IEEE MTT-S Young Professionals Workshop on Electromagnetic Modeling and Optimization

EMO 2024

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Program Book

MTT-S
IEEE MICROWAVE THEORY & TECHNOLOGY SOCIETY

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EMO2024

IEEE MTT-S Young Professionals Workshop on Electromagnetic Modeling and Optimization

Workshop Agenda (in China Standard Time, UTC+8)

Saturday, November, 2, 2024 Zoom Conference (ID: 836 6430 6438, https://us06web.zoom.us/j/83664306438)	
Opening Ceremony **Chair: Jing Jin,** *Central China Normal University*	
08:30 ~ 08:35	**Welcome from Advisory Committee Chair** Qi-Jun Zhang, Carleton University, Canada
08:35 ~ 08:40	**Welcome from the General Chair** Jing Jin, Central China Normal University, China
Young professionals talks **Focus Session: Space Mapping – Memorial of Prof. John W. Bandler** **Chair: Jianan Zhang,** *Southeast University* **Shuxia Yan,** *Tiangong University*	
08:40 ~ 09:10	**Invited Talk 1:** **Mesh Space mapping with Simplified Carse Model and Mesh Deformation** Feng Feng, Tianjin University
09:10 ~ 09:40	**Invited Talk 2:** **Rapid design of litz wire using surrogate-assisted optimization based on space mapping** Jiahua Lyu, The Hong Kong Polytechnic University

09:40 ~ 10:10	**Invited Talk 3:** **Gain characteristics estimation of heteromorphic RFID antennas using neuro-space mapping** Weiguang Shi, Tiangong University
10:10 ~ 10:40	**Invited Talk 4:** **An Efficient Optimization Scheme for Antenna Decoupling Networks using Space Mappings** Fan Jiang, Guangdong University of Technology
Young professionals talks **Regular Session: Part I - Morning** **Chair: Jianan Zhang,** *Southeast University* **Shuxia Yan,** *Tiangong University*	
10:40 ~ 11:10	**Invited Talk 5:** **A Two-Stage Optimization for Designing Reconfigurable Intelligent Surfaces Based on Microwave Network Theory** Zhen Zhang, Guangzhou University
11:10 ~ 11:40	**Invited Talk 6:** **High-Speed Nonlinear Circuit Macromodeling Using Hybrid-Module Clockwork Recurrent Neural Network** Sayed Alireza Sadrossadat, Yazd University
Young professionals talks **Regular Session: Part II - Afternoon** **Chair: Wei Zhang,** *Beijing University of Posts and Telecommunications* **Wenyuan Liu,** *Shaanxi University of Science and Technology*	
14:00 ~ 14:30	**Invited Talk 7:** **Computer-Aided Tuning by Coupling Matrix Extraction and Optimization** Ping Zhao, Xidian University
14:30 ~ 15:00	**Invited Talk 8:** **A Large-Scale DoF-Inverse Topological Design Method (LSDoF-ITDM) Based on Machine Learning for Frequency Selective Surface (FSS) Structures** Li-Ye Xiao, Xiamen University

15:00 ~ 15:30	**Invited Talk 9:** **Mirroring the Physical Reality: Non-Conventional Microwave Filter Synthesis** Yi Zeng, Southern University of Science and Technology
15:30 ~ 16:00	**Invited Talk 10:** **A CNC-machined WR-2.2 Band Orthogonal Mode Transducer for a Radiometer** Yang Yu, National Space Science Center
16:00 ~ 16:30	**Invited Talk 11:** **Systematic Neuro-Transfer Function Parametric Modeling With a Compact Embedded Format** Wei Liu, Tianjin University
16:30 ~ 17:00	**Invited Talk 12:** **Automated Model Generation for Microwave Components Using Adjoint Neural Network and EM Sensitivity Analysis** Weicong Na, Beijing University of Technology
Interaction with senior professionals (Evening Session) **Chair: Jing Jin,** *Central China Normal University* **Feng Feng,** *Tianjin University*	
21:00 ~ 21:05	**Suggestions for young professionals** Qi-Jun Zhang, Carleton University, Canada
21:05 ~ 21:20	**Short presentations and comments from senior professionals** **21:05 – 21:10 Presentation 1: Jiaping Fu** **21:10 – 21:15 Presentation 2: Linglong Liu** **21:15 – 21:20 Presentation 3: Jinyuan Cui**
21:35 ~ 21:50	**Panel sessions** Qi-Jun Zhang, Carleton University, Canada Zhizhang (David) Chen, Dalhousie University, Canada José Ernesto Rayas-Sánchez, ITESO, Mexico Qingsha Cheng, Southern University of Science and Technology, China
21:50 ~ 21:55	**Close the workshop and thanks**

