26th NATIONAL CONFERENCE ON COMMUNICATIONS (NCC) 2020

21-23 February 2020

Indian Institute of Technology Kharagpur

INDEX

From The Desk of General Co-Chairs

The National Conference on Communications (NCC) is arguably the most important national conference in India today in the area of Communications and Signal Processing. The NCC is organized and mentored by the Joint Telematics Group of the IITs and the IISc. In a span of little over two decades, the conference has acquired substantial recognition and is now well known in overseas as well. It is the proud privilege of IIT, Kharagpur to organize NCC-2020, which will be the 26th edition of the conference. On behalf of the entire organizing committee of NCC-2020, we welcome you to the conference and wish you a very enjoyable and meaningful stay at the IIT, Kharagpur.

Organizing NCC-2020 has been a challenging experience. First, fund raising became a serious issue, as getting sponsors was proving to be difficult. Then not being located in major cities has its own overhead. Also, the conference came too close to the silver jubilee edition organized last year by the IISc, Bangalore and thus, expectations became high. Lastly, to add to the woes, there has been a sudden outbreak of Novel Corona virus which made several of our foreign delegates cancel their visits that they had earlier committed to take up. Still, it is the sheer dedication and round the clock hard work of many of the committee members that have enabled us to tide over the crisis and bring NCC-2020 to a stage, where we can hope it to be at par with some of the top NCCs of recent past.

Like last year, this year too, we followed a double blind review policy. Also, we revived the process of poster presentation, as one objective of the NCC since its inception has been to provide as much chance to prospective authors to present their work as possible, without, of course, compromising on the quality. The conference has arranged a keynote lecture in the area of graph signal processing and machine learning by a world leader (to be delivered via Skype), three plenaries by eminent experts from overseas, four invited talks and six tutorials on cutting edge topics, of which two are from industries. Wherever possible, we have also tried to maintain a balance of coverage among communications, signal processing and networking.

Lastly, success of a conference ultimately lies in the hand of the participants, presenters and speakers. We believe your participation will add significant value to the conference and your interactions with others during the conference will be of great mutual benefit.

We invite you again to all the sessions of NCC-2020 and make the program thoroughly memorable.

Sincerely,

Mrityunjoy Chakraborty, Prabir K. Biswas and Raja Datta,
GENERAL CO-CHAIRS, NCC 2020

Welcome Message From TPC Co-Chairs, NCC 2020

On behalf of the Organizing Committee, we welcome you with great pleasure to the twenty-sixth National Conference on Communications (NCC 2020). The conference will be held at IIT Kharagpur campus during February 21-23, 2020.

The National Conference on Communications (NCC) is a flagship conference in India dedicated to advanced research in the areas of Communications, Signal Processing and Networks. Over the years, it has emerged as a forum for researchers from academia and industry from all areas of communications, signal processing and networks to exchange their ideas, foster collaboration, and cover new grounds. Thanks to the sincere efforts of the organizing committee and the dedication of the TPC and reviewers, we have a deep, diverse and excellent technical program that, apart from regular papers, includes one keynote presentation, three plenary lectures with two from academia and one from industry and four invited talks. The conference also features four tutorials from academia and two tutorials from industry along with hands-on demo.

In this year's conference, the TPC has done a wonderful job in attracting quality submissions from different regions within India and abroad. As a result, we have received an overwhelming response from both academia and industry. Overall, we have received a very good number of submissions totalling 215, and this allows us to work out a very high quality technical program for this conference. We are specially thankful to the effort and dedication of all TPC members of this conference for successfully carrying out all reviews in a timely manner. We are proud of a very strong team-work and spirit demonstrated within the TPC which is the key to the success of this conference.

In keeping with the quality of the conference over the years, each paper was carefully reviewed by three to four reviewers from the TPC. We congratulate all authors for the acceptance of their papers in the conference, and take the opportunity to thank all reviewers for their efforts in the success of the conference. A total of 78 oral presentation (with an acceptance rate of 36%) and 30 poster papers will be distributed across 16 oral presentation sessions and 2 poster sessions respectively

on Feb 22 and Feb 23, with a balanced distribution of topics between theory and application, as well as established and emerging areas.

We have continued the new NCC tradition to remove any systemic bias in the review process by making it double-blind. To our satisfaction, the process and its obligations were taken seriously and received broad support from authors and reviewers alike. We would like to take this opportunity to thank the authors for largely adhering to the requirements of the double-blind review process. We would also like to thank the reviewers for being vigilant in identifying the papers that violated this policy.

We encourage all participants to attend as many sessions as possible to make the most of the conference. We are confident that with the strong presence of academia and industry at the conference, new synergies will be found, forging greater innovations in the years to come.

We are very grateful to the Joint Telematics Group (JTG), the coordination body of NCC consisting of IITs and IISc, for the opportunity to host NCC 2020 at IIT Kharagpur. We are thankful to Prof. V. K. Tewari, Director of IIT Kharagpur for his continuous support and guidance. We are also grateful to the generous sponsorship of our industrial sponsors: Qualcomm (diamond sponsor), MathWorks (gold sponsor), Texas Instruments (silver sponsor), and Wipro (silver sponsor), as well as the technical co-sponsors: IEEE and IEEE Kharagpur section.

We sincerely hope that you will have a rewarding and enjoyable time at NCC 2020 in Kharagpur. We welcome each one of you again, and are grateful to each speaker, author, organizer, sponsor, volunteer and attendee for the success of NCC 2020.

