guo-ping Jiang[2,C]

[1]Nanjing University of Posts and Telecommunications, College of Electronic and Optical Engineering, Nanjing, 210023, China
[2] Nanjing University of Posts and Telecommunications, College of Automation, Nanjing, 210023, China
[A]Email: 137803425@qq.com, [B]Email: 1813526861@qq.com, [C]Email: jianggp@njupt.edu.cn.
[*]Corresponding author: yangh@njupt.edu.cn

Abstract：This paper proposed a novel group-based index modulation for differential chaos shift keying (DCSK), which helps to obtain higher bit rate and better bit error rate performance with low complexity cost. In this scheme, entities (including but not limited to carriers, codes, etc.) for index modulation are divided into two groups, and elements in each group are indexed individually so that two separate index modulations can be performed on these two groups. With the help of this design, data signals transmitted in two groups can serve as the reference of each other, and the transmission of reference signals that carry no information bits can be avoided. Besides, this group-based index modulation also may help to increase the spectral efficiency in some cases, and thus much fewer entities will be required to obtain a certain bit rate. The proposed method can be applied in almost all existing index modulated DCSK systems. For demonstration, the applications in carrier index differential chaos shift keying and code-shifted differential chaos shift keying systems are considered, and theoretical bit error rate performances of relevant systems are analyzed over the AWGN and multipath Rayleigh fading channels, respectively.

Keywords：Index modulation, Group-based index modulation, Differential chaos shift keying, Bit error rate

Speaker's biography: Dr. Hua Yang received the Ph. D. degree in information and communication engineering from Nanjing University of Posts and Telecommunications, China in 2014. From 2014, she has been an associate professor with the School of Electronic Science and Engineering, Nanjing University of Posts and Telecommunications, China. In 2015 and 2016, she worked as a Postdoctoral Fellow in the Department of Electronic Engineering, City University of Hong Kong. In 2017, she visited the School of Electrical, Computer and Energy Engineering in Arizona State University, USA. Her current research interests include application of nonlinear circuits and systems, index modulation and chaos-based communications.

Design of A New CIM-DCSK-Based Ambient Backscatter Communication System

Ruipeng Yang[1,A], Yi Fang[1,*]

[1]Guangdong University of Technology of GuangZhou, 510000, China
[A]Email: yrp_1995@126.com, [*]Corresponding author: fangyi@gdut.edu.cn

Abstract: To improve energy efficiency and data rate in differential chaos shift keying (DCSK) based ambient backscatter communication (AmBC) system, we propose a new AmBC system based on code index modulation DCSK (CIM-DCSK), referred to as CIM-DCSK-AmBC. In the proposed scheme, the CIM-DCSK signal transmitted in the direct link is used as the radio frequency source of the backscatter link. The proposed design of backscatter modulated signal can carry more information bits than that in the short reference DCSK based AmBC (SR-DCSK-AmBC) system. The CIM-DCSK signal and the backscatter signal can be received and demodulated simultaneously and the interference between direct link and backscatter link can be well eliminated. The theoretical bit error rate (BER) expressions of CIM-DCSK-AmBC system are derived and verified over both additive white Gaussian noise (AWGN) and multipath Rayleigh fading channels. Numerical results reveal that CIM-DCSK-AmBc system can achieve better BER performance in direct link and higher throughput in backscatter link than SR-DCSK-AmBC system.

Keywords: Ambient backscatter communication, differential chaos shift keying (DCSK), code index modulation.

Speaker's biography: Ruipeng Yang received the B.E. degree in electronic information engineering and the M.E. degree in electronics and communication engineering from Xidian University, Xi'an, China, in 2018 and 2021, respectively. He is currently pursuing a PhD degree with the Department of Communication Engineering, Guangdong University of Technology. His research interests include chaotic communications and backscatter communications.

SM4 Chaotic Masking Scheme Against Power Analysis Based on FPGA

Zijing Jiang[1], Qun Ding[*]
School of Electronic Engineering, Heilongjiang University, Harbin, 150080, China
Email: zijingjiang@ aliyun.com,
[*]Corresponding author: qunding@aliyun.com

Abstract： SCA is one of the biggest threats to the security of encryption chip. It can crack the unprotected encryption chip at lower cost and faster speed, which weakens the security of the SM4 encryption algorithm circuit without any protection. In this paper, the SM4 encryption algorithm is implemented on FPGA. The pseudo-random sequence generated by discrete chaotic system is used to randomly mask the intermediate value in the SM4 encryption process. This will disrupt the power consumption in the encryption process, thus preventing power analysis. Experimental results show that the proposed chaotic mask scheme can effectively prevent intermediate value leakage and protect the SM4 encryption system from power analysis attack.

Keywords： CPA; FPGA; Mask; Power analysis; SM4

Zijing Jiang: Zijing Jiang was born in 1994. he is currently pursuing the doctor's degree with Heilongjiang University. His research interest includes hardware IP and hardware side channel security.

A Novel Color Image Encryption Scheme Based on Hyperchaos and Hopfield Chaotic Neural Network

Yanan Wu[1]，Qun Ding[*]

School of Electronic Engineering, Heilongjiang University, Harbin, 150000, China
Email: 2201734@s.hlju.edu.cn
[*]Corresponding author: qunding@aliyun.com

Abstract： Problems such as insufficient key space, lack of a one-time pad, and a simple encryption structure may emerge in existing encryption schemes. To keep sensitive information safe, this paper proposes a plaintext-related color image encryption scheme. Firstly, a new hyperchaotic system is constructed in this paper. Secondly, the Hopfield chaotic neural network was applied to construct a new encryption algorithm. The keys are generated from chunking image blocks. The pseudo-random sequences iterated by the aforementioned systems are used as key streams. Therefore, the proposed pixel-level scrambling can be completed. Then the chaotic sequences are utilized to dynamically select the rules of DNA operations to complete the diffusion encryption. This paper also presents a series of security analyses of the proposed encryption scheme and compares it with other schemes to evaluate its performance. The results show that the key streams generated by the two systems improve the key space. The proposed encryption scheme provides a satisfying visual hiding result. Furthermore, it is resistant to a series of attacks and the problem of structural degradation caused by the simplicity of the encryption system's structure.

