

“智能通信技术赋能物联网”

哈尔滨工业大学 2022 年国际暑期学校项目介绍

一、 哈尔滨工业大学电子与信息工程学院介绍

电子与信息工程学院始建于 1959 年，设有“信息与通信工程类”一个大类招生专业，包括通信工程、电子信息工程、信息对抗技术、遥感科学与技术、电磁场与无线技术五个专业。设有信息与通信工程一级学科及电磁场与微波技术二级学科。2007 年通信与信息系统二级学科被评为国家重点学科，信号与信息处理为国家重点培育学科，2017 年教育部双一流学科评估 A-，同年作为哈尔滨工业大学控制科学与工程学科群、计算机科学与技术学科群的重要组成部分入选世界一流学科建设名单。

学院有教学科研人员等 151 人，教授 50 人、副教授 79 人，同时具有博士生导师 63 人，硕士生导师 133 人。其中中国科学院和中国工程院院士 1 人，双院士刘永坦教授为我国著名雷达及电子信息系统专家，2018 年获得国家最高科学技术奖。学院现有在校本科生 954 人，硕士研究生 379 人，博士研究生 255 人。

结合国际学术前沿和国家重大战略需求，学院已经形成新体制雷达与对海探测技术、空间信息网络、抗干扰数据链传输技术、移动通信系统与移动互联网、航天测控和工业智能测试、空间对地观测信息处理、微波智能材料、毫米波/太赫兹高分辨率成像技术等研究方向。作为宇航科学与技术、无线通信技术和信息感知技术三个 2011 协同创新中心的重要成员，学院近五年来承担 973、863、自然科学基金、国防类基础科研和校企合作研究等科研项目 500 多项，累计经费突破 5 亿元；发表了 SCI 论文 400 余篇，授权专利 400 余项；获国家最高科学技术奖 1 项，中国专利奖银奖 1 项，国家科技进步一等奖 2 项、二等奖 2 项，省部级

科技奖 30 余项，为国防装备建设和国家经济发展做出了重大贡献，奠定了双一流建设的基础。

2018 年，双院士刘永坦教授获得国家最高科学技术奖。刘永坦教授是我国著名雷达与信号处理技术专家，对海探测新体制雷达理论与技术奠基人和引领者。他领导和培育的创新团队，率先在国内开展了新体制雷达研究，技术成果“领跑”世界，成功实现工程应用，为我国筑起“海防长城”做出了卓越的贡献，在保卫祖国海疆中发挥着不可替代的作用。

二、 国际暑期学校主题

本次国际暑期学校主题为：“智能信息技术赋能工业互联网”，主要从 5G、人工智能、工业互联网和工业大数据等相关领域的前沿技术出发，通过国际一流学者的系列课程和主题讲座，引导本科生了解先进信息和通信技术领域最新的发展现状及未来发展趋势，加深 5G、AI 以及工业互联网等技术对智能制造和工业互联网的理解，深入理解日益智能化的信息通信技术在智能制造和人工智能时代给世界格局（政治、经济、文化等）和人类生活模式带来的深远影响，培养本科生对未来信息通信技术、人工智能技术以及相关交叉研究领域的兴趣。

本次暑期学校的学术讲座部分将由哈尔滨工业大学电信学院、IEEE ComSoc Harbin Chapter 和 IEEE Communication Society 共同邀请学者，并组织实施。



三、 国际暑期学校学习和活动内容

本次国际暑期学校从 2022 年 7 月 11 日开始，7 月 24 日结束，包括学术讲座、课堂教学和创新实践三个环节，总体内容如下表所示。

模块	内容	学时	学分
学术 讲座	智能信息方向主题报告 Lajos Hanzo (院士)	2	2
	IRS 辅助的射频和光学无线通信 Robert Schober	2	
	通信技术的发展与演进 Hsiao-Hwa Chen	2	
	5G 物联网网络 Yonghui Li	2	
	未来无线网络的能源自持性 Kun Yang	2	
	建筑物的基本无线性能 Jiliang Zhang	2	
	利用无线光纤传感系统 进行人体传感 Qingquan Sun	2	
	引导新兴通信网络的经济学和博弈论 Lingjie Duan	2	
	智能电网与未来能源-信息和通信技术 (ICT) 将如何改变我们的生活 Hongjian Sun	4	
	面向 6G 和物联网的移动边缘计算 Yan Zhang	2	
	基于 AI 的 RAN 服务优化 Tao Chen	2	
	能量收集通信：理论与原则 Yunfei Chen	4	
	基于遥感数据的变化检测 Tian JiaoJiao	2	
	自动驾驶中的环境感知和建模 Shiyong Cui	2	
课程 教学	3D 视频信号压缩和通信 国际前沿技术 Wei Xiang	16	1
实践 创新	无线电 GPS 信号源设计	32	2
学时合计		学分合计	
80		5	

