Tutorials

27th National Conference on Communications

Tutorial Schedule

T1: Streaming Codes **27th July 2021 (0800-1030 hours)**	**T2: Radar Signal Processing** **27th July 2021 (0800-1030 hours)**
Sponsor Video: Qualcomm (1030-1040 hours)	
T3: Model-based deep learning for wireless communications **27th July 2021 (1040-1310 hours)**	**T4: Blockchain Technology: An Enabler for Trust** **27th July 2021 (1040-1310 hours)**
Lunch Break (1310-1340 hours)	
T5: Aerial and Spaceborne Communications: The Journey from 5G to 6G **27th July 2021 (1340-1610 hours)**	**T6: Computing the Discrete Fourier Transform: From Classical FFTs to Structured FFTs** **27th July 2021 (1340-1610 hours)**
Sponsor Video: Saankhya Labs (1610-1620 hours)	
T7: Reconfigurable Intelligent Surfaces: From Electromagnetics to Communications **27th July 2021 (1620-1850 hours)**	**T8: Design Challenges in RF Power Amplifiers and Wireless Transmitters for 5G cellular Applications** **27th July 2021 (1620-1850 hours)**
Sponsor Video: Amazon, Texas Instruments, Keysight, Agmatel, Tejas Networks (1850-1900 hours)	
T9: Journey Towards Realizing the Full Potential of Advanced Air Mobility **27th July 2021 (1900-2015 hours)**	**T10: Data Analytics on Graphs: A New Paradigm in Machine Intelligence** **27th July 2021 (1900-2015 hours)**
T11: Blockchain protocols made efficient and scalable **30th July 2021 (0900-1015 hours)**	
T12: Reconfigurable Intelligent Surfaces and Holographic Massive MIMO: Vision, Fundamentals, and Key Open Problems **30th July 2021 (1020-1320 hours)**	

			
P. Vijay Kumar	**Nikhil Krishnan**	**Myna Vajha**	**Vinayak Ramkumar**

T1: Streaming Codes

by

P. Vijay Kumar, Nikhil Krishnan, Myna Vajha, Vinayak Ramkumar

Date & Time: 27th July 2021 (0800-1030 hours) Indian Standard Time

Abstract:

Streaming codes are relevant to the 5G objective of achieving ultra-reliable, low-latency communication (URLLC) and address the need for an error-correction scheme at the packet level, that ensures reliability in the face of dropped or lost packets.

The streaming codes discussed here may be viewed at the packet level as convolutional codes, but which are yet built out of scalar block codes by employing a diagonal-embedding technique.

A sliding-window channel model is adopted as a tractable approximation to the two-state Gilbert Elliott channel, which is capable of causing both random and burst erasures. Rate bounds and efficient code constructions will be presented, as well as an experimental demonstration that includes adaptation to a time-varying channel.

Bio:

P. Vijay Kumar received the B.Tech. and M.Tech. degrees from IIT Kharagpur and IIT Kanpur respectively, and the Ph.D. degree from USC. From 1983-2003, he was on the faculty of the EE-Systems Department at USC. Since 2003, he has been on the faculty of IISc, Bengaluru. His current research interests include codes for distributed storage, low-latency communication and low-correlation sequences. He is a recipient of the 1995 IEEE Information Theory (IT) Society's Prize-Paper award and the IEEE Data Storage Best Paper Award of 2011/2012. A pseudorandom sequence family designed in a 1996 paper co-authored by him formed the short scrambling code of the 3G WCDMA cellular standard. He was a plenary speaker at ISIT 2014 and is currently chair of the IT Society Conference Committee. He is a

Fellow of the INAE, IAS, and INSA Indian academies, a JCB National Fellow as well as a Fellow of IEEE.

Nikhil Krishnan received his B.Tech. (Electronics and Communication Engineering) degree from Amrita School of Engineering, Amritapuri Campus, Kerala in 2011. He received both his M.E. (Telecommunications) and Ph.D. (Electrical Communication Engineering) degrees from Indian Institute of Science (IISc), Bangalore, in 2013 and 2019, respectively. He was a postdoctoral fellow at the Department of Electrical & Computer Engineering, University of Toronto from November 2019 to June 2021. Since July 2021, he is working as an Assistant Professor in IIIT Bangalore. His research interests include coded computation, streaming codes and distributed storage.

Myna Vajha received Bachelors degree in ECE from IIT Kharagpur, in 2011, and Masters from EE Department, University of Southern California (USC), in 2013. She has recently obtained her a Ph.D. from ECE Department, Indian Institute of Science. She currently works at Qualcomm Research, Bangalore. Her research interests include coding theory and information theory, with applications to distributed storage systems, low latency streaming and privacy.