Keywords： image encryption; hyperchaotic system; Hopfield chaotic neural network; DNA coding

Speaker's biography: Yanan Wu graduated from Qufu Normal University with a Bachelor's degree in Communication Engineering. Currently, she is a master of electronic communication and engineering at Heilongjiang University. Her main research interests are chaotic system, chaotic neural network, encryption algorithm design and hardware implementation.

Chaotic secure communication based on convolutional neural networks and silicon photonic microcavity（invited）

Yan Wang[1,A]，Jiagui Wu[1,*]

[1]School of Physical Science and Technology, Southwest University, Chongqing 400715, China)

[A]Email: wy199909@email.swu.edu.cn

[*]Corresponding author: mgh@swu.edu.cn

Abstract： Chaotic secure communication based on silicon photonic microcavity (SPM) has the advantages of high integration and complementary metal oxide semiconductor (CMOS) compatibility but also inevitably has the challenges of parameter matching and difficulties in fabricating process. Therefore, we propose a hybrid scheme of convolutional neural network (CNN) and SPM to enhance the feasibility of chaotic secure communication. By loading the non-return-to-zero (NRZ) bit sequences, we successfully use CNN to perform high-quality chaos synchronization and encrypt and decrypt NRZ sequences. The synchronization coefficient of this scheme is as high as 99.8%, which is substantially higher than the conventional Runge-Kutta-4 functions and obtains a clear decrypted eye diagram. These results provide a possible wat for multipoint-to-multipoint information transmission and advance secure communications.

Keywords: Secure communication, Silicon photonic microcavity, Convolutional neural network

Yan Wang: is currently working towards a Master of Engineering degree in computer science and technology at Southwestern University in China. Her research interests include neural networks, chaotic secure communications, and FPGA-based network design.

Chaotic fingerprint for transmitter identification in physical layer security of optical network（invited）

Hongxiang Wang

Beijing University of Posts and Telecommunications

Optical networks have become one of the most important fundamental infrastructures. More and more attacks in physical layer are emerging which threaten the security of optical network much. Besides eavesdropping, injection attacks of optical signals are becoming serious, such as in- and out-band interference attack, illegal optical signal insertion, malicious tampering, and so on.Fingerprint identification of optical transmitters is recognized as an effective way for injection attacks. However, the current hardware fingerprints of optical transmitters are not secure enough and easy to be faked, with small fingerprint space and weak anti-noise performance as well. This report reviews the research progress of current hardware fingerprints of optical transmitters, and proposes a fingerprint constructing method for optical transmitters for physical layer security by using chaos characteristics. In this method, an electro-optical chaos signal is wavelength division multiplexed with a modulated optical signal to identify the optical transmitter, followed by an opticalfractional Fourier transformer to guarantee the security of fingerprint. The proposed optical transmitter fingerprint constructing method is validated, and the recognition accuracies of fingerprint with a 2D-CNN are discussed.

Nonlinear dynamics and broadband chaos generation in spin-VCSELs

Nianqiang Li*

1Shool of Optoelectronic Science and Engineering & Collaborative Innovation Center of Suzhou Nano Science and Technology, Soochow University, Suzhou 215006, China

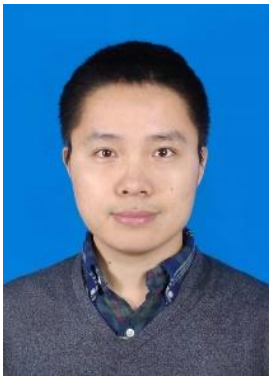
2Key Lab of Advanced Optical Manufacturing Technologies of Jiangsu Province & Key Lab of Modern Optical Technologies of Education Ministry of China, Soochow University, Suzhou 215006, China

*Corresponding author: wan_103301@163.com

Abstract： As optics chaos can be applied to several important applications, such as secure communications and random bit generation, its generation has been widely studied. This paper investigated the nonlinear dynamics of spin-VCSELs and revealed some interesting phenomena, which would be of interest to the chaos-related community. Besides, broadband chaos generation was also numerically demonstrated in spin-VCSELs, which would be of importance to enhance the performance of chaos-based applications.

Keywords： Bifurcation; dynamics; chaos; spin-VCSELs

Nianqiang Li received the B.S. degree in communication engineering and the Ph.D. degree in optoelectronics from Southwest Jiaotong University, China, in 2008 and 2016, respectively. He began to work at Soochow University as a full professor in January 2019. He has authored or co-authored more than 100 peer-reviewed journal papers, including more than 60 first/corresponding SCI papers. His current research mainly focuses on the area of laser dynamics, chaos-based communication and random number generation, and microwave photonics. He is an Associate Editor of the IEEE ACCESS.



Coherent optical chaos communication with probabilistic shaping（invited）

Longsheng Wang[1,2], Lin Jiang[5], Anbang Wang[1,2,3,4*], Lianshan Yan[5], Yuncai Wang[3,4]

[1]Key Lab of Advanced Transducers & Intelligent Control System, Ministry of Education and Shanxi Province, Taiyuan 030024
[2]College of Physics and Optoelectronics, Taiyuan University of Technology, Taiyuan 030024
[3]School of Information Engineering, Guangdong University of Technology, Guangzhou 510006
[4]Guangdong Provincial Key Laboratory of Photonics Information Technology, Guangzhou 510006
[5]Center for Information Photonics & Communications, School of Information Science and Technology, Southwest Jiaotong University, Chengdu 610031
[*]Corresponding author: wanganbang@tyut.edu.cn

Abstract： Coherent optical chaos communication is promising in protecting high-speed data transmission from eavesdropping, but encounters implementation difficulty induced by harsh demand on high-quality chaos synchronization. Here, we propose a coherent optical chaos communication with probabilistic shaping (PS) which eases this harsh demand. The PS redistributes the constellation points of 16-ary quadrature amplitude modulation (16QAM) and enlarges the Euclidean distance between them according to the probabilistic distribution factor, which improves the system tolerance to synchronization degradation. Numerical results show that secure transmission of PS-16QAM with a symbol rate of 10GBd can still be realized when the synchro-coefficient decreases to 0.905 or even below. The effects of probabilistic distribution factor on the transmission rate and system security are analyzed with respect to different synchro-coefficients. It is believed that the proposed scheme will contribute to promoting the practical applications of coherent optical chaos communication.

