NTU GICE
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Graduate Institute of Communication Engineering, National Taiwan University

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GICE Honors

Teco Award

Teco Technology Foundation

Prof. Homer H. Chen

To witness the technology development and humanism achievement in Taiwan, the "TECO AWARD" honors domestic elites who have achieved the highest level of innovation in their own fields but also made direct contribution to the society.

Fellow of the Chinese Institute of Electrical Engineering, 2023

The Chinese Institute of Electrical Engineering, CIEE

Prof. Ming-Syan Chen

Delta Young Technology Scholar Award

Delta Electronics, Inc.

Prof. Hung-Yu Wei

Delta Electronics, Inc. is a leading provider of power management solutions, specializing in smart energy, industrial automation, data centers, and EV charging. With a focus on research and development in power electronics, power systems, electric vehicles, robotics, and smart manufacturing, Delta instituted the "Delta Young Technology Scholar Award" to recognize outstanding scholars and promote impactful research. Professor Wei received this award for his pioneering research in integrating smart charging, edge computing, and 6G IoT for future electric vehicle systems.

Qualcomm Innovate in Taiwan Challenge

Qualcomm

PetaRay (A spinoff of Prof. Homer H. Chen's lab)

The Qualcomm® Innovate in Taiwan Challenge (QITC) 2023 is a continuation of an initiative by Qualcomm, run by its affiliate Qualcomm Technologies, Inc. (QTI), that was started in 2019 to support the development of Taiwan's ICT ecosystem by identifying and nurturing innovative, new small and medium-sized companies and products. This Qualcomm initiative is a collaboration with Taiwan's National Science and Technology Council (NSTC) and Taiwan Tech Arena (TTA) to support the growth of Taiwanese startups in areas such as 5G, cellular connected IoT, machine learning, smart cities, and multimedia with our mobile platforms and technologies.

Wide-angle Wideband Polarization-insensitive Absorber Inspired from Uniaxial Perfectly-Mathced Layer (UPML)

Prof. Yih-Peng Chiou

Major Research Areas

Device modeling, design, and applications in optoelectronics and electromagnetics

Metamaterial (MM) absorbers and their associated devices have attracted significant attention due to their promising applications in stealth technology, communication, and biomedical imaging. A MM perfect absorber typically comprise a periodic frequency-selective surface (FSS), a dielectric spacer, and a metal ground plane, forming a resonant cavity. The attenuation of incident light was mainly originated from the large metallic ohmic losses accompanied with the resonance at the designed spectral regime. Such conventional resonant-type absorbers often struggle to achieve broad absorption, resulting in a narrow fractional bandwidth, typically less than 20%. Additionally, many designs suffer from efficiency degradation at large oblique incidence, limiting their versatility and utility.

In pursuit of broad-spectrum performance, MM absorbers have been designed using highly lossy materials and low-quality factor multi-band resonators with closely spaced resonant modes across their absorption spectrum. Unfortunately, the absorption characteristics of these broadband absorbers are also frequently influenced by the polarization of incident waves at substantial oblique angles, compromising absorption levels and bandwidth. This issue can be alleviated by reluctantly increasing the overall thickness of the absorber made of magnetic-less materials.

To enhance performance of MM absorbers, we have tried to adopt the concept of the perfectly matched layer (PML) absorbing boundary conditions (ABC). The PML technique is widely used in the numerical simulation of electromagnetic waves to reduce spurious reflection due to artificial boundaries imposed in the computation domain. The PML is characterized by its ability to work effectively across a wide range of angles, frequencies, and polarization states, making it valuable not only in electromagnetic simulations but also in other fields like acoustics. In our lab, we propose a MM absorber comprising a paired slot-FSS, a vertical rod VIA, and a split-ring resonator (SRR) to emulate the behavior of the uniaxial PML (UPML), as depicted in Figure 1. This innovative approach allows us to achieve outstanding performance by mirroring the advantages of the PML.