学术讲座学者及报告简介



Lajos Hanzo is a professor of the University of Southampton, IEEE Fellow, IET Fellow, Member of the Royal Academy of Engineering, Foreign Member of the Hungarian Academy of Sciences. Lajos Hanzo was the EIC of IEEE Press from 2008 to 2012; he also served as editor-in-chief and editor of several academic journals, such as the Proceedings of the IEEE, the Wiley Journal on Wireless Communications, Mobile Computing, Elsevier PhyCom, etc. Mobile Computing, Elsevier PhyCom, etc. He has published 18 highly cited John Wiley - IEEE Press monographs on Anglo-American studies, totaling over 10,000. In total, he has published more than 1800 articles in IEEE Xplore; more than 44,000 Google Scholar citations. In addition, Lajos Hanzo has received numerous honorary awards: FREng, 2004; FIEE 2003; FIEEE, 2004; DSc, 2004; VC's Teaching Award, 2006; IEE Signal. Proc. Distinguished Lecture; RAEng. Vodafone Lecturer 2007; WCNC'2007 Best Paper Prize; ICC'2009 Best Paper Prize; IEEE Wireless Technical Committee Achievement Award; IET Sir Monti Finniston Award; Fellow of the European Signal Processing Association 2011; Dr. Honoris Causa 2011, Budapest; WCNC'13 Best paper award; European Research Council Advanced Fellow 2012; RS Wolfson Fellow 2013; IEEE Radio Communications Achievement Award, 2013, IEEE VTS Avant-Garde Award 2014, Dr. Honoris Causa 2015, Edinburgh; IEEE VTS Avant-Garde Award 2014; Foreign Member of the Hungarian Academy of Sciences, 2016; EURASIP Papoulis Award'2018; IEEE ComSoc Education Award; Best Journal Paper Award'2019.



Robert Schober, he (S'98, M'01, SM'08, F'10) received the Diplom (Univ.) and the Ph.D. degrees in electrical engineering from Friedrich-Alexander University of Erlangen-Nuremberg (FAU), Germany, in 1997 and 2000, respectively. From 2002 to 2011, he was a Professor and Canada Research Chair at the University of British Columbia (UBC), Vancouver, Canada. Since January 2012 he is an Alexander von Humboldt Professor and the Chair for Digital Communication at FAU. His research interests fall into the broad areas of Communication Theory, Wireless Communications, and Statistical Signal Processing. Robert received several awards for his work including the 2002 Heinz Maier Leibnitz Award of the German Science Foundation (DFG), the 2004 Innovations Award of the Vodafone Foundation for Research in Mobile Communications, a 2006 UBC Killam Research Prize, a 2007 Wilhelm Friedrich Bessel Research Award of the Alexander von Humboldt Foundation, the 2008 Charles McDowell Award for Excellence in Research from UBC, a 2011 Alexander von Humboldt

Professorship, a 2012 NSERC E.W.R. Stacie Fellowship, and a 2017 Wireless Communications Recognition Award by the IEEE Wireless Communications Technical Committee. Since 2017, he has been listed as a Highly Cited Researcher by the Web of Science. Robert is a Fellow of the Canadian Academy of Engineering, a Fellow of the Engineering Institute of Canada, and a Member of the German National Academy of Science and Engineering. From 2012 to 2015, he served as Editor-in-Chief of the IEEE Transactions on Communications. Currently, he serves as Member of the Editorial Board of the Proceedings of the IEEE and as VP Publications for the IEEE Communication Society (ComSoc).

Title: IRS-aided RF and Optical Wireless Communication: Modeling, Design, and Optimization

Intelligent reflecting surfaces (IRSs) have the potential to transform both wireless radio frequency (RF) and free-space optics (FSO) communication channels into smart reconfigurable propagation environments. To realize the full potential of this new paradigm, careful physics-based modeling, scalable design, and efficient optimization techniques for IRS-assisted wireless systems have to be developed. In this presentation, we first consider IRS-assisted RF systems, for which we develop a physics-based model. Careful analysis of the proposed model reveals that large IRS with thousands of phase-shift elements are needed to compensate for the large end-to-end path-loss introduced by the multiplication of the individual path-losses of the transmitter-to-IRS and IRS-to-receiver channels. For scalable optimization we partition the IRS unit cells into several subsets, referred to as tiles, which are optimized in two stages, namely an offline design stage and an online optimization stage. Subsequently, for IRS-assisted FSO systems, different options for realizing optical IRS are discussed. Then, we model the resulting geometric and misalignment losses (GML) of the end-to-end channel, where we take into account the impact of building sway. Models based on geometric optics and the Huygens-Fresnel principle are compared. Finally, promising directions for future research on both IRS-assisted RF and IRS-assisted FSO systems are provided.