PROGRAM AT A GLANCE OF NCC-2020
(SESSION WISE)

FEBRUARY 21, 2020 (FRIDAY)

Time slot	Department of Electronics and Electrical Communication Engineering (E & ECE)			
	Registration : 08:30 am – 09:30 am			
	NKN Studio (E & ECE dept.)	RCC Seminar room (E & ECE dept.)	A-102 (E & ECE dept.)	F-302 (E & ECE dept.)
09:30 am – 12:30 pm (With a coffee break of 15 mins at 11 am)	Tutorial 5 (T5)	Tutorial 4 (T4)	Tutorial 3 (T3)	
12:30 pm – 2:00 pm	**Lunch (E & ECE Dept.)**			
02:00 pm – 05:00 pm (With a coffee break of 15 mins at 03:30 pm)	Tutorial 2 (T2)	Tutorial 1 (T1)		Tutorial 6 (T6)
	Gargi Auditorium, Vikramshila Building			
06:00 pm – 06:30 pm	**Conference Inauguration**			
06:30 pm – 08:00 pm	**Keynote Speech**			
08:00 pm – 09:00 pm	**Dinner (Vikramshila Foyer)**			

T1 : ``OTFS: A New Modulation Scheme for 5G and Beyond" by Prof. A. Chockalingam, IISc., Bangalore

T2 : ``Signal Processing and Deep Learning on Graphs", by Dr. Sundeep Prabhakar Chepuri, IISc., Bangalore

T3 : ``Energy Harvesting and RF Energy Transfer aided Sustainable IoT Networks", by Prof. Swades De, IIT, Delhi.

T4 : ``SGD and Friends", by Prof. Ketan Rajawat, IIT, Kanpur

T5 : ``Integrated Transceiver Architectures for 5G Cellular Base Stations", by Dr. Jaiganesh Balakrishnan, Mr. Sriram Murali, Texas Instruments, Bangalore

T6 : ``Hands-On Tutorial: Design and prototype SDR systems with MATLAB and Simulink", by Mr. Tabrez Khan, Ms. Hitu Sharma, Mathworks India, Bangalore.

PROGRAM AT A GLANCE OF NCC-2020
(SESSION WISE)

FEBRUARY 22, 2020 (SATURDAY)

Time slot	Vikramshila and Takhashila Complex		
	Registration : 08:00 am – 09:00 am		
	Gargi Auditorium	Moitrayee Auditorium	NKN Studio GSSST
09:00 am – 10:00 am	Plenary #1	–	–
10:00 am – 11:30 am	CommSyst	Speech#1	Bio#1
11:30 am – 11:50 am	**Coffee break**		
11:50 am – 01:00 pm	ChEst	mmOpt	–
01:00 pm – 02:00 pm	**Lunch (Vikramshila Foyer)**		
02:00 pm – 03:00 pm	Plenary #2	–	–
03:00 pm – 04:30 pm	DL	SigProc	Invited #1
04:30 pm – 04:50 pm	**Coffee break**		
04:50 pm – 06:20 pm	WirelessNet#1	Invited #2	–
07:00 pm – 10:00 pm	**Banquet (Railway Officers' Club)**		

Poster Session 1 : 3:00 pm – 4:30 pm, Vikramshila Foyer

CommSyst: Communication systems, **Speech#1:** Speech Classification and understanding - I, **Bio#1:** Bio Signal Processing - I, **ChEst:** Channel Estmation, **mmOpt:** Millimeter-Wave and Optical Communication, **DL:** Deep Learning and Patern Recognition, **SigProc:** Signal Processing Theory and Methods, **WirelessNet#1:** Wireless networks-I.

PROGRAM AT A GLANCE OF NCC-2020
(SESSION WISE)

FEBRUARY 23, 2020 (SUNDAY)

Time slot	Vikramshila and Takhashila Complex		
	Registration : 08:00 am – 09:00 am		
	Gargi Auditorium	Moitrayee Auditorium	NKN Studio GSSST
09:00 am – 10:00 am	Plenary #3	–	–
10:00 am – 11:30 am	CommTh	Speech#2	Image
11:30 am – 11:50 am	**Coffee break**		
11:50 am – 1:20 pm	DNN	Bio#2	WirelessNet#2
01:20 pm – 2:20 pm	**Lunch (Vikramshila Foyer)**		
02:20 pm – 03:50 pm	MicrowaveComm	NetworkApp	

Poster Session 2 : 11:50 am – 1:20 pm, Vikramshila Foyer

CommTh: Communication Theory, **Speech#2:** Speech Classification and understanding - II, **Image:** Image and Video Processing, **DNN:** Deep Neural Networks, **Bio#2:** Bio signal Processing - II, **WirelessNet#2:** Wireless networks - II, **MicrowaveComm:** Microwave Communication, **NetworkApp:** Network Application.

SESSION CHAIRS

22nd February

	Session Name	Session Chair
1.	CommSyst	Srikrishna Bhashyam, IIT Madras
2.	Speech#1	K. S. Rao, IIT Kharagpur
3.	Bio#1	Saswat Chakrabarti, IIT Kharagpur
4.	ChEst	Neelesh B. Mehta, IISc., Bangalore
5.	mmOpt	Adrish Banerjee, IIT Kanpur
6.	DL	Jayanta Mukhopadhyay, IIT Kharagpur
7.	SigProc	Chandra Murthy, IISc, Bangalore
8.	WirelessNet#1	S. L. Maskara, (Ex.) IIT, Kharagpur
9.	Invited#1	Ranjan K. Mallik, IIT Delhi
10.	Invited#2	Bikash De, IIT Bombay

23rd February

	Session Name	Session Chair
1.	CommTh	B. Sundar Rajan, IISc, Bangalore
2.	Speech #2	T. S. Lamba, (Ex.) IIT, Kharagpur
3.	Image	P. K. Biswas, IIT, Kharagpur
4.	DNN	Anirban Mukherjee, IIT Kharagpur
5.	Bio#2	Sudipta Mukhopadhyay, IIT Kharagpur
6.	WirelessNet#2	S. L. Maskara, (Ex.) IIT, Kharagpur
7.	MicrowaveComm	Ajoy Chakraborty, (Ex.) IIT, Kharagpur
8.	NetworkApp	S. S. Pathak, IIT Kharagpur

Conference Key Note

Graph Signal Processing and Geometric Deep Learning

José M. F. Moura, Carnegie Mellon University
moura@ece.cmu.edu, www.ece.cmu.edu/~moura

February 21 | 06:30 pm – 08:00 pm
Gargi Auditorium

Abstract:

There are many different characterizations of the 4th industrial revolution we are living in. I will focus on the analytics of data. Social networks, corporations, markets, health care providers, service industries, sensors instrumenting infrastructures, not to speak of each-and-every one of us with their cell phones and other personal devices are prolific sources of tremendous amounts of data. These data goes beyond time series, images, or video (signals indexed by time ticks and pixels) to be data now indexed by social agents, genes, customers, or some other enumeration suggested by the application. The last decade has seen a new foundational approach to processing data that accounts for the data underlying geometric structure – Graph Signal Processing (GSP). This talk will provide some motivating examples, then review the basics of GSP, and finally discuss geometric deep learning that combines deep learning and GSP.