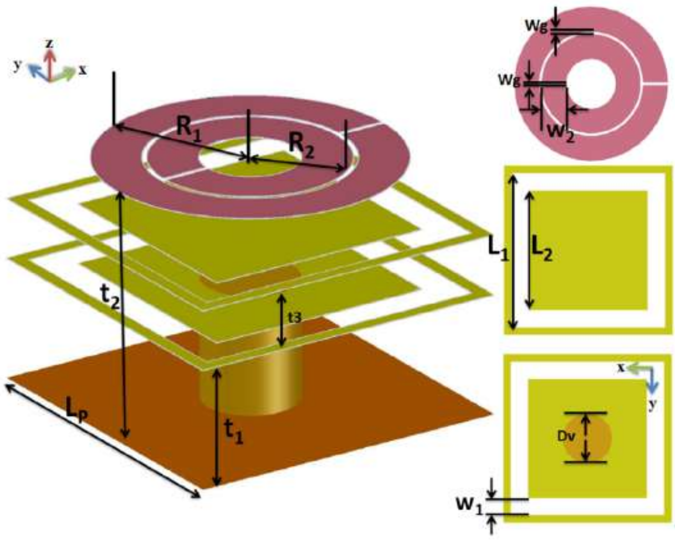


Fig. 1. A unit cell of proposed THz MM absorber.

Our investigation started with the analysis of the relative permittivity and permeability tensors in a uniaxial medium, with the aim of achieving near-perfect absorption. Subsequently, we applied circuit models to design the components of our terahertz metamaterial (MM) absorber, ensuring they met the necessary macroscopic material anisotropy requirements. Through meticulous tuning of the resonance of periodic VIAs and SRRs, we achieved effective anisotropic permittivity and permeability closely resembling UPML. The SRR, a bi-layered slot-FSS, and VIA structures were optimized to attain equivalent electric and magnetic plasma frequencies, along with similar dispersion profiles, thus approaching the effective permittivity and permeability tensor characteristics of an ideal UPML. Moreover, our research revealed the significant roles played by the SRR and VIA structures in field attenuation, particularly under oblique incidence. The lossy vertical conductor VIA contributed to the attenuation of the Ez field under oblique transverse magnetic (TM) incidence, while the SRR structure weakened the Hz field under oblique transverse electric (TE) incidence.

Finally, through full-wave simulations, we demonstrated, as shown in Figure 2, the reflectance of our MM absorber is below 10% in the frequency range of 0.9 THz to 10.5 THz under normal incidence, corresponding to 168.5% bandwidth to the central wavelength. The absorption retains upon 90% when the incident angle is ranging from 0° to 60°degrees for both transverse electric (TE) and transverse magnetic (TM) waves. This terahertz MM absorber, characterized by its wideband, wide-angle, and polarization-insensitive properties, holds great promise for applications in terahertz imaging, black-body radiation, and bolometric detectors. Furthermore, the design concept can be extended to encompass various frequency ranges, including microwave (e.g. stealth technology) and infrared optical frequencies (e.g. super black materials).

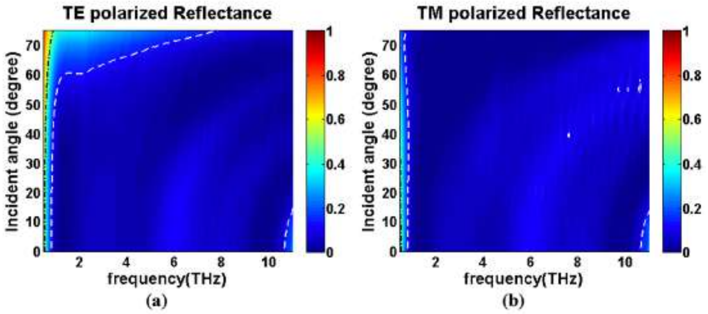


Fig. 2. Full-wave simulated reflectance spectra of the proposed structure as function of incident angles for (a) TE polarization and (b) TM polarization. The white dash curves and black dash-dot curves indicate the gradient contours for 10% and 50% reflectance, respectively.

References

S.-K. Tseng, H.-H. Hsiao, and Y.-P. Chiou*, "Wide-angle wideband polarization-insensitive perfect absorber based on uniaxial anisotropic metasurfaces," OSA Optical Materials Express, Vol. 10, No. 5, pp. 1193-1203, May 2020.

Prof. Yih-Peng Chiou

Major Research Areas

Device modeling, design, and applications in optoelectronics and electromagnetics

Research Summary

1. Design and applications of electromagnetic periodic and resonant structures, including photonic crystals (PhC), frequency-selective surfaces (FSS), electromagnetic bandgaps (EBG), phased-array elements, and various metamaterials.