Tao Chen is a research team leader on connectivity services and solutions at VTT Technical Research Centre of Finland, a honorary professor at University of Kent, UK, and an adjunct professor at University of Jyväskylä, Finland. He has more than 20 years of experience in the telecommunications sector. He has led several EU and national research projects, covering various topics from cognitive radio,

green communications, to software defined networking and 5G radio access networks. Dr. Chen

is technical editor of IEEE Wireless Communications Magazine and IEEE Transactions on Cognitive Communications and Networking. He has published more than 80 scientific publications. His current research interests include disaggregated RAN, software defined networking for 5G mobile networks, AI for communications, dynamic spectrum access, energy efficiency and resource management in heterogeneous wireless networks.

Title: AI for RAN service optimization

Radio access networks (RAN) have become extremely complex. For instance, in 5G networks, frequency bands are equally shared among 5G base stations, which makes the network-wide resource coordination very challenge. The use of the artificial intelligent (AI)/machine learning (ML) can help manage this complexity. In the recent O-RAN initiative, the intelligence has been introduced as a native feature to support RAN control. This talk will include two parts. The first part will provide an overview on AI/ML for resource optimization problems in RAN. The focus of AI/ML algorithms will be on Markov decision process, reinforcement learning, and deep Q-learning. The second part will introduce the native AI/ML support under the O-RAN control framework. The state of the current O-RAN development will be examined, followed by the solutions to integrate the Open AI platform with O-RAN control framework. The details will be given on how to design AI/ML flow to support smart RAN services. Finally, future research directions to apply AI/ML for RAN service optimization will be highlighted.



Qingquan Sun is currently an Associate Professor in the School of Computer Science and Engineering at California State University, San Bernardino, 92407, USA. He received the Master and Ph.D. degrees in the field of Electrical and Computer Engineering at Chinese Academy of Sciences and The University of Alabama, Tuscaloosa, AL, USA in 2009 and 2013, respectively. Dr. Sun's research interests include intelligent sensing, machine learning and data sciences in cyber-physical systems.

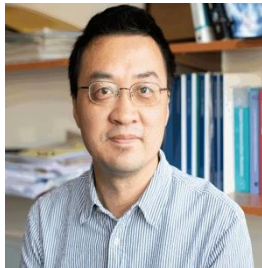
Dr. Sun has published around 20 IEEE journal/conference papers in his research fields. He also has led three NSF projects. Dr. Sun's research has been supported by U.S. NSF, U.S. NIH, and other resources. He serves as an Associate Editor for International Journal of Sensor and Sensing Systems and International Journal of Electronics and Communications, and a Reviewer for 8 IEEE Transactions/Journals.

Title: Human Sensing with Wireless Fiber-optic Sensing Systems

Human sensing covers the issues of detection, localization, count estimation, identification, and

activity recognition. Such issues can be solved by using behavioral biometrics. Behavioral biometrics, such as gesture, gait, walking trajectory, and speech rhythm, are advantageous in their tolerance of low sensory resolution, long sensing distance, and poor environmental conditions. Many applications in homeland security, energy efficient building, and healthcare require human sensing based on people's behavioral traits.

This presentation provides a framework of low-cost, low-data-throughput, fast-response solution for human sensing, which is based on binary wireless compressive sensing systems. Particularly, this presentation focuses on such a system based on fiber-optic sensors and walking trajectory biometrics. Integrated with compressive binary sensing technology, this system can perform human localization, tracking, and counting efficiently.



Yunfei Chen obtained his Bachelor's and Master's degrees from Shanghai Jiaotong University in China in 1998 and 2001, respectively. He obtained his PhD degree from the University of Alberta in Canada in 2006. He is currently a Reader in the School of Engineering at the University of Warwick in the UK. His main research interests include wireless system design and analysis, UAV communications, energy

harvesting communications, physical layer security, multiple-input-multiple-output, and statistical signal processing for communications in general. He served as editor for the IEEE Transactions on Communications, IEEE Wireless Communications Letters and IEEE Communications Letters, as well as guest editors for special issues in various IEEE and non-IEEE journals. He was awarded exemplary reviewer for the IEEE Transactions on Communications, IEEE Communications Letters and IEEE Wireless Communications Letters between 2015 and 2017. He won the Best Paper awards from the IEEE ICC 2016, VTC-Spring 2017, ICNC 2018, WOCC2019 and WCSP2019. He has co-authored nearly 300 peer-reviewed journal papers and 100 peer-reviewed conference papers. In addition, he contributed chapters in four books published by the IET Press and Springer, as well as completed a single-authored book on energy harvesting communications recently published by Wiley. His total Google citation is 8200. In 2020 and 2021, he was listed as Highly Cited Researchers by Clarivate and World's Top 2% Scientist by Standard University.