Keywords： laser chaos; secure communication, probabilistic shaping, coherent detection

Speaker's biography: Dr. Longsheng Wang received the B.S. degree in optical engineering and the Ph.D. degree in physical electronics from the Taiyuan University of Technology, China, in 2013 and 2017, respectively. In 2018, he joined the Taiyuan University of Technology, where he is currently an Assistant Professor with the Key Lab of Advanced Transducers and Intelligent Control System, Ministry of Education. His research interest includes nonlinear dynamics of semiconductor lasers, chaos synchronization, random bit generation, secure communication, and key distribution.

Studying the dynamical behaviors of chaotic optically injected semiconductor lasers（invited）

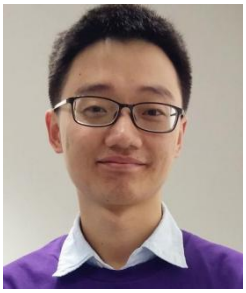
Xiao-Zhou Li[1,*], Xiaoqing Zhou[1], Bin Sheng[1], Yiying Gu[1], and Mingshan Zhao[1]

[1]School of Optoelectronic Engineering and Instrumentation Science,
Dalian University of Technology, Dalian 116024, China
[*]Corresponding author: xzli@dlut.edu.cn

Abstract：Chaotic dynamics of semiconductor lasers have enabled a variety of novel applications including secure communications, random bit generations, and ranging. The performances for most of the above-mentioned applications have been found to be directly related to the statistical properties and underlying dynamics of chaotic lasers. In this presentation, dynamical behaviors of chaotic optically injected semiconductor lasers are investigated and predicted by considering the laser emission intensity time series in numerical simulations. On one hand, the statistical properties of the chaotic waveforms are investigated by exploring the injection parameter space for different detection bandwidths. The results show the possibility of tuning operating parameters for generation of either rare events or Gaussian distributions, which can be useful for applications based on chaotic lasers. On the other hand, we demonstrate successful prediction of the continuous intensity time series for a time duration comparable to six times the reciprocal of the laser relaxation resonance frequency. Moreover, the prediction allows for accurate reproduction of the chaotic dynamical behaviors, including the microwave power spectrum, probability density function, autocorrelation function, and the reconstructed state space. The effect of the spontaneous emission noise on the accuracy of the prediction is also investigated. These approaches for studying the dynamical behaviors using intensity time series are readily extended for different simulations and experiments based on chaotic semiconductor lasers.

Keywords：**Chaos;** semiconductor lasers; dynamical behaviors; time series.

Speaker's biography: Xiao-Zhou Li (李晓洲) received the B.Eng. degree in communication engineering from the Harbin Institute of Technology, Harbin, China, in 2011, and the M.Phil. and Ph.D. degrees in electronic engineering from the City University of Hong Kong, Hong Kong, China, in 2013 and 2016, respectively. From 2016 to 2018, he was a Postdoctoral Research Fellow with Photonic Signals and Systems Group, Institut National de la Recherche Scientifique- Énergie, Matériaux et Télé-communications, Montréal, QC, Canada, from 2018 to 2019, he was a Postdoctoral Researcher with the School of Mechanical and Aerospace Engineering, Korea Advanced Institute of Science and Technology, Daejeon, South Korea. He is currently an Associate Professor with the School of Optoelectronic Engineering and Instrumentation Science, Dalian University of Technology, Dalian, China. His research interests include ultrafast optical signal processing and semiconductor laser dynamics.



Fast physical random bit generation with a photonic integrated chaotic semiconductor laser

Qiang Cai[1], Pu Li[2*], Yuncai Wang[2]

[1]Key Laboratory of Advanced Transducers and Intelligent Control System, Ministry of Education, College of Physics and Optoelectronics, Taiyuan University of Technology, Taiyuan 030024, China

[2]Guangdong Provincial Key Laboratory of Photonics Information Technology, School of Information Engineering, Guangdong University of Technology, Guangzhou 510006, China

[*]Corresponding author: lipu8603@126.com

Abstract:

Physical random bits (PRBs) have a wide range of applications in science and engineering. Because of the high bandwidth and large random fluctuation, laser chaos has been regarded the ideal entropy source for PRB generation. However, most of schemes for laser chaos generation are constructed using discrete optical and electronic devices and thus their whole systems are bulky and unstable.

The photonic integrated circuit is a promising technology to solve above problem. Here, we design and fabricate a photonic integrated chaotic semiconductor laser (PICSL) chip for PRB generation. There are two sections in the PICSL, one section is master laser (ML), and the other is slave laser (SL). These two lasers are integrated back-to-back to form a mutually coupled structure. It can generate broadband laser chaos with totally suppressed time delay signature. Further, by introducing a minimal post-processing technique and directly extracting four least significant bits (4-LSBs) at 40 GS/s sampling rate. A 160 Gbps physical random bit generator are achieved. The NIST test results show that the PRBs based on PICSL have good randomness and can pass all test items.

Keywords: random bit generator; laser chaos; photonic integrated circuit

Speaker's biography: Qiang Cai received the B.S. degree in optoelectronic information Science and Engineering from Taiyuan University of Science and Technology, Shanxi, China, in 2017. He is currently working toward the Ph.D. degree at the Key Laboratory of Advanced Transducers and Intelligent Control System (Ministry of Education of China), Taiyuan University of Technology, Shanxi, China. His current research interests include nonlinear dynamics of semiconductor lasers.