Detailed Zoom Conference Information:

Topic: 2024 IEEE MTT-S Professional Workshop on Electromagnetic Modeling and Optimization (EMO 2024)

Time: Nov 2, 2024, 08:30 AM Beijing, Shanghai

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Invited Senior Professionals

Qi-Jun Zhang

Qi-Jun Zhang received the B.Eng. degree from the Nanjing University of Science and Technology, Nanjing, China in 1982, and the Ph.D. Degree in Electrical Engineering from McMaster University, Hamilton, Canada, in 1987.

He was a research engineer with Optimization Systems Associates Inc., Dundas, Ontario, Canada during 1988-1990 developing advanced optimization software for microwave modeling and design. He joined the Department of Electronics, Carleton University, Ottawa, Canada in 1990 where he is presently a Chancellor's Professor. His research interests are modeling, optimization, and neural networks for high-speed/high-frequency electronic design. He is an author of the book Neural Networks for RF and Microwave Design (Boston: Artech House, 2000), a coeditor of Modeling and Simulation of High-Speed VLSI Interconnects (Boston: Kluwer, 1994), and a coeditor of Simulation-Driven Design Optimization and Modeling for Microwave Engineering (London, UK: Imperial College Press, 2013).

Dr. Zhang is a Fellow of the IEEE, a Fellow of the Canadian Academy of Engineering, and a Fellow of the Engineering Institute of Canada. He is a Topic Editor on Design Automation for the IEEE Journal of Microwaves. He was the Chair of the Technical Committee on Design Automation (MTT-2) of the IEEE Microwave Theory and Technology (MTT) Society. He is the Guest co-editor of the Special Issue on Machine Learning for Microwave Engineering for the IEEE Microwave Magazine (October 2021), and a Guest-Editor of the Special Issue on AI and Machine Learning Technologies for Microwaves for the IEEE Transactions on MTT (November 2022).

Qi-Jun Zhang, Carleton University
qjz@doe.carleton.ca

Invited Senior Professionals

Zhizhang (David) Chen

Zhizhang Chen received a Bachelor's degree in Radio Engineering from Fuzhou University, China, a Master's degree in Radio Engineering from Southeast University, P. R. China, and a Ph.D. degree in Electrical Engineering from the University of Ottawa, Canada. He was an NSERC postdoctoral fellow at McGill University, Montreal, Canada. He is a professor in Electrical and Computer Engineering. He has been a guest editor, track editor, and associate editor for IEEE journals, including the IEEE Transactions on Microwave Theory and Techniques, IEEE Journal of Microwaves, and the IEEE Journal on Multiscale and Multiphysics Computational Techniques. His research interests include time-domain electromagnetic modelling techniques, ultra-wideband wireless communication systems, and wireless power transfer. He is a Fellow of the IEEE, the Canadian Academy of Engineering, and the Engineering Institute of Canada. He is an Ad-Com Member and the Wireless Power Transfer and Energy Conversion Committee Chair of the IEEE Microwave Theory and Techniques (MTT) Society.

Zhizhang (David) Chen, Dalhousie University, zz.chen@ieee.org .

Invited Senior Professionals

José Ernesto Rayas-Sánchez

José Ernesto Rayas-Sánchez received the B.Sc. degree in electronics engineering from ITESO, Guadalajara, Mexico, the Master's degree in electrical engineering from Monterrey Tec, Monterrey, Mexico, and the Ph.D. degree in electrical engineering from McMaster University, Ontario, Canada. He is *Professor Numerario* (honorary distinction) and Emeritus Professor with ITESO – The Jesuit University of Guadalajara, where he was Chair of the Doctoral Program in Engineering Sciences from 2013 to 2019. Since 2004, he leads the Research Group on Computer-Aided Engineering of Circuits and Systems (CAECAS) at ITESO. He is a member of the Mexican National System of Researchers (SNI, for its initials in Spanish), Level III. His research focuses on computer-aided and knowledge-based modeling, design and optimization of high-frequency electronic circuits and devices.