Title: Energy Harvesting Communications: Theories and Principles

Mobile devices rely on batteries for portable solutions. However, batteries often have a limited lifetime. Hence, mobile devices have to be stopped from time to time in order for their batteries to be recharged or replaced, causing considerable disruptions to mobile services. As a promising

solution to this problem, energy harvesting can be used for sustained operation of the mobile devices. In energy harvesting, the mobile device is equipped with an energy harvester and thus, it can collect energy from either dedicated or ambient sources using light or radio signals without relying on any fixed batteries. This is suitable for many low-power wireless applications, including wireless sensing. In this talk, the main theories in energy harvesting communications will be discussed. These include energy harvesting methods, energy harvesting detection, energy harvesting estimation and other important parts of a communications system. Then, several important examples of using energy harvesting communications, such as energy harvesting relaying and energy harvesting cognitive radios will be discussed. The talk will focus on the theories and principles used in energy harvesting communications.

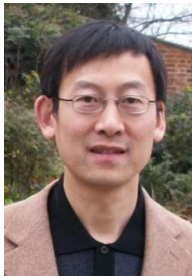


Hongjian Sun (S'07-M'11-SM'15) received BSc and MSc degrees from Harbin Institute of Technology in 2005 and 2007, respectively, and the Ph.D. degree from the University of Edinburgh, U.K., in 2011. He held post-doctoral positions with King's College London, U.K., and Princeton University, USA. Since 2013, he has been with the University of Durham, U.K., where he is now a Chair Professor, Director of Smart Grid Laboratory, and Fellow of Durham Energy Institute. He has authored or co-authored over 150 articles in refereed journals, conferences, patents and standards. His research mainly focuses on 1) smart grid: communications and networking; 2) smart grid: demand side management and demand response; and 3) smart grid: renewable energy sources integration. He is an Editor-in-Chief for *IET Smart Grid* journal, and an Editor for *Journal of Communications and Network*. He also served as a Guest Editor of the *IEEE Communication Magazine* and *IEEE Transactions on Industrial Informatics* for several feature topics. He has secured a number of research grants from a variety of funding bodies and Industry (including EU H2020, UK EPSRC, UK BEIS, Innovate UK, GCRF networking, ERDF etc.), and led large research consortia involving Universities of Tübingen, Princeton, Klagenfurt, California, Heriot-Watt, Southeast (China), and Chinese Academy of Sciences. He is also a Chartered Engineer and visiting Professorial Fellow in Chinese Academy of Sciences.

Title: Smart Grid & Future Energy – How Information and Communication Technologies (ICT) will change our lives

“Energy is the dominant contributor to climate change, accounting for around 60% of total global greenhouse gas emissions.”- United Nations. Meanwhile, access to energy services plays a vital role in enhancing both a country’s economic development and human’s quality of life. However,

globally one in five people don't have access to modern electricity. Even in developed countries, energy systems are going through rapid and substantial changes, due to the decarbonization needs and technological innovations. Conventional centralized energy system design causes technical inefficiencies or failures. A few points in the energy network have large-scale generation, but when they fail the whole system fails. Smart grid technologies will be needed to better integrate renewable energy sources in various scales to provide reliable and stable power supply. Other energy systems, such as heat and transport, also need to be decarbonized, but this will cause more challenging issues. Information and Communication Technologies (ICT) could improve the design and operations of such a system. This series of talks will cover fundamentals of smart grid and future energy technologies, together with a high-level summary of recent advances of using ICT in this system, e.g., artificial intelligence, Blockchain.



Kun Yang (杨鲲) is a Member of Academia Europaea (MAE). He obtained his PhD from the Department of Electronic & Electrical Engineering, University College London (UCL), UK. He is currently a Chair Professor and the Head of Network Convergence Laboratory in the School of Computer Science and Electronic Engineering, University of Essex, UK. He is also an affiliated professor in UESTC, Chengdu. Before joining in the University of Essex at 2003, he worked at UCL on several EU research projects in the area of network management and context-aware services. Now his main research interests focus on wireless networks, future Internet architecture, data and energy integrated communication networks, mobile edge computing (MEC), etc. He has published more than 300 technical papers and filed 20 patents. He manages research projects funded by EU FP7/H2020, EPSRC, and industries such as British Telecom. He serves on the editorial boards of a number of IEEE journals (e.g., IEEE TNSE, ComMag, WCL) and is an IEEE ComSoc Distinguished Lecturer (2020-2021). He has been a Judge of the GSMA GLOMO (Global Mobile Awards) at WMC (World Mobile Congress) since 2019. He is on the panels of various EU and national funding bodies such as EU FP7/ERC, UK EPSRC and China's NSFC, etc.