Vinayak Ramkumar received his B. Tech. in Electronics and Communication Engineering from National Institute of technology, Calicut, in 2015 and M. Sc. (Engg) from the Department of Electrical Communication Engineering, Indian Institute of Science (IISc), Bangalore, in 2017. He is currently a Ph.D. student at the Department of Electrical Communication Engineering, IISc. His research interests include streaming codes, codes for distributed storage and coded PIR.

Shobha Sundar Ram

T2: Radar Signal Processing

by

Shobha Sundar Ram

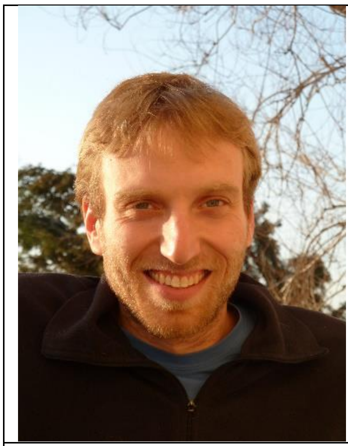
Date & Time: 27th July 2021 (0800-1030 hours) Indian Standard Time

Abstract:

The tutorial is intended for bachelors, masters and doctoral students who may be interested in pursuing research in radar signal processing specifically in context to automotive radars. The tutorial will be divided into five sections. In the first section, an introduction to radar systems will be presented including concepts pertaining to the transmitter, receiver, targets, clutter and noise encountered in automotive radar scenarios. This will be followed by the second section, where the radar signal models for simple and extended targets will be discussed in detail. The third part of the tutorial will delve into the specifics of radar waveforms and the corresponding signal processing algorithms – matched filtering for range estimation, Doppler processing and Fourier based azimuth and elevation estimation. The following part of the tutorial will cover the fundamentals of radar detection with a focus on the ubiquitous Neyman-Pearson detection rule, the likelihood ratio test and the constant false alarm rate detection. In the final section, advanced concepts related to the use of modern machine learning and deep learning algorithms on automotive radar data for varied applications such as pedestrian detection, object classification and parking assistance will be presented. Throughout the tutorial, MATLAB based software demos will be presented to supplement the theoretical concepts.

Bio:

Shobha Sundar Ram is Associate Professor, Dept. of Electronics and Communications Engineering, Indraprastha Institute of Information Technology, Delhi. She did her Bachelor of Technology in ECE from the University of Madras, India in 2004 and then her Master of Science and Ph.D. in electrical engineering from the University of Texas at Austin, USA in 2006 and 2009 respectively. Before joining IIIT Delhi, she worked as a research and development electrical engineer at Baker Hughes Inc. USA. She is engaged in research and education principally in the areas of radar signal processing and electromagnetic sensor design and modeling. She is a Senior Member of IEEE, an active member of the Aerospace and Electronics Systems Society and an Associate Editor for the IEEE Transactions on Aerospace and Electronics Systems.



Nir Shlezinger

T3: Model-based deep learning for wireless communications

by

Nir Shlezinger

Date & Time: 27th July 2021 (1040-1310 hours) Indian Standard Time

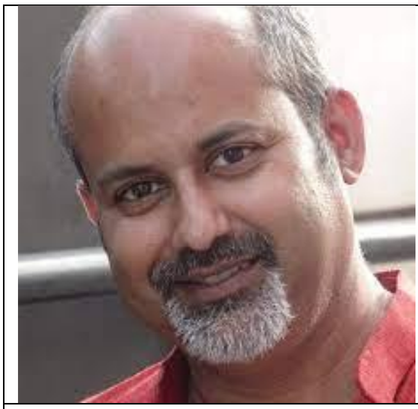
Abstract:

Recent years have witnessed a dramatically growing interest in machine learning (ML) methods. These data-driven trainable structures have demonstrated an unprecedented empirical success in various applications, including computer vision and speech processing. The benefits of ML-driven techniques over traditional model-based approaches are twofold: First, ML methods are independent of the underlying stochastic model, and thus can operate efficiently in scenarios where this model is unknown, or its parameters cannot be accurately estimated; Second, when the underlying model is extremely complex, ML algorithms have demonstrated the ability to extract and disentangle the meaningful semantic information from the observed data. Nonetheless, not every problem can and should be solved using deep neural networks (DNNs). In fact, in scenarios for which model-based algorithms exist and are computationally feasible, these analytical methods are typically preferable over ML schemes due to their theoretical performance guarantees and possible proven optimality. A notable application area where model-based schemes are typically preferable, and whose characteristics are fundamentally different from conventional deep learning applications, is wireless communications. In this talk, I will present methods for combining DNNs with traditional model-based algorithms. We will show hybrid model-based/data-driven implementations which arise from classical methods in wireless communications, and demonstrate how fundamental

classic techniques can be implemented without knowledge of the underlying statistical model, while achieving improved robustness to uncertainty.