Dr. Rayas-Sánchez serves as reviewer for many scientific publications, including IEEE Transactions on Microwave Theory and Techniques, IEEE Transactions on Antennas and Propagation, IEEE Microwave and Wireless Technology Letters, IEEE Microwave Magazine, IEEE Antennas and Wireless Propagation Letters, IEEE Journal on Multiscale and Multiphysics Computational Techniques, IEEE Journal of Microwaves, IEEE Transactions on Emerging Topics in Computing, IET Microwaves, Antennas & Propagation Journal, International Journal of RF and Microwave Computer-Aided Engineering, and International Journal of Numerical Modelling: Electronic Networks, Devices and Fields. He is member of the Technical Program Reviewers Committee of the IEEE MTT-S International Microwave Symposium (IMS). He was Chair (2018-2019) and Vice-Chair (2016-2017) of the Technical Committee on Computer Aided Design (former MTT-1 on CAD, now TC-2 on Design Automation, of the IEEE Microwave Theory and Technology Society (MTT-S). Since 2019, he is the MTT-S Representative for IEEE EDA Council.

He was the General Chair of the First IEEE MTT-S Latin America Microwave Conference (LAMC-2016, Puerto Vallarta, Mexico, Dec. 2016), and the General Vice-Chair of LAMC-2023 (San Jose, Costa Rica, Dec. 2023). During 1994-1996, he was the IEEE Guadalajara Section Chair. During 2004-2005, he was the IEEE Mexican Council Chair, as well as the IEEE Region 9 Treasurer. Since 2013, he is IEEE MTT-S Regional Coordinator for Latin America. He has been an elected AdCom member of the IEEE MTT-S for the years 2016-2024.

Invited Senior Professionals

Qingsha S. Cheng

Dr. Qingsha Cheng (SMIEEE) is currently a tenured associate professor with the Department of Electrical and Electronic Engineering, Southern University of Science and Technology (SUSTech), Shenzhen, China. He is also with Shenzhen Key Laboratory of EM Information as a vice director. He received the B.Eng. and M. Eng. from Chongqing University, China. He received his Ph.D. at McMaster University, Canada in 2004. He was with the Department of Computer Science and Technology, Peking University, China. He took positions of post-doctoral fellow, research associate academic, research engineer and lecturer with the Department of Electrical and Computer Engineering and the Faculty of Engineering, McMaster University. In 2014, he joined SUSTech as an assistant professor. He has co-organized and co-chaired special sessions in international conferences such as IEEE NEMO and IEEE ACES. His research interests include smart modelling and optimization of microwave components and antennas, surrogate modelling and optimization, multi-objective optimization, and artificial intelligence. He has authored or co-authored more than 200 publications in book chapters, international technical journals, and refereed conference proceedings. His research is funded by the National Natural Science Foundation of China (NSFC) and the Ministry of Science and Technology (MOST) of China.

Invited Talk 1

Mesh Space mapping with Simplified Carse Model and Mesh Deformation

Feng Feng

School of Microelectronics,
Tianjin University

Abstract

Space mapping (SM) is a recognized engineering optimization methodology in the microwave area. The space mapping concept combines the computational efficiency of coarse models with the accuracy of fine models. For high performance RF/microwave component and system design. Mesh space mapping (MSM) is an advanced SM technique which addressed the situation that the traditional equivalent circuit based coarse model is not practically available. MSM uses coarse mesh model as the coarse model to speed up the optimization process.

This talk introduces recent advances of MSM techniques with Simplified Carse Model and Mesh Deformation. In the introduced techniques, the coarse mesh model is not only uses coarse mesh but also have a simplified structure to make the mesh even coarser. Mesh deformation technique is also used to guarantee the continuity of the coarse mesh model response w.r.t. geometrical changes, resulting a better coarse mesh optimization convergency.

Biography

Feng Feng received the B.Eng. degree in Tianjin University, Tianjin, China, in 2012, and the Ph.D. degree in the School of Microelectronics at Tianjin University, Tianjin, China, and the Department of Electronics at Carleton University, Ottawa, ON, Canada, in 2017. From 2017 to 2020, he was a Postdoctoral Fellow in the Department of Electronics at Carleton University, Ottawa, ON, Canada. In 2020, he joined the School of Microelectronics at Tianjin University, Tianjin, China, where he is currently a Full Professor. His research focuses on electromagnetic (EM)/multiphysics parametric modeling and design optimization algorithms, and has authored/co-authored over 100 journal and conference papers.