2. Design and applications of waveguide devices for integrated optics and optical communications.

Program-Guided Robot Learning

Prof. Shao-Hua Sun

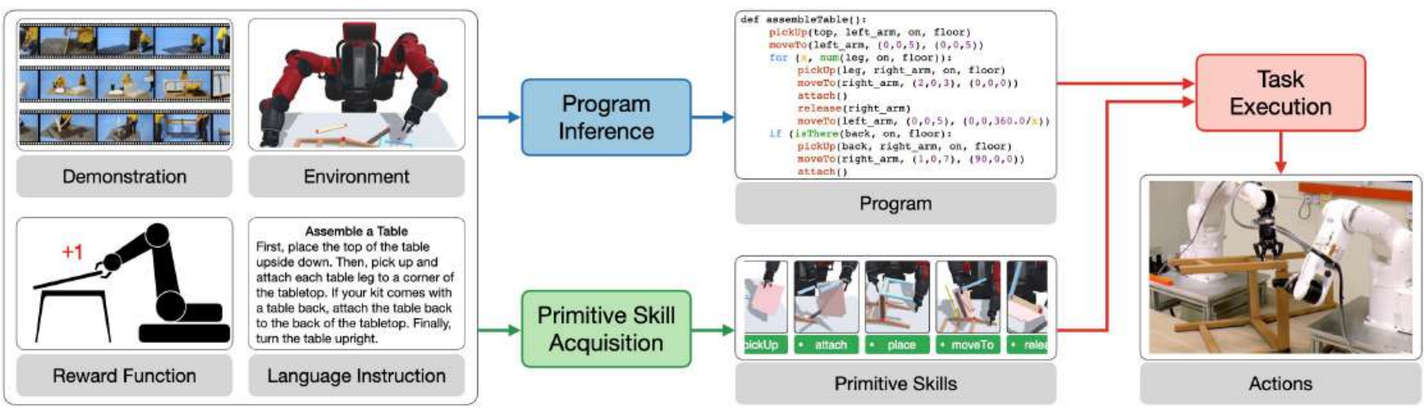
Assistant Professor at National Taiwan University at the Department of Electrical Engineering and the Graduate Institute of Communication Engineering.

He was awarded Yushan Young Fellow by the Ministry of Education, Taiwan. His research interests span Robot Learning, Reinforcement Learning, Program Synthesis, and Machine Learning.

The recent development in the field of artificial intelligence has empowered machines to understand images and videos, comprehend natural languages, and outperform humans in complex games. However, building reliable artificial intelligence agents (i.e., robots) that can physically interact with their surroundings as well as learn to operate in unstructured environments, manipulate unknown objects, and acquire novel skills – to free humans from tedious or dangerous manual work – remains challenging.

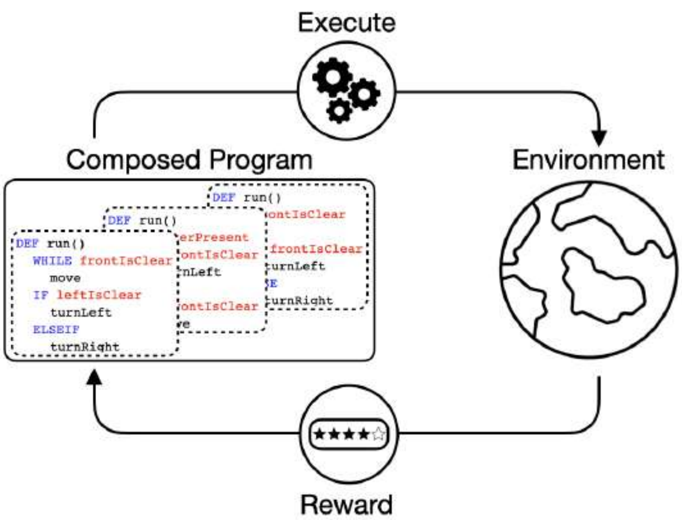
The focus of Prof. Shao-Hua Sun's research is to develop a robot learning framework that allows robots to acquire long-horizon and complex skills with hierarchical structures such as furniture assembly and cooking. Specifically, he presents an interpretable and generalizable Program-Guided Robot Learning (PGRL) framework, which represents desired behaviors as a program as well as acquires and utilizes primitive skills for learning to execute desired skills. Instead of learning in an end-to-end manner, he proposes to design specialized learning modules that aim to (1) perform program inference to explicitly infer underlying programs that describe the skills of interest, (2) acquire primitive skills that can be used to compose more complex and longer-horizon skills, and (3) perform task execution by following the inferred program and utilizing acquired primitive skills to replicate the desired skills.