Bio:

Nir Shlezinger is an assistant professor in the School of Electrical and Computer Engineering in Ben-Gurion University, Israel. He received his B.Sc., M.Sc., and Ph.D. degrees in 2011, 2013, and 2017, respectively, from Ben-Gurion University, Israel, all in electrical and computer engineering. From 2017 to 2019 he was a postdoctoral researcher in the Technion, and from 2019 to 2020 he was a postdoctoral researcher in Weizmann Institute of Science, where he was awarded the FGS prize for outstanding achievements in postdoctoral research. His research interests lie in the intersection of signal processing, machine learning, communications, and information theory.



Sandeep K. Shukla

T4: Blockchain Technology: An Enabler for Trust

by

Sandeep K. Shukla

Date & Time: 27th July 2021 (1040-1310 hours) Indian Standard Time

Abstract:

Since its introduction in 2008 in the form of the Bitcoin blockchain, blockchain technology has been known more as a cryptocurrency enabler than its actual foundations as a platform for enabling trust. The idea of cryptocurrency blockchain was anonymous transactions, mining of currency in the digital platform itself, and to provide trust through transparency of a public, distributed and replicated ledger of all transactions which are cryptographically signed. The use of cryptographic signature, and use of has functions to link blocks of transactions provided the defense against forgery, and attack on integrity of the digital records of transaction. The permanence of the records is ensured by crowd sourcing computational power of a large number of participants making it almost impossible to change the history of transactions unless 51% of computational power is procured by a single participant or a group of colluding participants.

Blockchain 2.0 ushered in the concept of smart contracts – thereby enabling more automation of digital transactions, and also the ability to tokenize non-currency assets. However, with the programmability in a Turing complete language, came the possibility of bugs in smart contracts and thereby security vulnerabilities. A number of cyber attacks followed and in several cases, insider attack on crypto-exchanges led to huge losses to account holders. On top of all these, the pseudo-anonymity offered by the crypto-currency blockchains made it a favorite medium of transaction for criminals – starting from the Silk Road to today's ransomware gangs. We also find malicious usage

of the cryptocurrency platforms for illegal gambling, phishing, money laundering and various other crimes.

While all these led to suspicion about cryptocurrency among regulators and law enforcement, technologists discovered that the trust offered by blockchain technology itself has very many transformative potential. With the advent of Blockchain 3.0 with the introduction of Hyperledger and similar distributed ledger technology platforms, we started seeing use of blockchain platforms for supply chain provenance, renewable energy billing, land registry systems, voting systems, agri-market transactions, and more recently NFTs.

In this tutorial, we first introduce the concept of blockchain and its underlying technologies including public key crypto systems, hashing, distributed computing,. Fault-tolerant consensus, byzantine algorithms, public-vs private ledgers, permissioned vs permission-less ledgers etc. We then gently introduce why non-currency usage of blockchain can enhance trust in data integrity in many applications which are today implemented in centralized system – leading to trust deficit among the users of the systems – such as land record registration system, supply chain integrity, DND system by mobile operators, or even DNS system.

We will expose the audience to various applications of permissioned private blockchains in creating trust mechanism in such applications. Finally, we will touch on certain security issues for these applications.

Bio:

Sandeep K. Shukla is a program director of C3i Hub, a joint coordinator for C3i Center, a joint coordinator for the national blockchain project, as well as a professor of Computer Science at IIT Kanpur. He is an ACM distinguished scientist and a Fellow of IEEE.

Giovanni Geraci

T5: Aerial and Spaceborne Communications:

The Journey from 5G to 6G

by

Giovanni Geraci

Date & Time: 27th July 2021 (1340-1610 hours) Indian Standard Time

Abstract:

Barely seen in action movies until a decade ago, the progressive blending of UAVs into our daily lives will greatly impact labor and leisure activities alike. Most stakeholders regard reliable connectivity as a must-have for the UAV ecosystem to thrive, and the wireless research community has been rolling up its sleeves to drive a native and long-lasting support for UAVs in 5G and beyond. Moving up, the recent introduction of more affordable insertions into the low orbit is luring new players to the space race, making a marriage between the satellite and cellular industries more likely than ever. In this talk, we will navigate from 5G to 6G use cases, requirements, and enablers involving aerial and spaceborne communications, also acting as a catalyst for much-needed new research.