Speaker Biography:

José M. F. Moura, www.ece.cmu.edu/~moura, is the Philip L. and Marsha Dowd University Professor at CMU, with interests in signal processing and data science. He holds a D. Sc. in Electrical Engineering and Computer Science, M.Sc., and EE degrees all from MIT and an EE degree from Instituto Superior Técnico (IST, Portugal). He was a visiting Professor at the Center for Urban Science and Progress (CUSP) and at

Conference Key Note

NYU in 2013-2014, a visiting Professor at MIT (2006-2007, 1999-2000, and 1984-86), a visiting scholar at USC (Summers of 79-81), and was on the faculty of IST (Portugal). A detector in two of his patents with Alek Kavcic is found in over 60% of the disk drives of all computers sold worldwide in the last 15 years (4 billion and counting)–leading to a US $750 Million settlement between CMU and Marvell. He was the 2019 IEEE President and CEO. He was the Editor-in-Chief for the Transactions on SP. Moura received the IEEE Signal Processing Society Technical Achievement Award and Society Award. He is Fellow of the IEEE, AAAS, and the US National Academy of Inventors, holds an honorary doctorate from the University of Strathclyde, is a corresponding member of the Academy of Sciences of Portugal, and member of the US National Academy of Engineering. He received the Great Cross of the Order of The Infante D. Henrique bestowed to him by the President of the Republic of Portugal.

Conference Plenaries (plenary #1)

Real-time Internet of Things Challenges: Convergence of Data, Communications and Learning

Prof. Marimuthu Palaniswami, University of Melbourne

February 22 | 9:00 am – 10:00 am
Gargi Auditorium

Abstract:

Internet of Things has evolved from a simple network of networks to a massive web of things. Currently there are about 30 billion Internet of Things (IoT) devices connected to the Internet. By 2020, an estimated 75 billion devices will be connected. Availability of low-cost sensors, increased memory capacity, higher computational power and advanced communications have led to generation of massive amounts of data. This is creating several challenges for real-time IoT applications. This talk will present and discuss some of the main challenges. The talk will also provide IoT case studies relevant to smart cities, intelligent transport systems, environment and healthcare. This talk presents how IoT can seamlessly integrate physical infrastructure and digital information across diverse platforms and applications to develop a common operating picture (COP).

Speaker Biography:

Marimuthu Palaniswami is a Fellow of IEEE and a distinguished lecturer of the IEEE Computational Intelligence Society. He received his Ph.D. from the University of Newcastle, Australia before joining the University of Melbourne, where he is a Professor of Electrical Engineering and Director/Convener of a large ARC Research Network on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP) with about 100 researchers on various interdisciplinary projects. Previously, he was a Co-Director of Centre of Expertise on Networked Decision & Sensor Systems. He served in various international boards and advisory

Conference Plenaries (plenary #1)

committees including a panel member for National Science Foundation (NSF). He has published more than 500 refereed journal and conference papers, including 3 books, 10 edited volumes.

He was given a Foreign Specialist Award by the Ministry of Education, Japan in recognition of his contributions to the field of Machine Learning and communications. He received University of Melbourne Knowledge Transfer Excellence Award and Commendation Awards. He served as associate editor for Journals/transactions including IEEE Transactions on Neural Networks, Computational Intelligence for Finance. He is editor of Journal of Medical, Biological Engineering and Computing and the Subject Editor for International Journal on Distributed Sensor Networks. Through his research, he supported various start-ups, local and international companies.

As an international investigator, he is involved in FP6, FP7 and H2020 initiatives in the areas of smart city and Internet of Things (IoT). To enhance outreach research capacity, he founded the IEEE international conference series on sensors, sensor networks and information processing and served as General Chair for over 15 IEEE and IEEE sponsored Conferences. He has given several keynote/plenary talks in the areas of sensor networks, IoT and machine learning. His research interests include Smart Sensors and Sensor Networks, Machine Learning, IoT and Biomedical Engineering and Control.

Conference Plenaries (plenary #2)

Communication-efficient distributed signal processing

Prof. Soummya Kar, Carnegie Mellon University

February 22 | 2:00 pm – 3:00 pm
Gargi Auditorium

Abstract:

The past decade has seen tremendous growth in research and infrastructure development for decision-making in networked cyber-physical systems and Internet-of-Things type environments, primarily focusing on centralized (cloud-based) paradigms for signal processing and machine learning. While beneficial in many applications, centralized computing and decision-making has limitations and there is a strong trend towards handling computation, data and decision-making at the periphery of the network, on devices and network agents. In addition to issues of scalability and high latency, the motivation for this trend is driven by the issue of user privacy and data security.

As an alternative to traditional fusion-center based cloud setups, in this talk we focus on fully decentralized IoT type architectures in which devices themselves perform the necessary computations using local data and peer-to-peer information exchange with neighbouring devices to make inferences about an environment. Focusing on the problem of recursive parameter estimation, in the first part of the talk, we review distributed estimation approaches and algorithms based on the (iterative) consensus+innovations paradigm. We discuss performance metrics such as rates of convergence, communication complexity, and optimality. While order-optimal in the sense of error decay, the vanilla consensus+innovations approach is not optimized for communication efficiency, a key concern in resource constrained deployments. In the second part of the talk we present recent results on a new variant of the consensus+innovation approach tailored to achieve enhanced communication efficiency. The key idea is based on

Conference Plenaries (plenary #2)

employing a sequential sparsification in inter-device communication, i.e., the inter-device communication rate is made to decay over time at a controlled rate. We demonstrate that the proposed modification achieves significant communication savings (in the order sense), while retaining the order of error decay. We also discuss applications of the proposed communication-efficient approach to problems of more general M-estimation and optimization (for machine learning).