Dr. Feng is a vice chair of the Technical Committee on Design Automation (TC-2) of the IEEE Microwave Theory and Technology Society (MTT-S). He serves as reviewer for many IEEE scientific publications, including IEEE Transactions on Microwave Theory and Techniques, IEEE Microwave and Wireless Components Letters, IEEE Access, etc. He served as the Publication Chair of IEEE MTT-S International Conference on Numerical Electromagnetic and Multiphysics Modeling and Optimization (NEMO) in 2015, a Session Chair and a member of Technical Program Committees of IEEE MTT-S NEMO in 2020, a Session Chair of IEEE MTT-S UK-Europe-China Workshop on Millimetre-Waves and Terahertz Technologies (UCMMT) in 2020, and the General Chair, 2021 IEEE MTT-S Young Professionals Workshop on Electromagnetic Modeling and Optimization (EMO 2021).

Invited Talk 2

Rapid design of litz wire using surrogate-assisted optimization based on space mapping

Jiahua Lyu
Department of Electrical and Electronic Engineering,
The Hong Kong Polytechnic University

Abstract

Space mapping (SM) is a powerful mathematical technique employed in optimization algorithms to address inaccuracies between coarse and fine models. By establishing a mapping between the input parameters of complex models and their simpler counterparts, SM facilitates efficient optimization and analysis. This method is particularly valuable in the design of microwave components, as it significantly reduces computational costs while preserving result accuracy.

This talk will explore the innovative application of SM in the field of power electronics, specifically in the structural design of Litz wire, which is widely utilized in high-frequency power applications. The implementation of the SM optimization algorithm for the intricate cable structure of Litz wire can enhance efficiency by over tenfold compared to traditional optimization methods. Furthermore, this advancement in Litz wire manufacturing optimizes power loss, reduces costs, and accelerates design speed, showcasing the transformative potential of SM in modern engineering practices.

Biography

Jiahua Lyu received his B.Eng. degree from Huazhong University of Science and Technology, Wuhan, China, in 2018, and his Ph.D. degree from The Hong Kong Polytechnic University, Hong Kong, China, both in Electrical Engineering. Dr. Lyu is currently a postdoctoral fellow at the Department of Electrical and Electronic Engineering, The Hong Kong Polytechnic University. His research focuses on computational electromagnetics, optimization algorithms, and wireless power transfer.

Dr. Lyu serves as reviewer for many IEEE scientific publications, including IEEE Transactions on Power Electronics, IEEE Transactions on Industrial Electronics, IEEE Transactions on Magnetics, IEEE Access, etc. He received the Best Paper Award at the IEEE 7th International Electrical and Energy Conference (CIEEC).

Invited Talk 3

Gain characteristics estimation of heteromorphic RFID antennas using neuro-space mapping

Weiguang Shi

School of Electronics and Information Engineering,
Tiangong University

Abstract

Existing gain estimation methods for RF antennas often depend on costly experimental setups and are limited to classic structures, restricting their application scopes. This talk introduces an accessible method for estimating the gain of heteromorphic RFID antennas, leveraging the advantages of space mapping (SM) techniques.

The proposed method incorporates three key innovations. First, a neuro-space mapping framework is utilized, which effectively combines the computational efficiency of coarse models with the accuracy of fine models, thereby reducing time consumption and minimizing labor-intensive measurements. Second, we implement a diverse extraction integration strategy to optimize training data acquisition, balancing estimation accuracy with data size. Finally, a novel adaptive particle swarm optimizer is embedded with a scale elaboration strategy to enhance the approximation from gain estimation models to high-fidelity simulations. Testing on four RF antenna types reveals that our method achieves high accuracy and strong applicability, demonstrating the transformative potential of space mapping in RF antenna design.

Biography

Weiguang Shi received the B.S. degree from Tianjin Polytechnic University, Tianjin, China, in 2006, and the M.S. and Ph.D. degrees from Tianjin University, Tianjin, China, in 2008 and 2012, respectively. He is currently an associate professor with the School of Electronics and Information Engineering, Tiangong University. His research interests include intelligent information processing, wireless localization, RFID, optimization algorithm, and antenna technology.

Invited Talk 4

An Efficient Optimization Scheme for Antenna Decoupling Networks using Space Mappings

Fan Jiang

School of Physics and Optoelectronic Engineering,
Guangdong University of Technology

Abstract

Multi-port antenna designs using decoupling networks (DNs) often require optimization and have high computational cost when using full electromagnetic solvers. In order to reduce the computational cost, space mapping is proposed in the design of multi-port antenna. The lack of a continuously tunable “coarse” model is a key challenge in applying SM to multi-port antennas. Two methods are considered to build the SM coarse model required for the antenna. The former is based on traditional DNs, while the latter uses a new application of the Internal multi-port method (IMPM). Various parameter extraction (PE) techniques for SM suitable for DN design have also been developed. Two antennas were optimized to demonstrate the effectiveness and efficiency of the proposed scheme, including 2-port and 3-port designs. Compared with the traditional optimization scheme, the optimization speed of the proposed scheme is increased by about 20 times, and importantly, the antenna design specifications of all calculation examples are satisfied. An optimal design of a 3-port antenna is also made. The measurement results are in agreement with the simulation results, which further verifies the effectiveness of the method.