Bio:

Giovanni Geraci is an Assistant Professor at University Pompeu Fabra in Barcelona and the coordinator of the Telecommunications Engineering program. He was previously a Research Scientist with Nokia Bell Labs and holds a Ph.D. from the UNSW Sydney. He serves as a Distinguished Lecturer of the IEEE ComSoc & VTS and as an Editor for the IEEE Transactions on Wireless Communications and IEEE Communications Letters. Giovanni is a co-Editor of the book "UAV Communications for 5G and Beyond" by Wiley—IEEE Press and he received the IEEE ComSoc Outstanding Young Researcher Award for Europe, Middle East, and Africa.

T6: Computing the Discrete Fourier Transform: From Classical FFTs to Structured FFTs

by

Aditya Siripuram

Date & Time: 27th July 2021 (1340-1610 hours) Indian Standard Time

Abstract:

The importance and ubiquity of the Discrete Fourier Transform (DFT) cannot be overstated. Algorithms to compute the DFT (collectively referred to as the Fast Fourier Transform or FFT) have a long history, starting probably in the 19th century itself. The goal of this tutorial is to give a brief overview of the development of FFT. The tutorial will be in three parts. In the first part, we review the classical approach to the FFT, including the Cooley-Tukey algorithm, Prime-factor algorithm and Rader's FFT.

With the ever-increasing data sizes that we operate with, there is a need to reduce the complexity beyond what a classical FFT provides. In addition, even though data sizes are increasing, they also have underlying structure, thus providing algorithm designers with opportunities to exploit this structure for faster computation. Recent research on the FFT operates at the intersection of these two notions: the focus is on speeding up the DFT computation for a structured (or restrictive) class of signals. The most popular structural model is spectral sparsity: where we assume the signal has very few non-zero frequency coefficients. In the second part of the tutorial, we discuss the key ideas behind sparse FFT algorithms. Our coverage here will be more illustrative than exhaustive. While many of these sparse FFT algorithms are randomized, we also discuss some deterministic algorithms for sparse FFT.

In the final portion of the talk, we attempt to go beyond sparsity. In particular, we may try to find the DFT when more structural information on the spectral support is available. We briefly discuss some work on finding the DFT of

block-sparse signals, and conclude with some of our recent work that tries to make some progress towards structured FFTs.

Bio:

Aditya Siripuram received his B.Tech and M.Tech degrees in Electrical Engineering from the Indian Institute of Technology, Bombay in 2009. He completed PhD from Stanford University in 2017 and was a recipient of the Stanford Graduate Fellowship. He is currently a faculty member in the Department of Electrical Engineering at IIT Hyderabad. He is interested broadly in the theory of signal processing and machine learning; particularly in sampling, Fourier analysis and graph signal processing.


Marco Di Renzo

T7: Reconfigurable Intelligent Surfaces:

From Electromagnetics to Communications

by

Marco Di Renzo

Date & Time: 27th July 2021 (1620-1850 hours) Indian Standard Time

Abstract:

A reconfigurable intelligent surface (RIS) is an emerging technology that enables the control of the electromagnetic waves. An RIS is a thin sheet of electromagnetic material, which is made of many nearly passive scattering elements that are controlled through low cost and low power electronic circuits. By appropriately configuring the electronic circuits, different wave transformations can be realized. Recent research works have shown that RISs whose geometric size is sufficiently large can outperform other technologies, e.g., relays, at a reduced hardware and signal processing complexity, and can enhance the reliability of wireless links by reducing the fading severity. In addition, the achievable performance of RIS-assisted systems has been proved to be robust to various hardware impairments, e.g., the phase noise, which may further reduce the implementation cost. To quantify the performance gains offered by RISs in wireless networks, realistic communication models need to be employed. In this talk, we offer a critical appraisal of the communication models currently employed for analyzing the ultimate performance limits and for optimizing RIS-assisted wireless networks. Furthermore, we introduce a new tractable, electromagnetic-compliant, and circuit-based communication model for RIS-assisted transmission and discuss its applications to the modeling and optimization of wireless systems.