Prof. Shao-Hua Sun has made significant and promising progress toward building the proposed framework and will continue pursuing research along this line. The novelty, feasibility, and potential impact of the proposed framework have been justified by a series of publications presented at top-tier conferences in machine learning (Neural Information Processing Systems, International Conference on Machine Learning, International Conference on Learning Representations), robot learning (Conference on Robot Learning), computer vision (IEEE/CVF Conference on Computer Vision and Pattern Recognition, European Conference on Computer Vision), and natural language processing (Empirical Methods in Natural Language Processing).



Hierarchical Programmatic Reinforcement Learning via Learning to Compose Programs - ICML 2023

Prof. Shao-Hua Sun recently collaborated with Guan-Ting Liu (Ph.D. student at the Graduate Institute of Networking and Multimedia at NTU), En-Pei Hu (M.S. student at Graduate Institute of Electrical Engineering, NTU), Prof. Pu-Jen Cheng (Dept. of Computer Science and Information Engineering, NTU), and Prof. Hung-Yi Lee (Dept. of Electrical Engineering, NTU) and published a paper at the International Conference on Machine Learning (ICML) 2023. This research work re-formulates solving a reinforcement learning task as synthesizing a task-solving program that can be executed to interact with the environment and maximize the return. It first learns a program embedding space that continuously parameterizes a diverse set of programs sampled from a program dataset. Then, it trains a meta-policy, whose action space is the learned program embedding space, to produce a series of programs (i.e., predict a series of actions) to yield a composed task-solving program. An illustration of this project and a detailed description of this project is as follows.



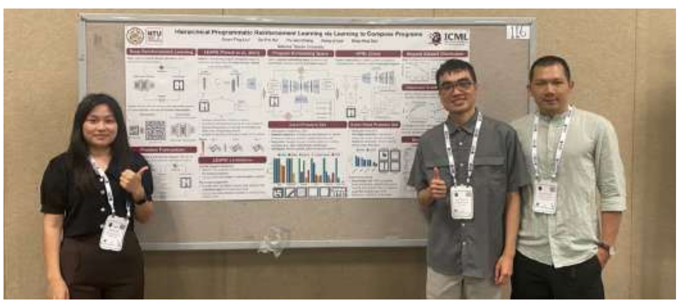
Deep reinforcement learning (DRL) leverages the recent advancement in deep learning by reformulating the reinforcement learning problem as learning policies or value functions parameterized by deep neural networks. DRL has achieved tremendous success in various domains, including controlling robots (Gu et al., 2017; Ibarz et al., 2021; Lee et al., 2019; 2021), playing board games (Silver et al., 2016; 2017), and strategy games (Vinyals et al., 2019; Wurman et al., 2022). Yet, the black-box nature of neural network-based policies makes it difficult for the DRL-based systems to be interpreted and therefore trusted by human users (Lipton, 2016; Puiutta & Veith, 2020). Moreover, policies learned by DRL methods tend to overfit and often fail to generalize (Zhang et al., 2018; Cobbe et al., 2019; Sun et al., 2020a; Liu et al., 2022).

To address the abovementioned issues of DRL, programmatic RL methods (Bastani et al., 2018; Inala et al., 2020; Landajuela et al., 2021; Verma et al., 2018) explore various more structured representations of policies, such as decision trees and state machines.

In particular, Trivedi et al. (2021) present a framework, Learning Embeddings for lAtent Program Synthesis (LEAPS), that is designed to produce more interpretable and generalizable policies. Specifically, it aims to produce program policies structured in a given domain-specific language (DSL), which can be executed to yield desired behaviors. To this end, LEAPS first learns a program embedding space to continuously parameterize diverse programs from a pre-generated program dataset, and then searches for a task-solving program in the learned program embedding space when given a task described by a Markov Decision Process (MDP). The program policies produced by LEAPS are not only human-readable but also achieve competitive performance and demonstrate superior generalization ability.