Biography

Fan Jiang received bachelor’s degree in electronic engineering from the University of Electronic Science and Technology of China, Chengdu, China, in 2014, a master’s degree in engineering from the IMT Atlantique Bretagne Pays de la Loire, Brest, France, in 2017, and the Ph.D. degree from The Hong Kong University of Science and Technology (HKUST), Hong Kong, in 2021. From 2021 to 2023, he was a senior EMC engineer in the industry. He is an assitant professor at the Guangdong University of Technology, Guangzhou.

Invited Talk 5

A Two-Stage Optimization for Designing Reconfigurable Intelligent Surfaces Based on Microwave Network Theory

Zhen Zhang

School of Electronic and Communication Engineering, Guangzhou University

Abstract

Reconfigurable intelligent surfaces (RISs) are of potential use in wireless communication systems due to their ability to perform beam steering, harmonic wave manipulation, and polarization conversion. However, the main challenge in designing RISs is to obtain their electromagnetic (EM) responses, which is time-consuming and computationally prohibitive. In this work, an efficient modeling method is proposed for fast evaluation of the reflection coefficient and far-field patterns of RISs. The proposed method utilizes the microwave network theory to compute the accurate reflection coefficient of RISs elements under the illumination of incident waves from arbitrary directions. Compared to the classical equivalent circuit model, it enables the separate design of meta-atoms and tunable devices at the network level. Based on the proposed model, a genetic algorithm is then used to choose suitable port loadings such as tunable components, shortcircuit, and open-circuit. For the tunable components, we adopt a gradient-based optimization method to determine their working states. To verify the performance of the proposed method, a reflection phase-modulated RIS is designed and fabricated. Simulation and experimental results are in good agreement with design goals, demonstrating the effectiveness and efficiency of the proposed method.

Biography

Zhen Zhang (Member, IEEE) received the bachelor's degree from the Anhui University of Science and Technology, Huainan, China, in 2015, the master's degree from Northwest A&F University, Xianyang, China, in 2018, and received the Ph.D degree from the Harbin Institute of Technology, Harbin, China, in 2022. From 2020 to 2022, she was a Visiting Ph.D. Student with the University of Glasgow, Glasgow U.K. She is currently a lecturer with School of Electronics and Communication Engineering, Guangzhou University, Guangzhou, China. She is also currently with the State Key Laboratory of Millimeter Waves, Southeast University, Nanjing, China, as a Visiting Researcher.

Her research interests include the physical modeling and design optimization of reconfigurable intelligent surfaces, the design optimization and yield optimization for antenna and microwave components.

Invited Talk 6

High-Speed Nonlinear Circuit Macromodeling Using Hybrid-Module Clockwork Recurrent Neural Network

Sayed Alireza Sadrossadat

Department of Computer Engineering, Yazd University, Yazd, Iran

Abstract

In CAD area, the recurrent neural network has shown notable functionality in generating fast and high-performance models rather than the models in simulation tools. Predicting time sequences is a challenging problem that may require identifying the dependencies between sequences that RNN is capable of performing. Despite all its features, conventional RNN still faces challenges such as limited accuracy and a large number of parameters. Therefore, we propose new macromodeling methods for nonlinear circuits called the Clockwork-RNN (CWRNN) and its hybrid version which is a more powerful but simpler implementation of a conventional RNN architecture with relatively little model complexity. In addition, CWRNN inherently models complex dependencies without the need for a large number of parameters. As a result, the computational cost is less than conventional RNN. Moreover, understanding and implementing the CWRNN is relatively simple and provides great flexibility in architectural configuration by introducing modules with several clock rates of exponents of 2. In addition to the above new modelling technique, we proposed the Hybrid-Module CWRNN as another new modelling method that utilizes modules of various exponents of different numbers resulting in further accuracy improvement of the CWRNN. Furthermore, the models obtained from the proposed techniques required much smaller simulation times compared to the current models used in simulation tools.