Speaker Biography:

Soummya Kar received a B.Tech. in electronics and electrical communication engineering from the Indian Institute of Technology, Kharagpur, India, in May 2005 and a Ph.D. in electrical and computer engineering from Carnegie Mellon University, Pittsburgh, PA, in 2010. From June 2010 to May 2011, he was with the Electrical Engineering Department, Princeton University, Princeton, NJ, USA, as a Postdoctoral Research Associate. He is currently an Associate Professor of Electrical and Computer Engineering at Carnegie Mellon University, Pittsburgh, PA, USA. His research interests include decision-making in large-scale networked systems, stochastic systems, multi-agent systems and data science, with applications to cyber-physical systems and smart energy systems.

Conference Plenaries (Plenary #3)

Role of Licensed and Unlicensed Millimeter Wave in delivering the Promise of 5G

Dr. Krishna Gomadam, Facebook

February 23 | 9:00 am – 10:00 am
Gargi Auditorium

Abstract:

The perception of what it takes to be "connected" is rapidly emerging; from text to photos to video to 360 videos with VR/AR. Each level of immersion is built on the new generation of wireless technology from 2G, to 3G, to 4G and now 5G. The monthly data consumption "per sq-km" in urban centers across the globe is expected to be in the range of 100s of Terabytes by 2021. In order to meet this massive data demand "per sq-km", extremely dense telecom networks are essential. The existing network infrastructure and deployment approaches will be challenged to meet such needs. Utilizing mmWave networks has several promising advantages over fiber for that last few hundred meters or a km. It is more affordable, requires a lower up-front investment, and deployment costs. Furthermore there is a time to market advantage. mmWave networks can be planned and deployed quickly. They are also more easy to maintain. Various design challenges and solutions for mmWave networks will also be discussed.

Speaker Biography:

Krishna Gomadam is currently a Wireless Systems Architect at Facebook where he is a technical lead for the mmWave wireless distribution network program (Terragraph). Previously he has had various stints at Marvell Semiconductor. Broadcom, and Qualcomm working on various aspects of LTE and LTE-Advanced modem design. Dr. Gomadam has made several contributions that are essential to 3GPP Releases 10 & 11.

Conference Plenaries (plenary #3)

He has also made fundamental contributions to IEEE 802.11ay for the fixed wireless use case. He holds more than 75 patents.

Dr. Gomadam received the B.Tech. degree in electronics engineering from the Madras Institute of Technology, India, and the M.S. and Ph.D. degrees in electrical engineering from the University of California (UC), Irvine. He is a recipient of the UC Irvine CPCC graduate fellowship for 2005 and 2006. He received the UC Irvine EECS best paper award in 2007.

INVITED TALKS (SESSION: INVITED#1)

Joint channel estimation and soft-symbol detection in massive MIMO systems with low resolution ADCs

Prof. Chandra R. Murthy
Department of ECE, IISc, Bangalore

February 22 | 03:00 pm – 04:30 pm
NKN Studio, GSSST

Abstract:

In this talk, we present a variational Bayes' algorithm for joint channel estimation and soft symbol decoding in an uplink massive multiple input multiple output (MIMO) receiver with low resolution analog to digital converters (ADCs). The posterior beliefs obtained from the algorithm can be easily used to compute the bit log likelihood ratios, which can be input to a channel decoder. We evaluate the symbol error probability and the normalized mean squared error of the channel estimates of the proposed algorithm using Monte Carlo simulations, and benchmark it against an unquantized variational Bayesian algorithm with perfect and imperfect channel state information (CSI). Also, we empirically show that the perfect CSI assumption that is considered in a few low resolution ADC based massive MIMO papers greatly overestimates the performance of the system. This is joint work with Sai Subramanyam Thoota and Ramesh Annavajjala.

Speaker Biography:

Prof. Chandra R. Murthy is with the Electrical Communication Engineering Department, Indian Institute of Science, Bangalore. His research interests include signal processing, information theory, estimation theory, compressive sensing, and performance analysis and optimization of wireless systems.

INVITED TALKS (SESSION: INVITED#1)

Ordered Transmission Schemes for Energy-Aware Detection in Energy Harvesting Wireless Sensor Networks

Prof. Neelesh B. Mehta
Department of ECE, IISc, Bangalore

February 22 | 03:00 pm – 04:30 pm
NKN Studio, GSSST

Abstract:

Energy harvesting (EH) is a green solution that eliminates the problem of limited lifetime in wireless sensor networks (WSNs). However, the randomness in the energy harvested can cause some EH sensor nodes to be unavailable due to lack of sufficient energy to transmit. This affects the performance of the network and requires a redesign of the protocols for EH WSNs. For the Bayesian detection framework, we propose two novel energy-efficient ordered transmissions schemes for EH WSNs for the general case in which the log-likelihood ratio is bounded and has a continuous distribution function. They markedly reduce the number of nodes that transmit in the network and yet achieve error probabilities that are no more than that of the conventional unordered transmissions scheme, in which all nodes transmit, and sequential detection.

Speaker Biography:

Neelesh B. Mehta is a Professor in the Department of Electrical Communication Engineering at the Indian Institute of Science (IISc), Bangalore. He received his B. Tech. degree from IIT Madras in 1996 and his Masters' and PhD degrees from the California Institute of Technology, USA in 1997 and 2001, respectively. From 2001 to 2007, he worked in AT&T Research Labs, NJ, USA, Broadcom Corp., NJ, USA, and Mitsubishi Electric Research Labs, MA, USA. His research focuses on wireless communications. He has worked on 3G/4G/5G cellular

INVITED TALKS (SESSION: INVITED#1)

communication systems, energy harvesting sensor networks, cognitive radio, cooperative communications, multi-antenna technologies, and multiple access protocols.

He is a Fellow of the IEEE, Indian National Science Academy (INSA), Indian National Academy of Engineering (INAE), and National Academy of Sciences India (NASI). He is a recipient of the IIT Roorkee's Khosla National Award in Engineering, Shanti Swarup Bhatnagar Award, Hari Om Ashram Prerit Vikram Sarabhai Research Award, DST-Swarnajayanti Fellowship, and NASI-Scopus Young Scientist Award. He currently serves on the Steering Committee of the IEEE Transactions on Wireless Communications and on the IEEE ComSoc Awards committee. He served on the Executive Editorial Committee of the IEEE Transactions on Wireless Communications during 2014-17 and was its Chair during 2017-18. He served on the Board of Governors of the IEEE Communications Society from 2012-15.