Chaotic time-delay signature suppression using quantum noise

Haifeng Li[1,A]，Xiaomin Guo[1,B]，Tong Zhao[1,C]，Yanqiang Guo[1,*]

[1]Key Laboratory of Advanced Transducers and Intelligent Control System, Ministry of Education, Taiyuan University of Technology, Taiyuan 030024, China
[A]Email:lihaifeng20202020@163.com,[B]Email:guoxiaomin@tyut.edu.cn,[C]Email:zhaotong.tyut@outlook.com
[*]Corresponding author: guoyanqiang@tyut.edu.cn

Abstract: Semiconductor lasers subject to external optical feedback (EOF) represent a prominent platform for studying complex dynamics. Intrinsic quantum noise is rapidly and nonlinearly amplified by the dynamics, resulting in instability-induced large intensity, wide-band and high-dimensional ‘‘noise’’ outputs after long time. Whereas, the EOF gives rise to an inherent time-delay signature (TDS). The TDS could expose the external cavity length and degrade the complexity of chaos, deteriorating the quality of chaos-based secure communication and random number generation. It is essential to suppress the TDS and its reduction is beneficial to practical applications of chaotic lasers. Up to now, many schemes have been proposed to suppress the TDS of chaotic lasers and part randomness of the chaotic lasers is extracted. It is important to reveal the origins of the stochastic effects and extract random noise efficiently. However, the effect of quantum noise on the underlying dynamics and randomness of chaotic laser remains to be explored.

In this letter we numerically and experimentally demonstrate a technique to effectively suppress the TDS of chaotic lasers using quantum noise. The TDS and dynamical complexity are quantified using the autocorrelation function and normalized permutation entropy at the feedback delay time, respectively. Quantum noise from quadrature fluctuations of vacuum state is prepared through balanced homodyne measurement. The effects of strength and bandwidth of quantum noise on chaotic TDS suppression and complexity enhancement are investigated numerically and experimentally. Compared to the original dynamics, the TDS of this quantum-noise improved chaos is suppressed up to 94% and the bandwidth suppression ratio of quantum noise to chaotic laser is 1:25. The experiment agrees well with the theory. The improved chaotic laser is potentially beneficial to chaos-based random number generation and secure communication.

Keywords： Chaotic laser; Quantum noise; Balanced homodyne detection; Time-delay signature; Permutation entropy

Speaker’s biography: Dr. Yanqiang Guo is an associate professor at the College of Physics and Optoelectronics of Taiyuan University of Technology. He is the principal investigator of Precision measurement and characterization of noise source research group from the Key Laboratory of Advanced Transducers and Intelligent Control System, Ministry of Education. He received his PhD in optics from the State Key Laboratory of Quantum Optics and Quantum Optics Devices, Shanxi University in 2013. From 2014 to 2016, he was a project assistant professor of Center for Photonic Innovations, University of Electro-Communications, Tokyo, Japan. He received the “Sanjin Talent” for Young Excellent Talents awarded by the Shanxi Province in 2019. His research interests include nonlinear optics and its applications, quantum random number generation, and optical precision measurement.

Video Recognition based on Photonic Reservoir Computing

Chao Kai[1], Pu Li[2*], Yuncai Wang[2]

[1]Key Laboratory of Advanced Transducers and Intelligent Control System, Ministry of Education, College of Physics and Optoelectronics, Taiyuan University of Technology, Taiyuan 030024, China

[2]Guangdong Provincial Key Laboratory of Photonics Information Technology, School of Information Engineering, Guangdong University of Technology, Guangzhou 510006, China

[*]Corresponding author: lipu8603@126.com

Abstract: Video recognition has a wide range of applications such as visual surveillance systems, autonomous navigation systems, video retrieval, and human computer interaction. Meanwhile, accurate and efficient video recognition is still a challenging task in the domain of computer vision, because its modeling and feature representation are extended from two-dimensional space to three-dimensional space-time. We propose a video recognition approach using a time-delayed photonic reservoir computing. In this method, only a semiconductor laser subjected to self-delayed feedback is used as the solitary physical node in the reservoir. Through expanding this single node into a large number of virtual nodes by employing outputs of multiple delay times, we enable this reservoir to be a complex network. After optimizing the reservoir hyperparameters (viz., the sample size, virtual node size, mask standard deviation, current of response laser, injection strength, feedback strength and frequency detuning), our simulation results demonstrate that using our method, a high-performance 98% accuracy for video recognition can be achieved. Both of its simple architecture and compact size make our scheme be a lightweight candidate to neural networks for video recognition.

Keywords: photonic reservoir computing; video recognition; semiconductor laser; neural network; computer vision

Speaker's biography: Chao Kai received the B.S. degree in automation from Nanjing University of Information Science and Technology, Nanjing, China, in 2020. He is currently working toward the M.S. degree at the Key Laboratory of Advanced Transducers and Intelligent Control System (Ministry of Education of China), Taiyuan University of Technology, Shanxi, China. His current research interests include optical neural network.

Handwritten digit recognition based on a single dynamical node-based optical reservoir computing

Jiayi Li[1], Qiang Cai[1], Pu Li [2*], Yuncai Wang[2]

[1]Key Lab of Advanced Transducers and Intelligent Control System, Ministry of Education College of Physics and Optoelectronics, Taiyuan University of Technology, Taiyuan 030024, China

[2]Guangdong Provincial Key Laboratory of Photonics Information Technology, School of Information Engineering, Guangdong University of Technology, Guangdong 510006, China

[*]Corresponding author: lipu8603@126.com

Abstract: Handwritten digit recognition is a task central to machine learning and computer vision. With the development of artificial intelligence (AI), deep neural networks (DNNs), have achieved impressive performance on handwritten digit recognition task. However, these increasingly complex DNNs require significant computing resources, because they inevitably consist of multiple hidden layers where all of the connection weights have to be trained using backpropagation algorithms. This results in a newfound demand for lightweight alternatives to neural networks. Here, we propose a handwritten digit recognition approach using a single dynamical node based optical reservoir computing. Specifically, an optically injected semiconductor laser with self-delayed feedback is used as the reservoir. We perform a handwritten digit recognition task by greatly increasing the number of virtual nodes in delayed feedback using outputs from multiple delay times. Final simulation results confirm that the recognition accuracy can reach 99% after systematically optimizing the reservoir hyperparameters. Due to its simple architecture, this scheme may provide a resource-efficient alternative approach for handwritten digit recognition.