Title: Energy Self-Sustainability in Future Wireless Networks

The world is going wireless and mobile but not too much in energy transfer yet, at least not at a reasonably long distance. Researchers from both academia and industries have put much effort in achieving this goal. Starting from some introduction of the basics of wireless power transfer (WPT) covering its applications and principles the Talk moves on to a more exciting field of data and energy integrated communication networks (DEIN), i.e., transmitting information and

energy simultaneously and wirelessly. Some research outcomes from the speaker's research group will be reported, including various aspects of DEIN and a prototype system. Then the Talk will introduce a new concept called energy self-sustainability (ESS) which is envisaged as an inherent service for future wireless mobile networks such as 6G. Discussions on how ESS can be achieved with the support of emerging 6G enabling technologies such as THz and RIS (reconfigurable intelligent surface) will also be briefly presented.



Jiliang Zhang received the B.E., M.E., and Ph.D. degrees from the Harbin Institute of Technology, Harbin, China, in 2007, 2009, and 2014, respectively. He was a Postdoctoral Fellow with Shenzhen Graduate School, Harbin Institute of Technology from 2014 to 2016, an Associate Professor with the School of Information Science and Engineering, Lanzhou University from 2017 to 2019, and a researcher at the Department of Electrical Engineering, Chalmers University of Technology, Gothenburg, Sweden from 2017 to 2018. He is now a Marie Curie Research Fellow at the Department of Electronic and Electrical Engineering, The University of Sheffield, Sheffield, UK. His current research interests include, but are not limited to wireless channel modelling, modulation system, relay system, vehicular communications, ultra-dense small cell networks, and smart environment modelling. He served as editor for the Wireless Communication and Mobile Computing and Electronics.

Title: Fundamental Wireless Performance of a Building

Over 80% of wireless traffic already takes place in buildings. Like water, gas, and electricity, wireless communication is becoming one of the most fundamental utilities of a building. It is well known that building structures have a significant impact on in-building wireless networks. If we seek to achieve the optimal network performance indoors, the buildings should be designed with the objective of maximizing wireless performance. So far, wireless performance has not yet been considered when designing a building. In this talk, I will introduce a novel and interdisciplinary concept of building wireless performance (BWP) to a wide audience in both wireless communications and building design, emphasizing its broad impacts on wireless network development and deployment, and on building layout/material design. We first give an overview of the BWP evaluation framework proposed in our state-of-the-art works and explain their interconnections. Then, we outline the potential research directions in this exciting research area to encourage further interdisciplinary research.



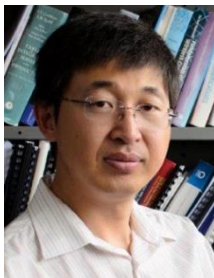
Lingjie Duan is an Associate Professor (Tenured) in the Engineering Systems and Design Pillar at Singapore University of Technology and Design, which was established in collaboration with MIT. He received Ph.D. degree in Information Engineering from The Chinese University of Hong Kong in 2012. He received Bachelor in Electrical Engineering from Harbin Institute of Technology in 2008. During 2011, he was a visiting scholar in the Department of Electrical Engineering and Computer Sciences at University of California at Berkeley.

Lingjie Duan has been actively working and contributing to the interdisciplinary research field “Network Economics”, by combining communication networks and game theory. He has used optimization and game theory extensively as both modeling languages and solution tools to study the cooperative or competitive interplay among various parties in communications and networking. He received 2016 SUTD Excellence in Research Award, and in 2015 he received the 10th IEEE ComSoc Asia-Pacific Outstanding Young Researcher Award. He was also the Finalist of Hong Kong Young Scientist Award 2014 under Engineering Science track. He has many highly-cited top engineering, business and AI publications. Among his recent publications, 5 journal papers were classified as ESI Highly Cited Papers by the ISI Essential Science Indicator on Web of Science. He is an Editor of both IEEE Transactions on Wireless Communications (TWC). He is also on the Editorial Board of IEEE Transactions on Vehicular Technology. He was also an Editor of IEEE Communications Surveys and Tutorials (COMST) from 2016 to 2019. He served as Guest Editor of IEEE Journal on Selected Areas in Communications (JSAC), IEEE Wireless Communications Magazine, and IEEE Transactions on Cognitive Communications and networking. He also served as the Co-Chair of Cognitive Radio and Networks Symposium of IEEE ICC 2019, the Workshop Co-Chair of IEEE WiOPT 2018, the Co-Chair of VTC 2017 Future Trends and Emerging Technologies track, the Program Co-Chair of IEEE INFOCOM’2014 GCCCN Workshop, ICCS’2014 special session on Economic Theory and Communication Networks, the Wireless Communication Systems Symposium of IEEE ICC 2015, the GCNC Symposium of IEEE ICNC 2016, and IEEE INFOCOM’2016 GSNC Workshop. He is also the Publicity Co-chair of IEEE WCNC 2017. He is a technical program committee (TPC) member of many leading conferences in communications and networking (e.g., ACM MobiHoc, IEEE INFOCOM, SECON, ICC, GLOBECOM and WCNC). He is a Senior Member of IEEE.