Invited Talks (Session: Invited#2)

Coded Caching with Error Correction

Prof. B. Sundar Rajan
Department of ECE, IISc, Bangalore

February 22 | 4:50 pm – 06:20 pm
Moitrayee Auditorium

Abstract:

The high temporal variability of wireless network traffic leads to congestion during peak-traffic times and under-utilization during off-peak times. Coded-Caching is a technique to reduce peak traffic rates by caching (pre-fetching) popular content into memories at the end users during off-peak traffic and using these partly to deliver requested contents during peak-traffic. Using coded cache content and/or coded delivery can lead to enormous caching gains (both local and global caching gains) which has been shown to scale with the size of the network. There are two phases (Placement phase and Delivery phase) in a coded caching scheme. The delivery phase is a collection of index coding problems with common side-information. Most of the works in coded caching assume error-free placement and delivery phases. In this talk we focus on the cases where the two phases are error-prone and discuss error correcting coded caching schemes. This extends the classical error correction coding techniques first to index coding and then further to coded caching schemes. [Joint work with my PhD student MR. Nujoom Karat Sageer]

Speaker Biography:

Dr. B. Sundar Rajan is currently Professor in the Department of Electrical Communication Engineering in IISc Bangalore and was Associate Professor in the Electrical Engineering Department of IIT Delhi from 1989 before joining IISc in 1997. He obtained his M.Tech and PhD degrees in

Invited Talks (session: invited#2)

Electrical Engineering from IIT Kanpur, B.Tech degree in Electronics from Madras Institute of Technology and B.Sc. In Mathematics from Madras University.

Dr. Rajan is a Fellow of IEEE, a J.C. Bose National Fellow, Fellow of the Indian National Science Academy (INSA), Fellow of the Indian National Academy of Engineering (INAE), Fellow of the Indian Academy of Sciences (IASc) and Fellow of the National Academy of Sciences, India (NASI). He was an Associate Editor of IEEE Transactions on Information Theory (2008-2011 & 2013-2015), an Editor of IEEE Transactions on Wireless Communications (2007-2011) and an Editor for IEEE Wireless Communications Letters (2011-2016). He served as TPC Co-Chair of the IEEE Information Theory Workshop (ITW'02). Dr. Rajan is a recipient of IEEE Wireless Communications and Networking Conference (WCNC 2011) Best Academic Paper Award, recipient of Prof. Rustum Choksi award by IISc for excellence in research in Engineering in 2009, recipient of Khosla National Award in 2010 from IIT Roorkee and recipient of the IETE Pune Center's S.V.C. Aiya Award for Telecom Education in 2004. His primary research interests include coding for computation, network coding for wired and wireless networks, coding for multi-user communication and signal processing and coding for MIMO wireless systems.

Invited Talks (Session: Invited#2)

On interference management in the cellular downlink

Prof. Srikrishna Bhashyam
Department of EE, IIT Madras

February 22 | 4:50 pm – 06:20 pm
Moitrayee Auditorium

Abstract:

Managing interference is an important aspect of wireless communication network design. Interference management strategies have evolved significantly in cellular networks from interference avoidance in early cellular networks to adaptive interference management techniques. After a brief review of this evolution, we present some results on a distributed interference management scheme for the cellular downlink with limited coordination among base-stations. Here, we consider a multi-cell multi-band downlink where the base-station (BS) in each cell has multiple transmit antennas, and each cell has one active mobile station (MS) with a single receive antenna and treats interference from other cells as noise. There is a sum transmit power constraint for each BS over all the bands. We propose an alternating maximization (AM) algorithm to determine the optimal power allocation among the bands and the optimal beamforming vectors for each BS in each band. This algorithm can be implemented in a distributed manner with limited exchange of interference constraints between the BSs, and only local channel state information at each BS.

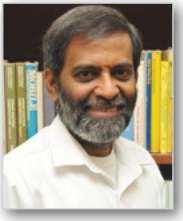
Speaker Biography:

Srikrishna Bhashyam received the B.Tech. degree in electronics and communication engineering from IIT Madras, India, in 1996, and the M.S. and Ph.D. degrees in electrical and computer engineering from

Invited Talks (session: invited#2)

Rice University, Houston, TX, USA, in 1998 and 2001, respectively. He was a Senior Engineer with Qualcomm, Inc., Campbell, CA, USA, from 2001 to 2003, working on wideband code division multiple access modem design. Since 2003, he has been with IIT Madras. He is currently a Professor with the Department of Electrical Engineering. His research interests include communication and information theory, statistical signal processing, and wireless networks. He served as an Editor of the IEEE Transactions on Wireless Communications during 2009–2014. He is serving as an Editor of the IEEE Transactions on Communications since 2017.

TUTORIALS 1 (T1)



OTFS: A New Modulation Scheme for 5G and Beyond

Prof. A. Chockalingam
Department of ECE, IISc, Bangalore

February 21 | 02:00 pm – 05:00 pm
RCC Seminar Room (E & ECE Dept.)

Abstract:

Next generation wireless systems are envisioned to support high-speed communications with high reliability and energy efficiency in various wireless environments. 5G wireless communication technology is expected to provide seamless and consistent high-mobility user experience in a variety of scenarios that include high-speed/bullet trains (200-500 km/h speed in sub-6 GHz bands) and aircrafts. Also, 5G technology is expected to operate in extremely heterogeneous environments and offer enhanced mobility support compared to 4G technology. Enabling high-speed and reliable communication in high-mobility scenarios requires techniques which are specially suited for the dynamic nature of the underlying channel. The wireless channels in such scenarios are rapidly time-varying and hence doubly-dispersive in nature, with the multipath effects causing time dispersion and Doppler shifts causing frequency dispersion. Conventional multicarrier modulation techniques are primarily designed to combat the multipath effects that cause inter-symbol interference (ISI). However, communication in high-mobility scenarios and communication using mmWave frequencies (e.g., 28 GHz) in low-to-medium mobility scenarios encounter high Doppler shifts and the consequent degrading effects of inter-carrier interference (ICI) in conventional multicarrier modulation schemes (such as OFDM).

Orthogonal time frequency space (OTFS) modulation is a recently introduced new modulation scheme suited for doubly-dispersive wireless channels. It is a 2-dimensional (2D) modulation scheme designed in the delay-Doppler domain, unlike traditional modulation schemes which are designed in the time-frequency domain. It multiplexes the information symbols in the delay-Doppler (DD) domain.