Bio:

Marco Di Renzo (Fellow, IEEE) received the Laurea (cum laude) and Ph.D. degrees in electrical engineering from the University of L'Aquila, Italy, in 2003 and 2007, respectively, and the Habilitation à Diriger des Recherches (Doctor of Science) degree from University Paris-Sud (now Paris-Saclay University), France, in 2013. Since 2010, he has been with the French National Center for Scientific Research (CNRS), where he is a CNRS Research Director (CNRS Professor) with the Laboratory of Signals and Systems (L2S) of Paris-Saclay University – CNRS and CentraleSupelec, Paris, France. In Paris-Saclay University, he serves as the Coordinator of the Communications and Networks Research Area of the Laboratory of Excellence DigiCosme, and as a Member of the Admission and Evaluation Committee of the Ph.D. School on Information and Communication Technologies. He is the Editor-in-Chief of IEEE Communications Letters and a Distinguished Speaker of the IEEE Vehicular Technology Society. In 2017-2020, he was a Distinguished Lecturer of the IEEE Vehicular Technology Society and IEEE Communications Society. He has received several research distinctions, which include the SEE-IEEE Alain Glavieux Award, the IEEE Jack Neubauer Memorial Best Systems Paper Award, the Royal Academy of Engineering Distinguished Visiting Fellowship, the Nokia Foundation Visiting Professorship, the Fulbright Fellowship, and the 2021 EURASIP Journal on Wireless Communications and Networking Best Paper Award. He is a Fellow of the UK Institution of Engineering and Technology (IET), an Ordinary Member of the European Academy of Sciences and Arts (EASA), and an Ordinary Member of the Academia Europaea (AE).

Karun Rawat

T8: Design Challenges in RF Power Amplifiers and Wireless Transmitters for 5G cellular Applications

by

Karun Rawat

Date & Time: 27th July 2021 (1620-1850 hours) Indian Standard Time

Abstract:

This talk discusses various aspects of wireless transmitters and the radio frequency (RF) power amplifier (PA) design for 5G cellular applications.

The wireless transmitters and RF PA design require several new considerations to be useful for New Generation Radio Access Network (NG-RAN) in 5 G applications. The wireless transmitter design must strive for spectrum and energy efficiency to provide linear power amplification of high crest factor signals with the least consumption of power. Maintaining good linearity can meet the spectrum efficiency requirements but requires special RF power amplification schemes to guarantee low power consumption. For example, linearization schemes such as digital predistortion require load modulation based power amplifier (PA) (Doherty PA or Chireix Outphasing PA etc.) for handling high crest factor signals with good power efficiency. Alternatively, delta-sigma modulation-based transmitters can exhibit good performance in terms of error vector magnitude (EVM), where high-efficiency switch-mode PAs can be used along with RF filters for suppressing out-of-band quantization noise.

Apart from the various transmitter and PA architectures, it is essential to enhance the bandwidth of the design to co-op with wideband modulated signals anticipated in 5G communication. In general, switch-mode PAs are a popular choice for systems where high efficiency is required. However, these PAs are inherently narrow bands. Moreover, it is difficult to obtain a feasible

design space that led to realizable loads resulting in high-efficiency operation over a wide bandwidth. In case load-pull is used, it is difficult to find this appropriate set of loads that can be realizable with a matching network. A continuum of class such as Class B/J and continuous Class F, Class E PAs provide many useful solutions which can be represented by a drain voltage waveform set at each frequency of operation over the band. In such a case, high efficiency is maintained over a wide bandwidth. This waveform engineering is performed by selecting an appropriate set of fundamental and harmonic loads at the intrinsic current generator plane of the transistor.

The talk will discuss the design aspects of wireless transmitters and RF PA design while discussing various challenges in transmitter architecture, device selection, circuit design, modeling, etc.

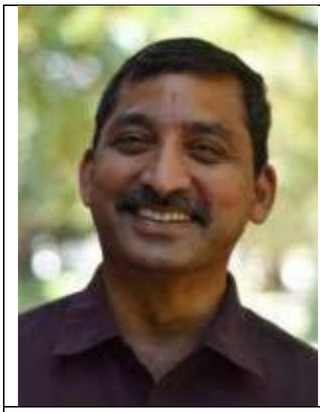
Bio:

Karun Rawat has received his PhD. degree in electrical engineering from University of Calgary, Canada in 2012, where he worked as a student research assistant and later Post-doctoral research fellow under the research grant of iCORE and CRC chair, Alberta, Canada. He is currently Associate Professor & Outstanding young faculty in the department of Electronics and Communication at Indian Institute of Technology (I.I.T) Roorkee, India. Prior to this, he was Assistant Professor in I.I.T Delhi from 2013-2014 and scientist in the Indian Space Research Organization, from 2003–2007.