Title: Economics and game theory for guiding emerging communication networks

It is becoming increasingly important for wireless network operators to jointly optimize economic and technological decisions for business success. An operator's decisions may involve the choices and timings of technology adoptions, the amount of resources to invest, and the prices to set for his services. These decisions are coupled with each other and need to be jointly optimized, and such optimization will be challenging when the operator faces limited resources, immature technology, and market competition.

This course or series of seminars introduces the models of microeconomics, game theory, and mechanism design from scratch, and gradually includes advanced applications of economics and game theory to emerging communication networks. The detailed topics include market mechanisms, user payoffs, operator profit maximization, welfare maximization, pricing, strategic games, pure and mixed strategies, Nash equilibrium, correlated equilibrium, backward induction, subgame perfect equilibrium, repeated game, Bayesian games, multi-agent mechanism designs (auction, pricing, contract), sharing economy, and distributed systems. It also provides guidance to student projects on applying network economics to research new problems in communication networks.



Yonghui Li is a Professor and Director of Wireless Engineering Laboratory, in School of Electrical and Information Engineering, the University of Sydney. He is the recipient of the prestigious Australian Research Council (ARC) Queen Elizabeth II Fellowship in 2008 and ARC Future Fellowship in 2012. His current research interests are in the area of wireless communications, Internet of Things, Wireless networks, 5G and wireless AI. He participated in \$500million Australian national Smart Grid Smart City project, the world first large-scale demonstration project. He has published more than 300 papers in IEEE journals and conferences. Several of his journal papers have been included in ESI highly cited papers. According to google scholar, his research works have been cited more than 12000 times. He is now an editor for IEEE Transactions on Communications, and IEEE Transactions on Vehicular Technology. He also served as a guest editor for several special issues of IEEE journals, such as IEEE JSAC special issue on Millimeter Wave Communications, IEEE Communications Magazine on Wireless AI, IEEE IoT Journal, IEEE Transactions on Industrial Informatics, IEEE Access. He received several best paper awards.

Title: 5G IoT Networks

Connected smart objects, platforms and environments have been identified as the next big technology development, enabling significant society changes and economic growth. The entire

physical world will be connected to the Internet, referred to as Internet of Things (IoT). The intelligent IoT network for automatic interaction and processing between objects and environments will become an inherent part of areas such as electricity, transportation, industrial control, utilities management, healthcare, water resources management and mining. Wireless networks are one of the key enabling technologies of the IoT. They are likely to be universally used for last mile connectivity due to their flexibility, scalability and cost effectiveness. The attributes and traffic models of IoT networks are essentially different from those of conventional communication systems, which are designed to transmit voice, data and multimedia. IoT access networks face many unique challenges that cannot be addressed by existing network protocols; these include support for a truly massive number of devices, the transmission of huge volumes of data burst in large-scale networks over limited bandwidth, and the ability to accommodate diverse traffic patterns and quality of service (QoS) requirements. Some IoT applications have much stringent latency and reliability requirements which cannot be accommodated by existing wireless networks. Addressing these challenges requires the development of new wireless access technologies, underlying network protocols, signal processing techniques and security protocols. In this talk, I will present the IoT network development, architecture, key challenges, requirements, potential solutions and recent research progress in this area, particularly in 5G massive connectivity and uRLLC.



Hsiao-Hwa Chen, Hsiao-Hwa Chen is currently a Distinguished Professor in the Department of Engineering Science, Taiwan Cheng Kung University. He obtained his BSc and MSc degrees from Zhejiang University, China, and a PhD degree from the University of Oulu, Finland, in 1982, 1985, and 1991, respectively. He authored or co-authored over 400 technical papers in major international journals

and conferences, six books, and more than ten book chapters in the areas of wireless communications. He served as the general chair, TPC chair, and symposium chair for many international conferences. He is the founding Editor-in-Chief of Wiley's Security and Communication Networks Journal. He is the recipient of the best paper award in IEEE WCNC 2008 and the recipient of IEEE 2016 Jack Neubauer Memorial Award. He served as the Editor-in-Chief for IEEE Wireless Communications from 2012 to 2015. He was an elected Member-at-Large of IEEE ComSoc from 2015 to 2016. He is serving as TPC Chair for IEEE Globecom 2019. He is a Fellow of IEEE, IET, and BCS.