Despite its encouraging results, LEAPS has two fundamental limitations. Limited program distribution: the program policies that LEAPS can produce are limited by the distribution of the pre-generated program dataset used for learning the program embedding space. This is because LEAPS is designed to search for a task-solving program from the learned embedding space, which inherently assumes that such a program is within the distribution of the program dataset. Such design makes it difficult for LEAPS to synthesize programs that are out-of-distributionally long or complex. Poor credit assignment: during the search for the task-solving program embedding, LEAPS evaluates each candidate program solely based on the cumulative discounted return of the program execution trace. Such a design fails to accurately attribute rewards obtained during the execution trajectories to corresponding parts in synthesized programs or penalize program parts that induce incorrect behaviors.

This work aims to address the issues of limited program distribution and poor credit assignment. To this end, we propose a hierarchical programmatic reinforcement learning (HPRL) framework. Instead of searching for a program from a program embedding space, we propose to learn a meta-policy, whose action space is the learned program embedding space, to produce a series of programs (i.e., predict a sequence of actions) to yield a composed task-solving program. By re-formulating synthesizing a program as predicting a sequence of programs, HPRL can produce out-ofdistributionally long or complex programs. Also, rewards obtained from the environment by executing each program from the composed program can be accurately attributed to each program, leading to more efficient learning.



Prof. Shao-Hua Sun, Guan-Ting Liu, and En-Pei Hu attended the conference and presented the research work in Honolulu, Hawaii, in July 2023.

Exchange experience at the Technical University of Munich (TUM)

Hsin-Jung Yang

Graduated master student from the Advanced Antenna Laboratory (AAL) of the Graduate Institute of Communication Engineering, NTU

Upon completing my MS oral defense at GICE, I chose to extend my academic journey by taking another year as an exchange student abroad rather than directly entering the workforce or pursuing a PhD like most of my peers did. With the blessing of my advisor, Professor Shih-Yuan Chen, I flew to the well-known engineering school, the Technical University of Munich (TUM), in Germany. Munich is home to the headquarters of notable tech companies, including the RF instrument company Rohde & Schwarz (R&S) and the automobile company BMW. Therefore, studying in Munich is a great opportunity to delve deeper into leading industries and related technologies.

The most important thing I experienced while staying in Munich was to work hard and play hard. The exams at TUM are known to be difficult, and the ways they are conducted are quite different from the ones in Taiwan, which took some time to get used to. To further expand my skills in academic presentation and writing, I also took an advanced seminar course in high-frequency engineering that requires intensive discussions with the lecturers and peers, and impromptu speeches. This was a bit challenging but also rewarding for me, since I did not have this kind of training in Taiwanese schools. This course also gave me the chance to learn from experts at the Chair of High-Frequency Engineering at TUM, which shed some light on how highquality research is conducted in Europe. Apart from studying, engaging in student parties and activities is also an essence of studying in Europe, where we get to open our minds to talk and have a great time with people all over the world.

Besides staying in Munich or in the Bavarian state, I also seized the opportunity to travel during school breaks to experience different cultures and see historical monuments printed in history books with my own eyes. Some of my most memorable destinations are the Baltic states, where the cultural and gastronomical legacies of the Soviet Union blend with a taste of western influence; the Balkan states, where hidden treasures are found in every city, accompanied by the mystique of the Orthodox church. Exploring these lesser-known places is a chance for a lifetime, and I enjoyed every moment when visiting these countries during my exchange period.

Another important aspect of my life as a foreign student is 'essen und trinken' (food and drink). I learned to cook better since it isn't cheap to eat out often, unlike in Taiwan. The Oktoberfest in Munich is also the world-renowned beer festival, where people get to drink large jugs (1.0L) of delicious locally brewed beer and have a great time with friends and people next table.
My year in Germany was the most rewarding period of my life so far. I have learned a lot, not only academically but also culturally and socially. This invaluable experience really broadened my horizons and definitely equipped me better for the next chapter in my life.

Fig1. Group photo with my flatmates in the dorm gathering.

Fig2. Day trip organized by the university.