Biography

Sayed Alireza Sadrossadat (Senior Member, IEEE) received the B.Sc. degree from the University of Tehran, Tehran, Iran, in 2007, the master's degree from the University of Waterloo, Waterloo, ON, Canada, in 2010, and the Ph.D. degree from Carleton University, Ottawa, ON, Canada, in 2015. He is currently an assistant professor in the Artificial Intelligence Group, Department of Computer Engineering, Yazd University, Yazd, Iran and affiliated with the Electronics Group, Department of Electrical Engineering, Yazd University. His current research interests include optimization and neural network-based modelling of linear/nonlinear components and circuits, computer-aided design, deep learning, very large-scale integration design, probabilistic design, and yield maximization. He has been a Technical Reviewer for several IEEE/IET journals, such as IEEE TRANSACTIONS ON NEURAL NETWORK AND LEARNING SYSTEMS, IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUE, IEEE TRANSACTIONS ON VERY LARGE-SCALE INTEGRATION SYSTEMS, IET Microwave and Propagation, IET Electronic Letters, and IEEE CANADIAN JOURNAL OF ELECTRICAL AND COMPUTER ENGINEERING.

Invited Talk 7

Computer-Aided Tuning by Coupling Matrix Extraction and Optimization

Ping Zhao

School of Mechano-Electronic Engineering,
Xidian University

Abstract

Coupled-resonator networks are often employed to construct high-performance frequency-selective components such as filters and multiplexers. However, the scattering characteristics of these components are extremely sensitive to dimensional errors and material variations. As a result, post-production tuning is necessary to compensate for the fabrication error. Manual tuning is laboring, tedious, and costly. Tuning skills heavily depend on experience and do not have a well-established theory. The training of a tuning technician also contributes to the overall cost of massive production. For these reasons, efficient computer-aided tuning techniques have been desired by the wireless industry for a long time.

This talk introduces the most popular computer-aided tuning technique, which is based on the coupling matrix extraction by vector fitting. Once the coupling matrix is extracted from measured or simulated S-parameter data, the operator can easily tell which tuning elements need to be adjusted by identifying the difference between the extracted and the optimized target coupling matrix.

Biography

Ping Zhao received the B.Sc. degree from Nanjing University, Nanjing, China, in 2012, and the Ph.D. degree from The Chinese University of Hong Kong, Hong Kong, in 2017.

From 2017 to 2019, he was a post-doctoral fellow in the École Polytechnique de Montréal, Montreal, QC, Canada. He joined the National Key Laboratory of Antennas and Microwave Technology, Xidian University, in 2020. Since 2024, he has been with the State Key Laboratory of Electromechanical Integrated Manufacturing of High-performance Electronic Equipments, Xidian University, where he is currently an associate professor. His research interests include coupling matrix synthesis techniques for coupled-resonator networks, analytical computer-aided tuning (CAT) algorithms for microwave and millimeter-wave filters and diplexers with applications in cellular base stations and satellites. He is also interested in modeling and optimization of passive RF components, and computer-aided design techniques such as the homotopy method, the artificial neural network, and machine learning techniques.

Invited Talk 8

A Large-Scale DoF-Inverse Topological Design Method (LSDoF-ITDM) Based on Machine Learning for Frequency Selective Surface (FSS) Structures

Li-Ye Xiao

School of Electronic Science and Engineering, Institute of Electromagnetics and Acoustics
Xiamen University

Abstract

To explore additional degree of freedoms (DoFs) for frequency selective surfaces (FSS), a machine learning-based inverse design method named large-scale DoF-inverse topological design method (LSDoF-ITDM) is introduced in this talk. In the proposed LSDoF-ITDM approach, a set of desired $|S_{11}|$ curve is input, and the predicted effective information of the FSS is outputted in binary format, revealing the spatial structure, material type, and planar layout of the FSS. Furthermore, specific square wave noise is incorporated in LSDoF-ITDM to generate multiple solutions that satisfy the same electromagnetic responses, providing extensive options for material selection, environmental applications, and cost management. The effectiveness of LSDoF-ITDM is demonstrated through numerical examples involving single-layer and double-layer FSS structures with a large number of binary variables. Additionally, measurements of the fabricated topologies are carried out to validate the performance of the FSS designs derived from LSDoF-ITDM.

Biography

Li-Ye Xiao (Member, IEEE) received the B.S. degree in electronic information science and technology and the Ph.D. degree in radio physics from the University of Electronic Science and Technology of China (UESTC), Chengdu, China, in 2015 and 2019, respectively. In 2018, he was a Visiting Scholar with the Department of Electrical and Computer Engineering, Duke University, Durham, NC, USA. He is currently an Associate Professor with the Institute of Electromagnetics and Acoustics, Xiamen University, Xiamen, China. His current research interest includes computational electromagnetics, machine learning-based design method, parametric/ topological modeling method.