Title: To be orthogonal or not to be: CDMA technology revisited for B5G wireless

B5G wireless communications face a lot of serious challenges. Massive connectivity plus severe shortage of radio spectrum pose a big issue to implement wireless-everything, and the ultra-fast data rate requirement makes energy per bit extremely low to meet the minimum SNR requirement. On the other hand, traditional OMA will no longer be capable to ensure a very short latency in B5G systems, which is critical to time-sensitive wireless services, such as autonomous driving, remote surgery, etc. CDMA as an important NOMA scheme will play its vital role in B5G systems in a context of next-generation CDMA technologies. In this talk, we will revisit our research works on the NG-CDMA and will showcase what we have done so far as an effort to develop the NG-CDMA technologies, which include innovative signature code design based on REAL approach, multi-dimensional CDMA, space time spread coding (STSC) for MIMO applications, column-wise complementary coded CDMA for channel frequency/time selectivity mitigation, development of general code-domain NOMA schemes, single code cyclic shift (SCCS) multiple access, frequency diversity assisted CC-CDMA systems, etc.



Yan Zhang is currently a Full Professor with the Department of Informatics, University of Oslo, Norway. He received the Ph.D. degree from the School of Electrical and Electronics Engineering, Nanyang Technological University, Singapore. He received M.S. and B.S. from Beihang University and Nanjing University of Post and Telecommunications, respectively. His research interests include next-generation wireless networks leading to 6G, green and secure cyber-physical systems (e.g., smart grid and transport). Dr. Zhang is an Editor (or Area Editor, Senior Editor, Associate Editor) for several IEEE transactions/magazine, including IEEE Network Magazine, IEEE Transactions on Green Communications and Networking, IEEE Transactions on Network Science and Engineering, IEEE Transactions on Vehicular Technology, IEEE Transactions on Industrial Informatics, IEEE Communications Survey and Tutorials, IEEE Internet of Things Journal, IEEE Systems Journal, IEEE Vehicular Technology Magazine, and IEEE Blockchain Technical Briefs. He is a symposium/track chair in a number of conferences, including IEEE ICC 2021, IEEE SmartGridComm 2021, and IEEE Globecom 2017. He is the Chair of IEEE Communications Society Technical Committee on Green Communications and Computing (TCGCC). He is an IEEE Communications Society Distinguished Lecturer and IEEE Vehicular Technology Society Distinguished Speaker. He was an IEEE Vehicular Technology Society Distinguished Lecturer during 2016-2020. Since 2018, Prof. Zhang was a recipient of the global "Highly Cited Researcher" Award (Web of Science top 1% most cited worldwide). He is Fellow of IEEE, Fellow of IET, elected member of Academia Europaea (MAE), elected member of the Royal

Norwegian Society of Sciences and Letters (DKNVS), and elected member of Norwegian Academy of Technological Sciences (NTVA).

Title: Digital Twin for 6G and IoT

In this talk, we mainly introduce our recent studies on Digital Twin (DT) for 6G, Edge Computing, air-ground networks, and IoT. We will first introduce the main concepts and challenges related to Digital Twin and we will provide perspectives on why and how DT can be adapted for 6G. Then, we present a novel scenario DITEN (Digital Twin Edge Networks) and the research challenges related to offloading, edge association and resource optimization. Throughout the talk, we join DT and machine learning to add intelligence and present our ideas on utilizing machine learning (e.g., deep reinforcement learning, federated learning) for low-latency, privacy-preservation, and energy-efficiency in 6G networks. Finally, we point out several promising research directions when DT joins Intelligent Reflecting Surface (IRS), blockchain, and deep learning.



Shiyong Cui, obtained his PhD in computer science in 2014 from the Siegen University, Germany. Currently he is a senior scientist in machine learning and autonomous driving at Continental Inc. The current focus is the development of machine learning/deep learning for multi-sensor data fusion and comprehensive environment modeling and perception for autonomous driving. He has been leading the development of commercial systems for major OEM, such as BMW, Honda, Toyota, etc. Previously he had been working with the German Aerospace Center(DLR) for eight years. It was mainly involving large scale machine learning for big satellite data archive and the development of airborne imaging platform. He is a reviewer of major IEEE scientific journals, e. g., IEEE TGRS, IEEE JSTARS, IEEE TIP, IEEE GRSL, IEEE TII, IEEE ACCESS, ISPRS. He has published more than 50 papers in scientific journals and conferences.