Dr. Rawat is Senior member of IEEE since 2012 and member of IEEE MTT Microwave High-Power Techniques Committee (MTT-12). His current research interests are in the areas of RF power amplifier and transceiver design, digital transmitters, nonlinear device modeling, RF linear and nonlinear measurements and characterization, RF CMOS and GaN MMIC designs. His research has resulted in more than 70 publications in journals and conferences, three patents (applied), two state of art books and a book chapter. He has given several technical talks in reputed IEEE conferences including workshops in power amplifiers at IEEE ARFTG 2016 (USA), IEEE APMC 2015 (China), IEEE IMaRC 2014-2015 (India), IEEE IMS 2018 (USA), IEEE EuMW 2018 (Spain) etc. He has been organizer of NVNA forum in IEEE IMS (USA), 2018 and 2019. He has several invited papers in reputed conferences such as IEEE European Microwave Conference in Germany, International Symposium on Circuit and System, USA, IEEE International Wireless Symposium, China etc.

Dr. Rawat has received several awards including young scientist from national academy of science India and Scopus, outstanding young faculty award by I.I.T-Roorkee and research production award for three consecutive years from University of Calgary. He also received best design prize in 3rd Annual Smart Radio Challenge in 2010.

Dr. Rawat has also been associated with advisory committee of several RF industries, national laboratories and universities for brainstorming and research initiatives. He is founding director and chairman of start-up "Linearized Amplifier Technologies and Services Private Limited" which develops indigenous linearized power amplifiers for telecom and defense applications.



Kamesh Namuduri

T9: Journey Towards Realizing the Full Potential of Advanced Air Mobility

by

Kamesh Namuduri

Date & Time: 27th July 2021 (1900-2015 hours) Indian Standard Time

Abstract:

The flying taxi business is projected to be a $5 Billion/year market. The industry is moving fast to realize this potential, with both established and startup companies competing as well as collaborating in this race. Airline companies including Boeing, Airbus, and Bell, are building the electrical Vertical Takeoff and Landing (eVTOL) aircrafts. Uber is collaborating with NASA to plan flying taxi service in Dallas by 2023. The big question that we need to address is "Are we ready for the big challenges that come with unmanned air transportation?" Just to give a perspective, think about self-driving cars. When, where, and how did we begin this journey and where are we now in this journey? What are you likely see first - A fully autonomous self-driving car in an urban area or an unmanned air taxi? In this presentation, we will discuss the critical aspects of unmanned air transportation: (1) Technology Readiness (2) Safety, Security, Regulations and Standardization Efforts and (3) Privacy, Ethics and Community Acceptance.

We begin this discussion with a review of the technology capability levels as discussed in NASA's UTM initiative, which gives an idea of where the industry is today from a technology perspective. The capabilities that the industry is expected to demonstrate in the UTM project, including Beyond Visual Line of Sight (BVLOS) communications, navigation in GPS-denied areas, and Remote Identification of aircraft with applications to law enforcement and public safety, wild fire management, and package deliveries, give an idea of where we are today in terms of technology readiness. In another related activity,

NASA has just began a grand challenge on Urban Air Mobility. This will also be discussed.

Second, safety should be an important goal of Unmanned Air Transportation. While the industry mastered safety of manned aviation, the path to mastery was slow and steady. Is Unmanned Air Transportation as safe as manned aviation? Are there regulations to guarantee the desired levels of human safety? What needs to be done now to make unmanned aviation as safe as it needs to be? How are regulatory and standards organizations working towards achieving this goal?

The third topic is community acceptance. Community engagement at local and regional levels is also critical for the success of unmanned air transportation. How do we engage communities in this fast-paced evolution of unmanned air transportation? Community engagement includes education and training geared towards future workforce as well as town-hall meetings to inform the communities about changes that are coming to their communities and help prepare them for these changes. Their participation and inputs are very critical to the success of new endeavors that cities and municipalities are going to engage in.

We wrap up this discussion with a summary of our expectations from the industry perspective. Safety and trust can only be achieved through the whole community approach. Government-public-private partnership is the key to the success of safe and trusted unmanned transportation.