Invited Talk 9

Mirroring the Physical Reality: Non-Conventional Microwave Filter Synthesis

Yi Zeng
Department of Electronic and Electrical Engineering,
Southern University of Science and Technology

Abstract

"All the World is a Filter", which sounds funny but may be coming true to some extent nowadays. Microwave filters are one of the most essential and top-selling components in radio frequency (RF) front-end systems, widely used in various modules such as converters and receivers. Filter synthesis is the process of finding a suitable polynomial approximation of the filter functions according to the design specifications and then establishing a corresponding circuit model.

With the rapid evolution of communication technology, modern microwave filters are facing tighter physical constraints, such as limited size, restricted layout, and so on. Additionally, certain non-ideal factors, like parasitic parameters and dispersion effects, need to be taken into consideration for precise design and better reflection of the real physical world. It seems that the canonical synthesis theories tend to fail in more and more scenarios, and may have formed certain "mental barriers" for new ideas, the term first coined by S. B. Cohn. Therefore, physical realities need to be mapped into modern filter synthesis frameworks to boost the development of advanced microwave filters. This talk aims to present non-canonical microwave filter synthesis theories that can bring additional benefits in physical implementation, or guide a trade-off between electrical performance and physical layout.

Biography

Yi Zeng received the B.S. degree in electronic science and technology from the Huazhong University of Science and Technology, Wuhan, China, in 2019, and the Ph.D. degree from The Chinese University of Hong Kong (CUHK), Hong Kong, in 2022.

In 2022, she joined the Southern University of Science and Technology (SUSTech), Shenzhen, China, as a research assistant professor, and she is currently an assistant professor. Her current research interests include microwave device synthesis and design. She has authored/co-authored over 40 publications.

She is a reviewer of IEEE Transactions on Microwave Theory and Techniques (TMTT), IEEE Transactions on Circuits and Systems I: Regular Papers (TCAS-I), IEEE Microwave and Wireless Technology Letters (IEEE MWTL), IEEE Microwave Magazine, etc. She is also a Young Professional (YP) Affiliate Member of Technical Filter Committee (TC-5) in the IEEE Microwave Theory and Technology Society (MTT-S).

Ms. Zeng was a recipient of the Hong Kong Ph.D. Fellowship.

Invited Talk 10

A CNC-machined WR-2.2 Band Orthogonal Mode Transducer for a Radiometer

Yang Yu

Key Laboratory of Microwave Remote Sensing,
National Space Science Center

Abstract

This talk presents a WR-2.2 band waveguide orthogonal mode transducer (OMT) for an ice cloud remote sensing radiometer. A holistic approach is proposed to the design and man-ufacturing. Given the difficulties of using computer numerically controlled (CNC) milling techniques to fabricate the OMT and its assembly, both the design and fabrication processes are optimized to reduce the possi-bility of error, which could affect OMT per-formance. In the design, the OMT utilizes a side-arm structure, with a compact 90° waveguide twist designed in the side-arm path to reduce insertion loss and achieve two symmetric and opposing output ports in the radiometer. Regarding the challenges in CNC milling technology for such high frequencies, a comprehensive sensitivity analysis is per-formed following the OMT design to identify the design parameters with high sensitivity. Then, an acceptable tolerance range for CNC milling is obtained. To control fabrication un-certainty and minimize tolerance, an effec-tive fabrication refinement strategy is pro-posed for accessible CNC machining, reduc-ing the range of fabrication errors to −3 μm to 2 μm within 3 iterations. Comprehensive measurements and analyses are performed on the fabricated OMT as well as the one with an antenna and a receiver. The meas-ured insertion losses of the H and V co-polari-zation of the OMT are better than 1.4 dB and 2 dB, respectively. The isolation is better than 40 dB. The measured H and V cross-polarizations are better than 25 dB. They demonstrate the OMT with a good per-formance for radiometer system.

Biography

Yang Yu received the B.Eng. degree in communication engineering and the M.Eng. degree in information and communication engineering from Tianjin Polytechnic Univer-sity, Tianjin, China, in 2013 and 2016, re-spectively, and the Ph.D. degree in electronic and electrical engineering from the Univer-sity of Birmingham, Birmingham, U.K., in 2022. He is currently a Special Research As-sistant with the Key Laboratory of Micro-wave Remote Sensing, National Space Sci-ence Center, Chinese Academy of Sciences, Beijing, China. He is now focusing on mi-crowave, millimeter-wave, and terahertz RF front-end systems, and development of ra-diometric calibration system and techniques of terahertz radiometers for remote sensing and space applications.