Hsin-Jung Yang

Graduated master student from the Advanced Antenna Laboratory (AAL) of the Graduate Institute of Communication Engineering, NTU

The International Symposium on Information Theory (ISIT)

The International Symposium on Information Theory, referred to as ISIT, is an academic conference regularly held by the Information Theory Society (ITSOC) in the Institute of Electrical and Electronics Engineers (IEEE). ISIT aims at extensive interaction of academic achievements in communication and information theory. Since the success in obtaining the hosting right of the ISIT in 2023, referred to as ISIT 2023, various preparations for the conference have been actively underway. Among the key positions of the organizing committee were the professors of the GICE, including Prof. Wanjiun Liao, Prof. Hsuan-Jung Su, Prof. I-Hsiang Wang, and Prof. Shih-Chun Lin. Also ISIT2023 is sponsored and supported by Qualcomm and MediaTek.

Held at the Taipei International Convention Center from June 25 to June 30, ISIT 2023 lasted for a duration of 6 days, including 22 live conferences, 31 hybrid conferences, and 70 in-person conferences. Besides the 476 papers published in ISIT 2023, there were a total of 685 participants coming from 33 countries, including the US, Israel, Switzerland, Germany, the UK, Singapore, India, Japan, and China. Moreover, five keynote speakers invited in ISIT 2023 were as follows:

Fig 1. Interview with the Shannon Awardee Rudiger Urbanke

Maryna Viazovska from the École Polytechnique Fédérale de Lausanne (EPFL), who was among the winners of Fields Medal 2022;

Amir Dembo from Stanford University, who is among the members of the National Academy of Sciences;

Rudiger Urbanke from EPFL, who is the winner of Claude E. Shannon Award 2022;

Neri Merhav from the Technion – Israel Institute of Technology;

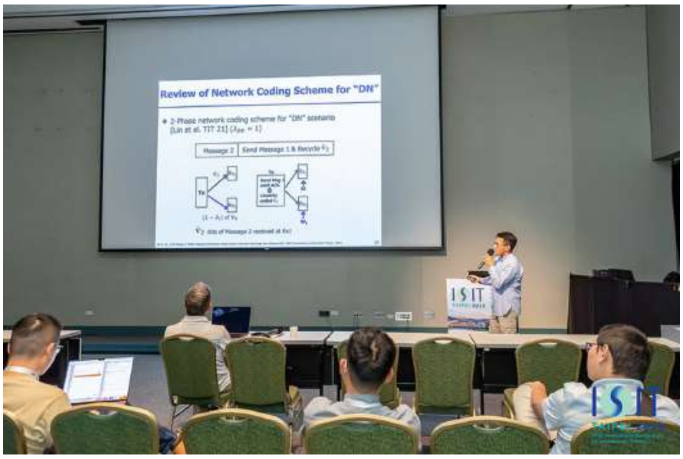
Antonia Tulino from the University of Naples Federico II (UNINA) & Nokia Bell Labs.

A variety of activities such as discussion sessions, the welcome reception, conference dinner, and local tours were also arranged, as well as the tutorials and paper presentations, for facilitating the interaction among participants.

Fig 2. Plenary talk of Maryna Viazovska

Fig 3. Talk of Prof. I-Hsiang Wang

Fig 5. Talk of MS graduate Yan-Cheng Chu (joint work with Prof. Shih-Chun Lin)