TUTORIALS 1 (T1)

This is in contrast to conventional multicarrier modulation schemes which multiplex symbols in the time-frequency (TF) domain. Also, the channel response is viewed in the DD domain as opposed to viewing it in the TF domain. An advantage of the DD representation of wireless channels is that the rapid fluctuations in time-varying channels exhibit slow variations when viewed in the DD domain. This, along with the fact that the channel in the DD domain has a sparse nature, simplifies channel estimation in rapidly time-varying channels. The slow variability of the DD channels reduces the overhead of frequent channel estimation in channels with small coherence times. Another attractive feature of OTFS is that it could be architected with pre- and post processing operations over any existing multicarrier system. It has been shown that OTFS offers significant performance advantages compared to OFDM in point-to-point and multiuser environments.

This tutorial will introduce OTFS modulation and highlight the various signal processing functions in the delay-Doppler domain and transforms needed for OTFS modulation implementation. OTFS signal detection methods and channel estimation techniques (using pilot symbols embedded in the delay-Doppler domain) will be presented. Performance comparison between OTFS and OFDM in SISO and MIMO settings will be highlighted. The talk will also highlight the peak-to-average power ratio (PAPR) characteristics of OTFS in comparison with that of OFDM. Multiuser communication using OTFS, where resource blocks in the delay-Doppler grid, called delay-Doppler resource blocks (DDRBs), are allocated to different users will be discussed. Performance advantage of OTFS multiple access (OTFS-MA) compared to OFDMA and SC-FDMA will be highlighted. Potential topics of OTFS research will be highlighted.

Speaker Biography:

A. Chockalingam received the B.E. (Honors) degree in ECE from P.S.G. College of Technology, Coimbatore in 1984 and the M.Tech degree in E & ECE from IIT, Kharagpur in 1985. In 1993, he obtained the Ph.D. degree in ECE from IISc, Bangalore. From Dec.1993 to May 1996, he was a Postdoctoral Fellow and an Assistant Project Scientist with the Department of ECE, University of California San Diego. From May 1996 to Dec. 1998, he was with Qualcomm, San Diego, as a Staff Engineer/Manager. Currently, he is a Professor in the Department of ECE, IISc, Bangalore.

TUTORIALS 2 (T2)

Signal Processing and Deep Learning on Graphs

Dr. Sundeep Prabhakar Chepuri
Department of ECE, IISc, Bangalore

February 21 | 02:00 pm – 05:00 pm
NKN Studio (E & ECE Dept.)

Abstract:

Graphs are mathematical objects that may be used for explaining relationships in many complex datasets, which are frequently encountered in many scientific disciplines. Unlike regular domains (e.g., time series or images, where the data is indexed by time ticks or pixels), data collected on networks or manifolds are indexed by an arbitrary enumeration and the underlying irregular domain structure can be described using graphs. Such graph- structured data are generated from platforms like environmental sensing, medical and brain imaging systems, social networking and e-commerce sites, to list a few. To extract meaningful information from graph-structured data, several concepts and tools are being developed in the emerging research fields of graph signal processing and geometric deep learning.

Graph signal processing research extends traditional signal processing concepts developed to represent, interpret, and analyze data collected on regular domains to signals defined on graphs and irregular (or, geometric non-Euclidean) domains. Deep learning methods, mainly deep convolutional neural networks (CNN) and recurrent neural networks (RNN), are very popular machine learning techniques that have recently proven to be very successful for solving complicated inference problems especially when large amounts of data are available. Using advances in graph signal processing, specifically, using the definition of convolutions and filters on graphs, deep learning algorithms have been generalized as geometric deep learning, formalized as graph convolutional neural networks (GCNN), to apply learning on graph-structured data.

TUTORIALS 2 (T2)

In this tutorial, the main focus will be on graph signal processing and graph neural networks. We will discuss concepts such graph filters, graph sampling and recovery, and graph topology inference. Then, we will discuss convolutional neural networks and recurrent neural networks for graphs-structured data.

Speaker Biography:

Sundeep Prabhakar Chepuri received his M.Sc. degree (cum laude) in electrical engineering and Ph.D. degree (cum laude) from the Delft University of Technology, The Netherlands, in July 2011 and January 2016, respectively. He was a Postdoctoral researcher at the Delft University of Technology, The Netherlands, a visiting researcher at University of Minnesota, USA, and a visiting lecturer at Aalto University, Finland. He has held positions at Robert Bosch, India, during 2007- 2009, and Holst Centre/imec-nl, The Netherlands, during 2010-2011. Currently, he is an Assistant Professor at the Department of ECE at the Indian Institute of Science (IISc) in Bengaluru, India.

Dr. Chepuri was a recipient of the Best Student Paper Award at the IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) in 2015, Best Student Paper Award (as co-author) at ASILOMAR 2019, and the Pratiksha Trust Young Investigator award. He is currently an Associate Editor of the EURASIP Journal on Advances in Signal Processing, and an elected member of the EURASIP Technical Area Committee (TAC) on Signal Processing for Multisensor Systems.

TUTORIALS 3 (T3)

Energy Harvesting and RF Energy Transfer aided Sustainable IoT Networks

Prof. Swades De
Department of EE, IIT Delhi

February 21 | 09:30 am – 12:30 am
A-102 (E & ECE Dept.)

Abstract:

The interests in wireless connectivity is ever-increasing and the needs for automated remote access, monitoring, and control are well-appreciated. However, widespread adoption of networked wireless devices or Internet of Things (IoT) nodes is largely constrained by their affordable deployment and maintenance costs and convenience of their long-term usage. In particular, in IoT communication networks, one of the main constraints is energy sustainability, as the wireless end nodes are characterized by limited energy resources.

In this discourse, considering a few typical application contexts, we will first discuss the contemporary approaches and optimization techniques for energy-efficient IoT communication with energy-constrained wireless devices. The contexts with ambient energy harvesting sources and energy-harvesting aware architectures as well as node-level and network protocol solutions will also be discussed. Subsequently, we will present the communication and networking propositions with dedicated on-demand wireless energy supply. We will specifically consider the cases of energy replenishment with radio frequency energy transfer (RFET). We will discuss two-dimensional (terrestrial mobile energy agent aided) as well as three-dimensional (unmanned aerial vehicle aided) RFET and joint RFET and information exchange approaches towards sustainable IoT networks. Throughout the discourse, from our research experience we will take a few example cases of state-of-the-art research solutions on energy-efficient and energy-harvesting network systems.