Bio:

Kamesh Namuduri is a Professor of Electrical Engineering and the director of Autonomous Systems Laboratory at the University of North Texas (UNT). He received his B.S. degree in Electronics and Communication Engineering from Osmania University, India, in 1984, M.S. degree in Computer Science from University of Hyderabad in 1986, and Ph.D. degree in Computer Science and Engineering from University of South Florida in 1992. Over the past eleven years, his research is focused on aerial networking and communications. He is serving as the chair for two Standards Working Groups (IEEE 1920.1: Aerial Communications and Networking and IEEE P1920.2: Vehicle-to-Vehicle Communications for Unmanned Aircraft Systems).

He is serving as the Chair for the IEEE Vehicular Technology Society's Ad Hoc Committee on Drones, as the Vice Chair for "Aerial Communications", an emerging technology initiative of the IEEE Communication Society, and as an Expert Adviser on UAVs, COM/Access Core Standards Committee, IEEE Communications Society. He is a co-editor for the book titled "UAV Networks and Communications" published by the Cambridge University Press in 2017. He is leading the Smart and Connected Community project on "Deployable Communication Systems" in collaboration with the government, public, and private organizations. This living laboratory project was demonstrated thrice during the Global City Teams Challenge hosted jointly by the National Institute of Standards and Technology and US Ignite in 2015, 2016, 2017, and 2018. He contributed to the development of research agenda, requirements and blueprints highly deployable communications systems led by the National Institute of Standards and Technology and National Public Safety Telecommunications Council. In 2020, Namuduri successfully led a team of seven organizations including three universities and four start-up companies engaging as an airspace partner in the Advanced Air Mobility, National Campaign Developmental Test project directed by NASA. He is working on a new book titled “Unmannered Air Transportation: Bringing Principles to Practice”, which is expected to be published by the Oxford University Press in 2022.

Danilo P. Mandic

T10: Data Analytics on Graphs:

A New Paradigm in Machine Intelligence

by

Danilo P. Mandic

Date & Time: 27th July 2021 (1900-2015 hours) Indian Standard Time

Abstract:

The current availability of powerful computers and huge data sets is creating new opportunities in computational mathematics to bring together concepts and tools from graph theory, machine learning and signal processing, creating Data Analytics on Graphs. In discrete mathematics, a graph is merely a collection of points (nodes) and lines connecting some or all of them. The power of such graphs lies in the fact that the nodes can represent entities as diverse as the users of social networks or financial market data, and that these can be transformed into signals which can be analyzed using data analytics tools. In this talk, we aim to provide a comprehensive introduction to generating advanced data analytics on graphs that allows us to move beyond the standard regular sampling in time and space to facilitate modelling in many important areas, including communication networks, computer science, linguistics, social sciences, biology, physics, chemistry, transport, town planning, financial systems, personal health and many others. Graph topologies will be revisited from a modern data analytics point of view, and we will then proceed to establish a taxonomy of graph networks. With this as a basis, we show how the spectral analysis of graphs leads to even the most challenging machine learning tasks, such as clustering, being performed in an intuitive and physically meaningful way. Unique aspects of graph data analytics will be outlined, such as their benefits for processing data acquired on irregular domains, their ability to finely-tune statistical learning procedures through local information processing, the concepts of

random signals on graphs and graph shifts, learning of graph topology from data observed on graphs, and confluence with deep neural networks, multi-way tensor networks and Big Data. Extensive examples are included to render the concepts more concrete and to facilitate a greater understanding of the underlying principles.

Bio:

Danilo P. Mandic is a Professor in signal processing with Imperial College London, UK, and has been working in the areas of adaptive signal processing and bioengineering. He is a Fellow of the IEEE and member of the Board of Governors of International Neural Networks Society (INNS). He has more than 300 publications in journals and conferences. Prof Mandic has received the 2019 Dennis Gabor Award by the International Neural Networks Society (for outstanding achievements in neural engineering), and the President Award for Excellence in Postgraduate Supervision at Imperial. He has authored research monographs "Recurrent Neural Networks for Prediction", Wiley 2001, "Complex Valued Nonlinear Adaptive Filters: Noncircularity, Widely Linear and Neural Models", Wiley 2009, and "Tensor Networks for Dimensionality Reduction and Large Scale Optimisation", Now Publishers, 2017. He is a 2018 recipient of the Best Paper Award in IEEE Signal Processing Magazine, for his paper "Tensor Decompositions for Signal Processing Applications". His work related to this talk is a series of three articles entitled "Data Analytics on Graphs", published in Foundations and Trends in Machine Learning", December 2020.