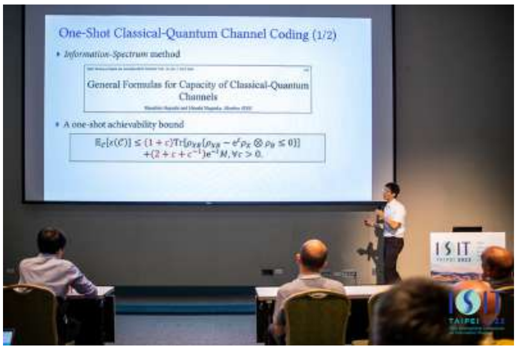


Fig 4. Talk of Prof. Hao-Chung Cheng

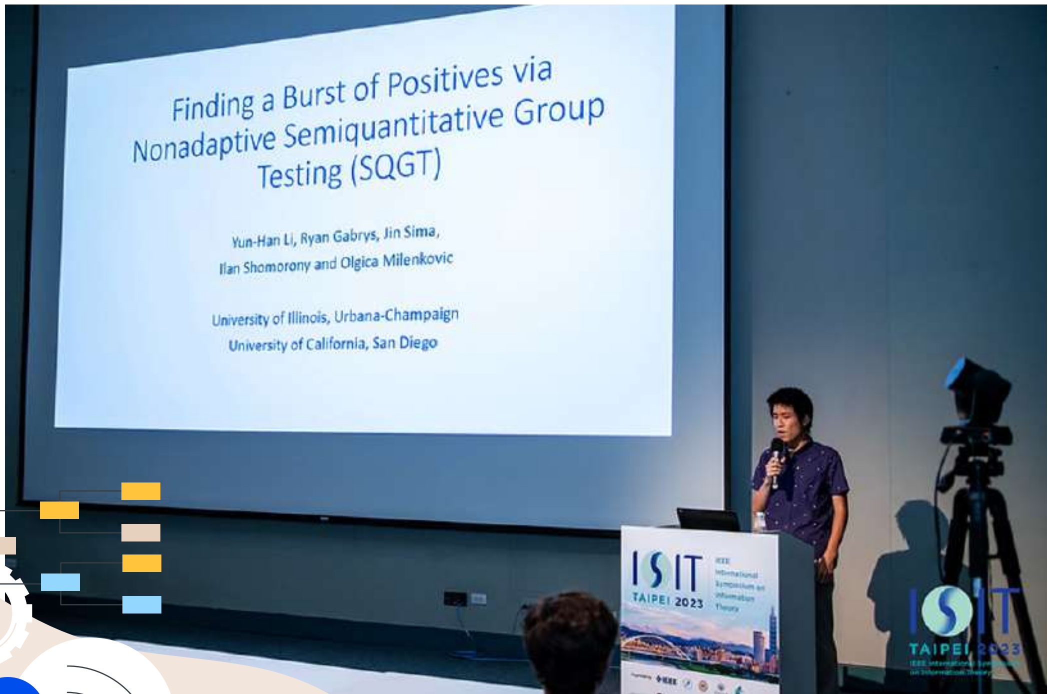


Fig 6. Talk of MS graduate Yun-Han Li (now a PhD student at UIUC)

The author thanks TAIICT for kindly providing the first version of this letter. Also the photos are from https://www.flickr.com/photos/198924395@N08/albums/with/72177720310621561

The 2023 2nd Semi-annual Workshop of Taiwan Electromagnetic Industry-Academia Consortium: Design and Application of Millimeter Wave Antennas

Millimeter waves (mm-Wave) have higher frequencies and wider transmission bandwidth, which can assist commercial application services such as smart factories and industrial Internet of Things, allowing Taiwan's industry to move towards high-quality and highly intelligent design, rapid packaging system development, and efficient simulation system analysis platforms. To this end, National Kaohsiung University of Science and Technology (NKUST) and Taiwan Electromagnetic Industry-Academia Consortium (TEMIAC) jointly connect industry-university-research resources in southern Taiwan and invite distinguished lecturers from the industry and academia to hold the event on October 27 (Friday). This workshop focused on the design and application of millimeter wave antennas, providing the latest technology development trends in industry and academia for the 5G millimeter wave industry. It is expected that southern Taiwan will become a key cluster for millimeter wave and other maritime satellite antenna industries, linking the development of the Great Industrial Chain in Southern Taiwan.

Fig. 1. TEMIAC held a Design and Application of mm-Wave Antenna workshop at NKUST

Fig. 2. Guests from industry, academia, and research institutes attended the workshop.

The workshop was held at NKUST, with about 170 attendees. It kicked off with an opening remark by Professor Ruey-Beei Wu, the TEMIAC Coordinator, and was followed by seven insightful speeches, each of which lasted about 40 minutes, including 5-minute Q&A. In addition, Himax Technologies, Inc. also held a talent recruitment briefing at noon that day, attracting many students to participate. This workshop not only provides an opportunity for industry and academia to communicate with each other, but also allows students to understand the development and application prospects of mm-Wave antennas. These will help promote Taiwan's future R&D synergy in mm-Wave low-earth-orbit (LEO) satellite-related technologies, enabling Taiwan to become one of the important settlements for 5G/B5G components, subsystems, and related services before 2028.

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