Title: Environmental perception and modeling in autonomous driving

This presentation will give an introduction to environmental perception and modeling in autonomous driving. To reach a status of fully autonomous driving, a comprehensive understanding of the surrounding environment of ego vehicle is highly demanded. To this end, various sensors, like camera, radar, lidar, ultrasonic, are deployed to acquire a comprehensive modeling of the environment, which comprise ego motion and localization, traffic participants, road model, static environment, traffic control information, etc. This presentation will focus on

these essential elements in environmental perception and modeling. Front technologies in machine/deep learning, computer vision, sensor fusion are involved in these topics and will be presented in this talk.



Jiaojiao Tian, is a senior researcher at German Aerospace Center (DLR). She received her Ph.D. degree in mathematics and computer science from Osnabrück University, Germany in 2013. Currently she leads the 3D Modelling group in Photogrammetry and Image Analysis Department, Remote Sensing Technology Institute (IMF). In 2011, she was a Guest Scientist with the Institute of Photogrammetry and Remote Sensing, ETH Zürich. She has published over 50 papers in international journals and conferences. Her research interests include change detection in 2D and 3D, digital surface model (DSM) generation, deep-learning based 3D point cloud semantic segmentation, object extraction, and classification.

Title: Change detection using remotely sensed data – from 2D to 3D

This presentation will focus on techniques and applications of remote sensing data based change detection in 2D and 3D. It will start with general considerations and techniques in 2D change detection. The traditional and deep learning based approaches and applications will be generally introduced. In the second part, important issues in 3D change detection methods will be addressed, including different types of 3D datasets and our recent work on fusion-based 3D change detection. In the end, opportunities and challenges in change detection are highlighted.

四、 课程内容介绍

3D视频信号压缩和通信国际前沿技术（16学时）

从3D视频的发展历史、应用场景出发，深入浅出地讲解3D视频的采集、编码、传输、渲染和质量评估中的技术关键点。通过本课程学习，引导学生了解3D视频的发展历史和3D视频的压缩标准，理解3D视频的压缩过程，掌握最基本的3D视频压缩方法。

五、 实践创新

无线电GPS信号源设计（32学时，理论4学时+实践28学时）

为电子信息类专业实践创新活动，以教师讲授为辅、学生动手实践为主，以培养学生的工程意识、创新意识为目标，以软硬件结合应用为基础，要求学生能够综合无线电知识，通信调制，编程思维等知识和工程技能。经过需求分析、资料查询、方案论证、设计调试、指标测试、分析总结等过程，完成基于软件无线电的GPS射频信号源的设计与实现。通过本课程的学习，学生可以掌握电子系统分析与设计的整个流程，形成系统级设计的理念，理解基本的无线电基本概念和技术架构，认识射频信号产生与发射的基本过程，并同步锻炼工科人才培养中必需发展的团队合作能力。最终，以独立设计和开发完成的的中小型应用电子系统作为实践成果。

具体学时分配与授课内容如下。

类别	学时	授课与实践内容
理论学时	2学时	GPS信号的应用，结构特点与实现方法
	2学时	软件无线电的概述、功能介绍和实现方法
实践学时	4学时	硬件端设备基本使用方法，Gnuradio软件介绍
	8学时	GPS信号源设计，仿真验证功能实现
	8学时	硬件端GPS射频信号生成
	8学时	硬件端GPS射频信号接收并有效解码

六、 其他活动安排

1.校内专业实验室参观与交流

本次国际暑期学校计划拟安排学员参观威海雷达站(线上)、哈工大博物馆、航天馆，电信学院雷达、通信、测控、遥感、微波相关科研和教学实验室，航天学院卫星研究所，机电学院机器人研究所。通过使学员近距离了解和感受哈工大的历史和传统，达到展示和宣传哈工大百年传承和世界一流工科强校的目的。

2.刘永坦院士先进事迹报告

由报告团骨干成员宗华老师主讲，力求向学员展现坦先生身上强烈的家国情怀和科学精神，以及作为哈工大“八百壮士”一员的刘永坦院士如何在哈工大这块沃土一步步施展才华和怀揣理想、开创中国的新体制雷达之路的成才历程。

3.户外活动

本次国际暑期学校计划安排学员参观中国甲午战争博物院陈列馆（威海，线上）、机器人集团、731遗址、北大荒纪念馆、东北抗联遗址遗迹，旨在突出龙江地方特色、突出实践教育，展现龙江人民艰苦奋斗的经历和不忘初心、开拓进取的精神。

七、 国际暑期学校申报信息

1.项目时间：2022年7月11日-7月24日

2.招生对象：2019、2020级优秀本科生

3.联系方式：刘老师，18645599889

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学院官网：<http://seie.hit.edu.cn/>



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