Keywords: handwritten digit recognition; artificial intelligence, neural network, optical reservoir computing

Speaker's biography: Jiayi Li received the B.S. degree in electronics and information engineering from Southwest Minzu University in 2020. He is currently pursuing the M.S. degree from Key Lab of Advanced Transducers and Intelligent Control System, Ministry of Education College of Physics and Optoelectronics, Taiyuan University of Technology, China. His research interest includes optical reservoir computing.

The Research of Chaotic System Based Four-Wave Mixing

Xueting Zhang[1,A], Kun Wang[1,B], Penghua Mu[2,*]

School of Physics and Electronic Information, Yantai University, Yantai, 264005, China
[A]Email: zhangxueting0315@163.com, [B]Email: wangkun19980211@163.com
[*]Corresponding author: mcgram007@126.com

Abstract: Phase conjugate feedback systems are more likely to generate optical chaotic signals than conventional optical feedback systems, and have the advantages of high security and large bandwidth, making them more suitable for chaotic confidential communications, random number generators and other fields. In this paper, we construct a phase conjugate feedback laser chaos system based on the four-wave mixing principle. We use a distributed feedback semiconductor laser to generate phase-conjugated light based on the four-wave mixing principle and construct a feedback loop to generate a broadband chaotic signal in a fiber optics experiment.

Keywords: Phase conjugate feedback; Four-wave mixing; Chaotic signals

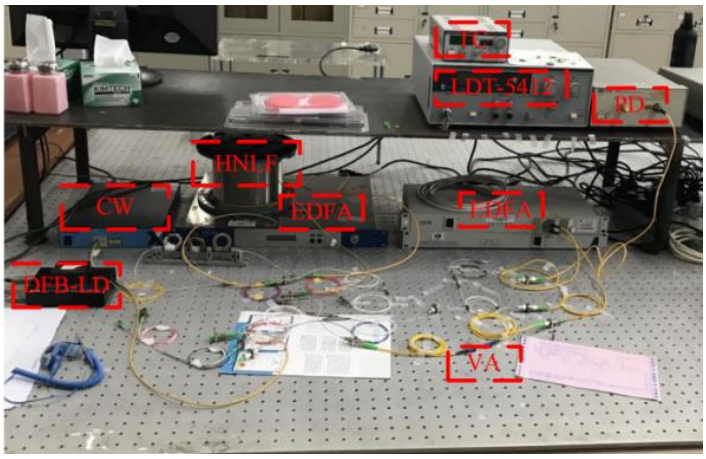


Fig.1. Diagram of the PCF-ECSL experimental setup

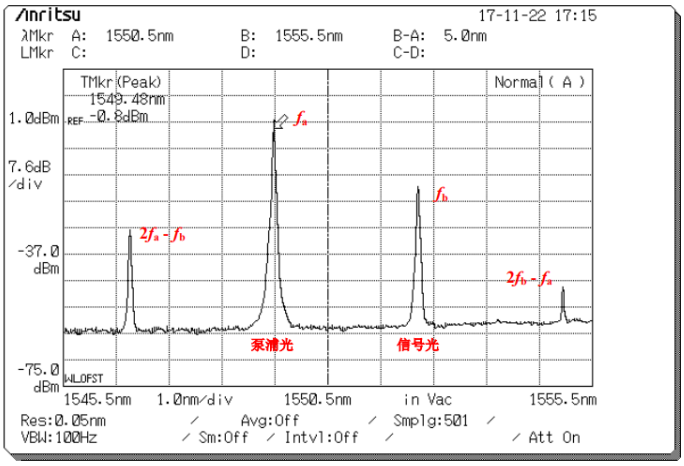


Fig. 2. Four-wave mixed signal

Speaker’s biography: Xueting Zhang received her bachelor's degree in communication engineering from Suqian University in 2022. At present, she is a graduate student majoring in electronic information at Yantai University, and her main research direction is laser chaos application.

Research on Discrete Chaotic Synchronization Methods And Applications

Zhang Jing[1,A]，Guo Pengteng[1,B]，Ding Qun[3,*]

Heilongjiang University, School of Electronic Engineering, Harbin, 150080, China
[A]Email: 2211806@s.hlju.edu.cn
[*]Corresponding author: 1984008@hlju.edu.cn

Abstract：Chaotic systems are a special type of nonlinear system, which means that there are seemingly random irregular motions in deterministic nonlinear systems with extremely high sensitivity to initial values. At the same time, chaotic signals have the characteristics of traversal, non-periodic, continuous broadband spectrum, and noise-like, which are especially suitable for secure communication and image encryption. With the deepening of the research of chaotic synchronization theory, if chaotic performance can be fully utilized, simultaneous encryption of synchronous transmission is a problem that needs to be solved in the field of chaotic secure communication. This paper focuses on the discrete chaotic synchronization method and its application in encrypted transmission system, and its research aims to construct an easy-to-implement, novel discrete chaotic synchronization method and encrypted transmission system, lay the foundation for digital chaotic synchronization technology and application, and promote the practical process of chaotic secure communication.

Keywords: Chaos; Chaotic Secure Communication; Discrete Chaotic Synchronization

Speaker's biography: Zhang Jing, received her bachelor's degree in June 2021. She is currently pursuing a master's degree in electronics and communication engineering at Heilongjiang University, with a research focus on secure communication technology and application.

A High-Resolution Image Encryption Algorithm Using a Dynamic S-box Based on Chaotic Map

Meng Xing[1,A], Wei Zhang[1,*], Zhiliang Zhu[1], Hai Yu[1]

[1]College of Software, Northeastern University, Shenyang 110167, China

[A]Email: xingmeng102@163.com

Abstract—With the development of mobile technologies and computer science, more and more different kinds of images are transmitted via the Internet in our daily life. High-resolution images have become one of the fastest-growing and most popular in various areas. However, their security problems are becoming more and more serious. Recently, issues have arisen regarding the existing image encryption algorithm's low encryption efficiency and high computational overhead. Meanwhile, almost the existing image encryption schemes generally focus on low-resolution images. Therefore, it is essential to design a high-resolution image encryption scheme that satisfies both security and computational efficiency. In this paper, a new high-resolution image encryption algorithm using a dynamic S-box is proposed that combines the 2D Logistic-Sine-Coupling Map and Logistic Map. Four steps comprise the encryption algorithm: the generation of encryption keys, the construction of the S-box, image permutation and image diffusion.