Invited Talk 11

Systematic Neuro-Transfer Function Parametric Modeling With a Compact Embedded Format

Wei Liu

School of Microelectronics,
Tianjin University

Abstract

Introducing transfer functions significantly enhances the capability of neural networks for electromagnetic (EM) parametric modeling. For modeling data based on vector fitting processing, the sub-transfer function (sub-TF) response represented by each pole-residue pair exhibits different physical properties and data characteristics. Embedding the transfer function in the neural network enables good modeling accuracy for the strongly resonant sub-TF response, but for the non-strongly resonant sub-TF response the poles/residues change abruptly as the geometrical parameters vary. This discontinuity issue of transfer function parameters for non-strong resonance results in poor robustness and modeling accuracy.

This talk introduces a systematic neuro-transfer function (neuro-TF) parametric modeling method with a compact form of partially embedding the transfer function in neural networks to systematically solve this problem. To accurately judge the embedding range, an embedding range judgment algorithm based on resonance degree is proposed. We outline the training process and derive the corresponding derivative formula to expedite gradient-based training convergence. It is noteworthy that the proposed model structure is not only simpler and more compact, but also achieves better modeling results. The proposed method demonstrates superior modeling accuracy and robustness compared to existing neuro-TF methods, even including methods that introduce other functions and structures.

Biography

Wei Liu received the B.Eng. degree from the Harbin Institute of Technology, Harbin, China, in 2017, the M.A.Eng. degree from Jilin University, Changchun, China, in 2020, and the Ph.D. degree in the School of Microelectronics at Tianjin University, Tianjin, China, in 2024. He joined the School of Microelectronics at Tianjin University, Tianjin, China, in 2024, where he is currently a Research Associate. He is also a visiting scholar at the Department of Electrical and Computer Engineering, National University of Singapore, Singapore, in 2024.

His research interests include neural network-based electromagnetic parametric modeling and design optimization algorithms, surrogate modeling and surrogate-assisted optimization algorithms, physics-informed neural networks for finite element method (FEM) of electromagnetic (EM), and model-order reduction based on FEM for EM.

Invited Talk 12

Automated Model Generation for Microwave Components Using Adjoint Neural Network and EM Sensitivity Analysis

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Abstract

Automated model generation (AMG) method has become a popular technique for systematically developing neural network models for microwave components by avoiding manual trial-and-errors. It integrates all subtasks like data generation, neural-network selection, training and test into one unified framework to convert the conventionally expensive process of microwave modeling into an AMG process. In addition to making neural network training more efficient, AMG also addresses two critical problems of neural network training, i.e., determining the suitable amount of training data and the suitable number of hidden layers and hidden neurons.

This talk introduces recent advances of AMG methods for microwave modelling, including AMG incorporated with EM sensitivities and efficient interpolation approach to make the adaptive sampling process much faster, efficient batch-adjustment algorithm for multilayer ANN structure adaptation, and AMG with l1 regularization for knowledge-based neural model development.

Biography

Weicong Na received the B.Eng. degree in Tianjin University, Tianjin, China, in 2012, and the Ph.D. degree in the School of Microelectronics at Tianjin University, Tianjin, China, and the Department of Electronics at Carleton University, Ottawa, ON, Canada, in 2018. In 2018, she joined the School of Information Science and Technology at Beijing University of Technology, Beijing, China, where she is currently an Associate Professor. Her research interests include microwave circuit modeling and design, automated neural network model generation algorithm, EM field knowledge-based modeling and optimization, and deep neural network modeling for microwave applications.

Dr. Na serves as reviewer for many IEEE scientific publications, including IEEE Transactions on Microwave Theory and Techniques, IEEE Microwave and Wireless Components Letters, IEEE Transactions on Electron Devices, etc. She served as the General Chair of 2023 IEEE MTT-S Young Professionals Workshop on Electromagnetic Modeling and Optimization (EMO 2023), a Session Chair and a member of Technical Program Committees of IEEE MTT-S International Wireless Symposium in 2022, and a Session Chair of IEEE MTT-S International Conference on Numerical Electromagnetic and Multiphysics Modeling and Optimization (NEMO) in 2020.

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