Sreeram Kannan

T11: Blockchain protocols made efficient and scalable

by

Sreeram Kannan

Date & Time: 30th July 2021 (0900-1015 hours) Indian Standard Time

Abstract:

Blockchain protocols such as Bitcoin have created the possibility of highly decentralized computing. However, existing blockchain protocols suffer from various problems: (1) energy inefficiency, (2) large confirmation latency (order of hours), and (3) lack of scalability (performance does not improve as more nodes are added to the system). In this mini-tutorial, we highlight how to solve these bottlenecks. We highlight the modeling of blockchain using tree-processes, which have both a randomized component as well as an adversarial component. We then use this abstraction to prove sharp phase-transitions of these processes yielding security theorems for the corresponding blockchain protocols. We then show how to use this abstraction to achieve (1) energy efficiency and (2) optimal confirmation latency. Finally, we show that (3) the scalability bottleneck of blockchains can be solved using an interesting connection to the classical result of Blackwell in dynamic game theory.

Bio:

Sreeram Kannan is an assistant professor at the University of Washington, Seattle, where he runs the information theory lab focussing on information theory and its applications in communication networks, machine learning and blockchain systems. He was a postdoctoral scholar at the University of California, Berkeley and a visiting postdoc at Stanford University between 2012-2014 before which he received his Ph.D. in Electrical and Computer Engineering and M.S. in Mathematics from the University of Illinois Urbana Champaign. He is a speaker in the 2021 National

Academy of Engineering Frontiers-of-Engineering US-Japan meeting, a recipient of the 2019 UW ECE Outstanding Teaching Award, 2018 Amazon Catalyst award, 2017 NSF Faculty Early CAREER award, the 2015 Washington Research Foundation Early Career Faculty award, and the Van Valkenburg outstanding graduate research award from UIUC.

Emil Björnson

T12: Reconfigurable Intelligent Surfaces and Holographic Massive MIMO: Vision, Fundamentals, and Key Open Problems

by

Emil Björnson

Date & Time: 30th July 2021 (1020-1320 hours) Indian Standard Time

Abstract:

Wireless connectivity is becoming as essential as electricity in our modern world. Although we would like to deliver wireless broadband services everywhere, the underlying physics makes it inherently complicated: the signal power vanishes very quickly with the propagation distance and is absorbed or scattered when interacting with objects in the way. Even when we have a “strong" signal, only one in a million parts of the signal energy is being received, thus, there is a huge room for improvements!

What if we could tune the propagation environment to our needs? This is the main goal of reconfigurable intelligent surfaces, which is an emerging concept for beyond-5G communications. The idea is to support the transmission from a source to a destination by deploying so-called metasurfaces that can reconfigure how incident signal waves are scattered and absorbed. These surfaces can be electronically configured to interact with the wireless signals as if they had different shapes. For example, it can be configured to behave as a parabolic reflector that is perfectly rotated to gather signal energy and re-radiate it as a beam focused on the receiver, and a few milliseconds later it can take a different virtual shape for another use case. This feature makes use of a new design dimension: we can not only optimize the transmitter and receiver but also control the channel properties. This can be a game-changer when communicating at mmWave and THz frequencies, where the traditional propagation conditions are particularly troublesome and can benefit from new

well-optimized propagation paths, and to manage interference in the spatial domain in dense deployments.

This might sound like science fiction but is theoretically possible. In this tutorial, you will first learn about the visions for the technology, which includes both passive surfaces known as “reconfigurable intelligent surfaces” and the active counterpart known as “Holographic Massive MIMO”. The core difference is whether the surface is co-located with transmitter/receiver or deployed in between. The fundamental models and behaviors will then be presented using signals-and-system theory, which leads to more familiar and intuitive derivations for communication engineers than previous examples based on electromagnetic theory. The tutorial will focus on the impact that these technologies have on delay spread, frequency selectivity, channel modeling, beamwidth, and near/far-field propagation properties. The system operation related to channel estimation and optimization of the surface-describing parameters will be covered for different use cases. The tutorial will culminate in the description of two major open problems that need to be tackled by the research community if this exciting new technology should have a role to play in 6G.

Bio:

Emil Björnson received the M.S. degree in Engineering Mathematics from Lund University, Sweden, in 2007. He received the Ph.D. degree in Telecommunications from KTH Royal Institute of Technology, Sweden, in 2011. From 2012 to mid-2014, he was a joint postdoc at the Alcatel-Lucent Chair on Flexible Radio, SUPELEC, France, and at KTH. He joined Linköping University, Sweden, in 2014 and is currently Associate Professor and Docent at the Division of Communication Systems. He teaches Master level courses on communications and is responsible for the Master programme in Communication Systems.