To satisfy the character of high-resolution images, a new key scheming is first investigated, in which the seeds of pseudo-random number generators are fully considered. New key-based cellular automata are presented to accomplish automatic keys along with the value of initial updating by combining an initial custom key and a cellular automaton. The keys generated by Key-based Cellular Automata are used as the initial values $\boldsymbol{x}$ along with control parameters $\boldsymbol{\mu}$ of the 2D Logistic-Sine-Coupling Map and the Logistic Map. After that, a new S-box is structured by producing two key sequences utilizing the 2D Logistic-Sine-Coupling Map that uses these two sequences to confuse the matrix in order to obtain the S-box. In addition, a parallelism permutation method combines pixel-level and block-level is proposed. Finally, a parallelism diffusion algorithm using forward diffusion was introduced.

Simulation results and security analysis are carried out which shows that the proposed scheme can provide high encryption/decryption efficiency and security while can effectively protect images from various attacks.

Key Words—Image encryption, Chaotic encryption, S-box, High-resolution images, Parallelism.

Neural Network-aided Detection Scheme For Index-Modulation DCSK System

Dongyang Peng[1,A], Yi Fang[1,*]
[1]Institute 1, School of Information Engineering, Guangdong University of Technology, Guangzhou 510006, China
[A]Email: dy_peng02@163.com, *corresponding author: fangyi@gdut.edu.cn

Abstract: In order to improve the BER performance of IM-DCSK system, a neural network (NN) aided index chaotic modulation intelligent receiver is proposed in this paper. Specifically, the proposed detection scheme mainly uses the two-layer long short-term memory (LSTM) structure in the receiver to extract the features of IM-DCSK signal and the correlation in internal signals, and combines multiple fully connected layers (FCL) to build the NN structure. In the proposed detection scheme, the information received through channel is taken as the training sample to train the network framework offline, and then the configured framework is used to estimate the transmitted index bit, which can achieve very good performance. The modulated bit is obtained from the index bit, thus the BER performance can be improved. In addition, the complexity of the proposed detection scheme is analyzed. The simulation results show that the proposed detection scheme can achieve better BER performance over multipath Rayleigh fading channels.

Keywords: Neural network (NN), index modulation differential chaos shift keying (IM-DCSK), deep learning (DL), long short-term memory (LSTM), multipath Rayleigh fading channel

Speakers biography: Dongyang Peng received the B.Sc. degree in Electronic Information Engineering from Nanchang Hangkong University, Nanchang, China, in 2021. He is currently pursuing the M.Sc. degree with the Department of Communication Engineering, Guangdong University of Technology, Guangzhou, China. His main research interests include spread spectrum modulation and deep learning.

A novel image encryption scheme based on 2D SILM and improved permutation-confusion-diffusion operations

Xinkang Liu, Kehui Sun*, Huihai Wang

School of Physics and Electronics, Central South University, Changsha 410083, China
*Corresponding author: kehui@csu.edu.cn

Abstract:

When a chaotic system is applied to encrypt image, it usually requires large parameter space, high ergodicity and easy implementation. In this paper, taking Sine and ICMIC map as seed maps, a novel 2D hyperchaotic Logistic map (2D-SILM) is designed based on the 2D parameter modulation model (PMM). Its dynamics are analyzed by means of attractor diagrams, Lyapunov exponents (LEs) spectrum and complexity diagrams. The results along with NIST SP-800 test prove the feasibility of 2D-SILM. Based on 2D-SILM and DNA coding, an image encryption scheme is proposed with two-round improved permutation-confusion-diffusion operations. SHA-512 function is introduced in the generation of the secret key. After applying the effective permutation process called chaotic grouping shuffle (CGS) on pixels position, DNA sequences procedures varied from different rounds are used to confuse the image pixels value. Finally, a novel diffusion method containing row and column operation is applied. Simulation results of the security indexes validate the secure performance of the proposed algorithm.

Keywords: Chaos, 2D SILM, Image encryption, SHA-512, DNA coding.

Xinkang Liu: is currently pursuing the master's degree in physics and electronic with the Central South University, China. His research interests include the areas of nonlinear dynamics and memristive circuits, including nonlinear circuits, systems, and corresponding applications such as image encryption.

A Class of Polynomial Chaotic Map With Image Encryption

Wenhao Yan[1], and Qun Ding[*]
School of Electronic Engineering, Heilongjiang university, Harbin 150080, China
Email: yanwh0512@163.com
[*]Corresponding author: qunding@aliyun.com

Abstract: Most existing chaotic systems have many defects in engineering applications, such as discontinuous chaotic parameter range, weak chaos, uneven output of chaotic sequences and dynamic degradation. Therefore, a generalized polynomial chaotic mapping model is proposed. By setting different control parameters and the highest degree of polynomial, a series of robust chaotic maps with specific Lyapunov exponent can be obtained. In order to avoid the output of the second state equation collapsing to a fixed value, a random disturbance variable which does not change with time is introduced. Furthermore, a numerical example is given to verify the effectiveness of the proposed model, and the dynamic analysis shows that the mapping has complex dynamic behavior. Finally, an image encryption scheme based on polynomial chaotic map is presented, whose security analysis indicates that the proposed image encryption scheme can resist violent attacks, correlation analysis, and differential attacks, so it has a higher security level.

Keywords：Lyapunov exponent, dynamic degradation, robust chaotic map, image encryption

Speaker's biography: He received the B.S degree in the Information and computing science from Northeast Petroleum University, China, in 2018. He is currently pursuing M.S degree in the information and communication engineering from Heilongjiang University, Harbin, since 2018. His research interests include nonlinear dynamics, chaos synchronization, and chaotic secure communication.