TUTORIALS 3 (T3)

Speaker Biography:

Dr. Swades De is a Professor in the Department of Electrical Engineering at Indian Institute of Technology Delhi. Dr. De's research interests are broadly in communication networks, with emphasis on performance modelling and analysis. Current directions include energy harvesting communication networks, broadband wireless access and routing, cognitive/white-space access networks, smart grid networks, and IoT communications.

Dr. De is currently an Area Editor for the IEEE COMMUNICATIONS LETTERS and an Associate Editor respectively for the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, IEEE WIRELESS COMMUNICATIONS LETTERS, IEEE NETWORKING LETTERS, and the IETE Technical Review Journal. Dr. De is a fellow of INAE (Indian National Academy of Engineering), and NASI (The National Academy of Sciences, India), respectively, and a senior member of the IEEE, and IEEE Communications and Computer Societies.

TUTORIALS 4 (T4)

SGD and Friends

Prof. Ketan Rajawat
Department of EE, IIT Kanpur

February 21 | 09:30 am – 12:30 am
RCC Seminar Room (E & ECE Dept.)

Abstract:

This tutorial delves into the world of Stochastic Gradient Descent (SGD) algorithm and its many variants that have been widely utilized in large-scale signal processing, machine learning, and communications. Early appearances of SGD include the Stochastic Approximation framework by Robbins-Monro in 1951, LMS algorithm for adaptive filtering by Widrow-Hoff in 1960, Perceptron classifier by Rosenblatt in 1957, and SVM classifier by Cortes-Vapnik in 1995. In the last decade, SGD has been widely used for training large-scale supervised learning models, even in settings where the training problem is non-convex and non-differentiable, such as in neural networks. Recent years have seen several attempts at explaining and specializing SGD to a variety of settings.

In the modern context, iteration complexity analysis is the de facto standard for studying and comparing the plethora of SGD variants. Such analysis allows us to obtain bounds on the total number of stochastic gradients required to reach a certain pre-specified accuracy and is useful for identifying the correct regime under which a particular variant works. This tutorial will provide a principled introduction to SGD iteration complexity analysis for the signal processing, machine learning, and communications audience. The tools covered here should enable the audience to modify the existing proofs for their applications of interest.

Additionally, the tutorial seeks to update the audience with all the state-of-the-art SGD variants. Beyond the classical SGD, we will analyze variance-reduced, compressed, distributed, asynchronous, and

TUTORIALS 4 (T4)

momentum-based versions, most of which have appeared only in the last two years. Different from the proofs presented in the corresponding seminal papers that tend to follow disparate styles, we will attempt to provide a few common analysis techniques that will serve to unify these approaches. The tutorial will conclude with a list of "low-hanging fruits" in the broad area of SGD and online learning.

Speaker Biography:

Ketan Rajawat (S'06–M'12) received his B.Tech and M.Tech degrees in Electrical Engineering from the Indian Institute of Technology (IIT) Kanpur, India, in 2007, and his Ph.D. degree in Electrical and Computer Engineering from the University of Minnesota, Minneapolis, MN, USA, in 2012. He is currently an Assistant Professor in the Department of Electrical Engineering, IIT Kanpur. His research interests are in the broad areas of signal processing, robotics, and communications networks, with particular emphasis on distributed optimization and online learning. His current research focuses on the development and analysis of distributed and asynchronous optimization algorithms, online convex optimization algorithms, stochastic optimization algorithms, and the application of these algorithms to problems in machine learning, communications, and smart grid systems. He is currently serving as an Associate Editor with the IEEE Communications Letters. He is also the recipient of the 2018 INSA Medal for Young Scientists and the 2019 INAE Young Engineer Award.

TUTORIALS 5 (T5)

Integrated Transceiver Architectures for 5G Cellular Base Stations

Dr. Jaiganesh Balakrishnan, Mr. Sriram Murali
Texas Instruments, Bangalore

February 21 | 09:30 am – 12:30 am
NKN Studio (E & ECE Dept.)

Abstract:

5G cellular network technologies offer increased channel capacity and data rates by employing massive MIMO, higher bandwidth, as well as new frequency bands. High-performance system-on-chip transceiver products, which integrate the RF/analog/digital signal processing front-ends and support multiple transmit, receive and feedback channels in a single device, with low power consumption, are key enablers in the deployment of 5G cellular base stations.

Products incorporating recent advances in high-performance integrated transceivers, which employ different signal chain architectures to cater to massive MIMO and mm-wave 5G technologies, have been key enablers to the commercial deployment of 5G cellular base stations. A zero-IF architecture is best suited for single band massive MIMO systems, requiring signal bandwidth support of a few 100s of MHz. An RF-sampling architecture, incorporating multi-GSPS high-performance data converters that directly sample the RF signal, is highly flexible, as it enables support for very wide signal bandwidths, in the order of GHz, as well as simultaneous multi-band transmission and reception.

This industry tutorial will introduce technology trends and practical constraints driving the architecture choices for integrated transceivers in 5G cellular base stations. We present an overview of the IF-sampling

TUTORIALS 5 (T5)

architecture used in legacy 3G/4G base stations, introduce advances related to zero-IF and RF-sampling architectures, and present system level trade-offs associated with each of these architectures that influences their suitability for different classes of 4G/5G base stations. We discuss the impact of RF/analog impairments, arising from practical IC designs, on critical system parameters of interest for wireless base stations. We also discuss practical challenges in the design of high-performance, low-power integrated transceiver SoC products employing these architectures and present various signal processing algorithms and digital design techniques to address these challenges. Specifically, we address aspects related to I/Q imbalance, ADC interleaving mismatch, transmit carrier leakage, automatic gain control and other system calibrations.