A non-degenerate *n*-dimensional integer domain chaotic map model with application to PRNG

Mengdi Zhao, Hongjun Liu*

University of Jinan, School of Mathematical Sciences, Jinan, 250022, China
Email: 1609195978@qq.com
*Corresponding author: sms_liuhj@ujn.edu.cn

Abstract: This paper proposed a non-degenerate *n*-dimensional (*n*≥2) integer domain chaotic map (*n*D-IDCM) model, which can construct any non-degenerate *n*D integer domain chaotic maps using the relationship between the parameter matrix of *n*D-IDCM and its Lyapunov exponents, and then analyzed the chaotic behavior of *n*D-IDCM through Lyapunov exponent. Furthermore, to verify the effectiveness of *n*D-IDCM, we provided two examples to illustrate how to control the positive Lyapunov exponents by setting parameter matrix, and then analyzed their dynamical behavior using Kolmogorov entropy, sample entropy, correlation dimension and randomness testing by TestU01. Finally, to evaluate practicability of *n*D-IDCM, we constructed a 3D-IDCM to design a keyed pseudo random number generator (PRNG) that can satisfy better randomness and unpredictability. Experimental results indicated that integer domain chaotic maps constructed using *n*D-IDCM have desirable Lyapunov exponents and have ergodicity within a sufficient larger chaotic range.

Keywords: Integer domain chaotic map; Non-degeneration; Lyapunov exponent; Jacobian matrix

Speaker's biography: Mengdi Zhao received her B.S. degree in Information and Computing Science from Shandong Jiaotong College, Shandong, China, in 2018. She is currently pursuing the M.S. degree with the School of Mathematical Sciences, University of Jinan, China. Her research focuses on the construction of multi-dimensional chaotic maps with application in cryptography.

Verifiable visually meaningful image encryption based on compressed sensing (CS) and improved game of life (IGOL)

Guoqiang Long[1,A], Lin Zhou[1,B,*] , Zhihua Gan[2,3,C,*], Xiuli Chai[1,3] , Zhifeng Fu[1], Yakun Ma[1]

[1]Institute 1, School of Artificial Intelligence, Henan Key Laboratory of Big Data Analysis and Processing, Henan University, Zhengzhou, 450046, China
[2]Institute 2, School of Software, Intelligent Data Processing Engineering Research Center of Henan Province, Institute of Intelligent Network System, Henan University, Kaifeng, 475004, China
[3]Institute 3, Henan Key Laboratory of Cyberspace Situation Awareness, Zhengzhou 450001, China
[A]Email: lgq@henu.edu.cn, [B]Email: zhoulin@henu.edu.cn, [C]Email: gzh@henu.edu.cn
[*]Corresponding author: zhoulin@henu.edu.cn, gzh@henu.edu.cn

Abstract: Image encryption converts the plain image into a noise-like one to protect information security. However, the obtained cipher images are easy to attract the attention of third parties during transmission and storage, and it is vulnerable to information damage and tampering caused by hacking or noise pollution, which in turn makes the receiver unable to obtain the correct decrypted image even spending many resources. To address these issues, this paper proposed a verifiable visually meaningful image encryption based on compressed sensing (CS) and improved game of life. Specifically, the plain image is preprocessed and compressed to obtain compressed image via CS, achieving the purpose of reducing the image size. Subsequently, to improve the encryption effect, dynamic cyclic shift confusion method and diffusion method based on improved game of life are presented and performed on the compressed image to obtain the secret image. Next, multiple shadow images are obtained using the secret image sharing based on the Chinese remainder theorem on the secret image, which improves the robustness of this scheme and achieves multi-party data transfer of image. Finally, the shadow images are embedded into the carrier images respectively to obtain visually meaningful cipher images, reducing the attacker's attention to the cipher images during transmission. Additionally, the Hamming distance authentication method relying on plain image and carrier image is applied, and users can perform identity authentication and integrity check on cipher image. Experimental results demonstrate the security and effectiveness.

Keywords: Image encryption, Secret image sharing, Compressed sensing, Game of life

Speaker's biography: Guoqiang Long received his B.S. degree in the School of Computer and Information Engineering from Henan University, China in 2020. He is currently pursuing his M.S. degree at school of Artificial Intelligence, Henan University. His research interests lie in visual meaningful image encryption, secret image share.

Cryptanalysis and construction of keyed strong S-Box based on random affine transformation matrix and 2D hyper chaotic map

Ruoran Liu[1], Hongjun Liu[2, *], Mengdi Zhao[3]

[1, 2, 3] School of Mathematical Sciences, University of Jinan, Jinan, Shandong 250022, China

Email: [1] llz117827@163.com, [2, *] smithliu@126.com (corresponding author), [3]1609195978@qq.com

Abstract: As the only nonlinear module, S-Box is widely used in stream cipher, hash function, and so on. However, there are some weaknesses in some existing S-Boxes, such as fixed point, reverse fixed point and short iteration period rings. In addition, S-Boxes in AES, SM4.0 are fixed, which makes S-Boxes vulnerable to attack. To address these weaknesses, first of all, we constructed a non-degenerate 2D chaotic map (2D-NDCM) with ergodicity in phase space. Based on 2D-NDCM, we applied the affine transformation combined with Boolean function to construct seed S-Boxes in batches, then we eliminated three possible weaknesses inside to obtain the keyed strong S-Boxes with highly nonlinearity. Experimental results demonstrated that, (1) the S-Boxes generated by affine transformation can remain a higher nonlinearity, and (2) the large number of keyed strong S-Boxes can meet the requirement of symmetric block cipher.

Keywords: 2D-NDCM; High nonlinearity; Boolean function; Random affine transformation matrix

*Corresponding author, Email: sms_liuhj@ujn.edu.cn (Liu HJ)

Irreversible and parallel key expansion algorithm based on a 2D discrete hyper chaotic map with memristor

Zhe Lin[1], Hongjun Liu[2, *]

[1, 2, 3] School of Mathematical Sciences, University of Jinan, Jinan, Shandong 250022, China

Email: [1] 905876411@qq.com, [2, *] smithliu@126.com (corresponding author)

Abstract: Key expansion plays an important role in symmetric block cipher, hence, to generate a large number of round keys quickly can enhance the encryption intensity greatly. First, we constructed a 2D memristor-based discrete hyper chaotic map (2D-MDHCM), through adding a memristor to the 2D discrete hyper chaotic map (2D-DHCM) , whose state point has ergodicity in phase space and good randomness in a sufficiently large parameter range. Took advantage of the irreversibility of the chaotic iteration, we designed a irreversible and parallel key expansion algorithm, which can generate the round keys with specified length flexibly, such as 128, 256, 512 or more bits, and the round keys are independent of each other. Experimental results demonstrated that the round keys have high sensitivity to initial key, and the Hamming distances between the initial key and round keys are all close to the ideal value.

Keywords: 2D hyper chaotic discrete map; Memristor; Irreversible and parallel key expansion algorithm; Independence of round-key

*Corresponding author, Email: sms_liuhj@ujn.edu.cn (Liu HJ)

广东工业大学简介

学校发展

秉承“与广东崛起共成长，为广东发展作贡献”办学理念
历经“四个阶段”跨越式发展

1958年 招收本科生
广州工学院本科招生
- 1970年 迁往韶关
- 1981年 迁回广州

1995年 扩规模
三校合并建广东工业大学
- 1986年 获硕士授权
- 1998年 获博士授权

2004年 拓空间
学校整体进驻广州大学城
- 2009年 进入省“211”工程

2015年 上水平
整体进入广东省高水平大学重点建设高校
- 2016年 省高水平理工科大学
- 2018年 冲补强“冲一流”高校

2021年 攀高峰
“攀撑计划”学科提升工程
- 冲击“双一流”
- 建设高水平创新型大学

六大校区

广州·大学城
行政中枢·突出工科特色
2400亩

广州·东风路
国际先进设计与规划特色
211亩

广州·龙洞
人文社科、理科特色
589亩

广州·番禺
中外合作办学特色
93亩

广州·沙河
大学科技园·成果转化特色
32亩

揭阳
绿色化工技术·新能源中心
956亩

学院概况

理工科学院（14个）
1. 机电工程学院
2. 自动化学院
3. 轻工化工学院
4. 材料与能源学院
5. 信息工程学院
6. 计算机学院
7. 土木与交通工程学院
8. 环境科学与工程学院
9. 数学与统计学院
10. 物理与光电工程学院
11. 生物医药学院
12. 集成电路学院
13. 生态环境与资源学院
14. 先进制造学院（揭阳）

人文社科学院（7个）
1. 管理学院
2. 经济与贸易学院
3. 艺术与设计学院
4. 法学院
5. 建筑与城市规划学院
6. 外国语学院
7. 马克思主义学院

其他机构（8个）
1. 国际教育学院
2. 继续教育学院
3. 国际交流学院
4. 体育部
5. 实验教学部
6. 通识教育中心
7. 环境生态工程研究院
8. 集成电路创新研究院

学科概况

6个
博士后流动站
（机械、控制、化工、管理、材料、环境）

9个
博士学位授权点
24个一级硕士点；
17种硕士专业学位点

5个
ESI学科排名前1%学科
工程学排名进入千分之一

13个
教育部第四轮学科评估
上榜 6个B档以上；
控制科学与工程A-、
机械工程B+

7个
广东省“冲一流”学科
（机械、控制、材料、环境、设计、化学工程与技术、集成电路科学与工程）

15个
广东省重点学科
（攀峰学科4个：机械、控制、材料、设计）

努力建成
以工为主、与产业深度融合、极具创造活力“特色鲜明、国内一流、世界知名”的高水平大学

办学理念	与广东崛起共成长、为广东发展作贡献
办学定位	发挥工科优势、引领广东产业、支撑创新发展
培养目标	高素质 创新性 应用型人才

信息工程学院
SCHOOL OF INFORMATION ENGINEERING

学院简介

- 广东省重要的信息技术人才培养基地
- 连续两年获国家基金杰出青年基金项目
- 近三年主持了2项国家重点研发计划
  重大/重点项目科研经费突破亿元

学科研究方向

学院现有全日制在校学生3046人

本科生 2394 人

博士生 36 人　　硕士生 616 人

学院师资队伍

4名	2名	1名
国家中年领军专家	国家青年拔尖英才	国际知名学者

2名	1名	3名	5名
省领军人才	珠江学者	省杰青	省青年拔尖人才

82名	21名	30名	14名	60名
专任教师	教授	副教授	博士生导师	硕士生导师

学院教学科研机构

通信系　电子系　应电系　先进光子技术研究院　教学实验中心

学院学位授权点

- “信息与通信工程”一级学科博士学位授权点
- “信息与通信工程”一级学科硕士学位授权点
- 通信与信息系统、信号与信息处理2个二级学科学术学位硕士授权点
- 电子信息专业学位硕士授权点

国家基金立项项目

项目类型	2019年	2020年	2021年
国际（地区）合作交流项目	1项		
国家杰出青年科学基金	1项	1项	
优秀青年科学基金项目		1项	
国家重大科研仪器研制项目	1项		2项
联合基金		1项	
面上基金	4项	4项	3项
青年科学基金项目	5项	7项	7项
专项项目	1项		
外国学者研究基金			1项
总计	13项	14项	13项

本科专业

信息工程
通信工程
电子信息工程

信息工程、通信工程
中国工程教育专业认证专业

信息工程、通信工程
国家级一流本科专业建设点

电子信息工程
广东省一流本科专业建设点

凝练特色谋发展，提质增效创一流

Sponsor

广东工业大学
Guangdong University of Technology

Initiators

东北大学
Northeastern University

香港城市大学
City University of Hongkong

Organizers

广东工业大学信息工程学院
School of Information Engineering, Guangdong University of Technology

广东省信息光子技术重点实验室
Guangdong Provincial Key Laboratory of Photonics Technology, Guangdong University of Technology