Speaker Biography:

Dr. Jaiganesh Balakrishnan is a Principal Architect and Fellow with the Analog Signal Chain department at Texas Instruments, Bangalore. He received his B.Tech in Electrical Engineering from IIT, Madras, in 1997, and Ph. D in Electrical and Computer Engineering from Cornell University, USA, in 2002. At TI, his research has been in the field of Signal Chain Architectures, Signal Processing Algorithms and Communication Systems on technologies spanning 4G/5G base stations, GPS/WLAN/FM transceivers, DVB-H and UWB. Jaiganesh has developed architectures/algorithms for various highly integrated high performance and low power consumption system-on-chip solutions, for mobile handsets and wireless base stations. He holds 70+ patents and is the recipient of the 2010 TR35 Young Innovator award by MIT's Technology Review Magazine.

Sriram Murali is a Principal Engineer and Senior Member of Technical Staff with the Wireless Infrastructure Business Unit at Texas Instruments, Bangalore. He received a B.Tech. in Electrical Engineering from IIT Madras in 2001, and an MS in Electrical Engineering from California Institute of Technology, USA, in 2002. His research interests are in architectures and algorithms for signal processing and communication systems. He has worked on highly integrated high performance and low power SoC products including 4G/5G transceivers, Automotive Radar, Low-power WLAN, Vehicular/Pedestrian Navigation, and FM transceivers. He has over 15 patents granted by the US Patent Office.

TUTORIALS 6 (T6)

Hands-On Tutorial: Design and prototype SDR systems with MATLAB and Simulink

Mr. Tabrez Khan, Ms. Hitu Sharma
MathWorks India

February 21 | 02:00 pm – 05:00 pm
F-302 (E & ECE Dept.)

Abstract:

The latest innovation in wireless communications brought the complexity of highly integrated digital, RF and antenna technologies. Many engineering teams designing such wireless complex applications recognize that they need a single integrated development environment to prevent isolated component designs, minimize error-prone implementation, and avoid expensive hardware verification.

Using MATLAB® and Simulink®, users can model and simulate end to end wireless communication system, integrate Analog Devices AD9361 RF Agile Transceiver™ as RF Front end and prototype on Xilinx® Zynq®-7000 All Programmable SoC.

Outcome:

In this 3-hour hands-on tutorial, you will learn how to:

- Model and simulate radio designs.
- Verify algorithms in simulation with streaming RF data
- Deploy radio designs on Zynq-based hardware with HDL and C-code generation.
- Participants will be provided trial licenses for MATLAB and relevant products prior to the event.

TUTORIALS 6 (T6)

Speaker Biography:

Tabrez Khan is a senior application engineer with MathWorks India specializing in the domain of signal processing and wireless communications. He has over 16 years of industry experience and has worked with various customers in Aerospace & Defense, Communications, Electronics, Semiconductor and Education industry to help them adopt MATLAB and Simulink based products in their signal processing and wireless communication applications. He holds Master's degree in Digital Electronics & Communication from NMAMIT, Nitte & Bachelor's degree in Electronics & Communication from BIET, Kuvempu University, Karnataka.

Hitu Sharma is a part of Application Engineering Group at MathWorks focusing on Signal processing and FPGA Prototyping. She has been supporting number of government and commercial establishments pan India for projects based on Signal Processing and Communication. She has been involved with educational establishments for Faculty development programs and project-based learning on low cost hardware. She has 11+ years of experience in FPGA based prototyping, product development and embedded design development (Linux/Windows) with AeroDef Industry.

Prior to joining MathWorks Hitu Sharma has worked as design engineer with HCL, TATA Advanced Systems and as a Senior R & D engineer for two startups. She has prototyped a serial cryptographic unit and a technical key generation unit. She as designed IP cores for cryptographic algorithms and Digital receiver chain for the ground surveillance RADAR systems. She has represented her work on many platforms, including Defense EXPO. Her areas of interest include FPGA design, Signal processing, and Digital Communication. She holds a bachelor's degree in Electronics and Communication Engineering.

Technical Program-Oral

Communication Systems

Session Chair : Srikrishna Bhashyam, IIT Madras

February 22 | 10:00 am – 11:30 am

Gargi Auditorium

Error Performance of OTFS in the Presence of IQI and PA Nonlinearity

Sapta Girish Babu Neelam (Bharat Electronics Limited & IIT Bhubaneswar, India)
Pravas Ranjan Sahu (IIT Bhubaneswar, India)

Orthogonal time frequency space (OTFS) modulation, which was proposed recently is a two dimensional modulation technique designed in the delay-Doppler (DD) domain unlike OFDM which was designed in the time-frequency (TF) domain. It is suited for doubly dispersive fading wireless channels. Some transformations are done at the transmitter and receiver of the conventional multicarrier modulation. In this paper, we predistort frequency dependent transmitter (Tx) IQ imbalance (IQI) and power amplifier (PA) nonlinearity in two steps. The bit error rate performance analysis of OTFS in the presence of receiver (Rx) IQI along with residual Tx IQI is analyzed. We develop an input-output relation of OTFS in the DD domain, with impairments in the presence of time varying (TV) channel. A message passing algorithm is used to detect the OTFS signal with impairments. We show that compensating IQI at the Tx and PA non-linearity has improved the BER performance.

Technical Program-Oral

An Efficient FPGA Implementation of Turbo Product Code Decoder with Single and Double Error Correction

Nitin Nageen (SAG, DRDO, India)
Subhashini Gupta (Defence Electronic Application Laboratory, India)
Vikas Bhatia (DRDO, India)

The paper presents FPGA implementation of turbo product code decoder with single and double error correcting BCH constituent codes that is capable of supporting high throughput and still maintains low complexity. The implementation is based on the Chase-Pyndiah algorithm, which exhibits a modular, simple structure with fine parallelism. Complexity reduction and pipelining for throughput and latency has been done through novel optimizations in submodules of TPC decoder. The resulting turbo decoder is implemented on a Xilinx Virtex-6 customized hardware and its BER performance is computed for various BCH constituent codes. Performance comparison against third party IP cores is also presented.

On Multi RF Chain Time Successive SSK-M-ary Modulation Transmitter

Palani Maheswaran (IIT madras, India)
Mandha Damodaran Selvaraj (IIITDM, Kancheepuram, India)

Space shift keying (SSK) is a modulation technique that conveys information using the indices of the activated antenna. Media Based Modulation (MBM) proposed recently uses the ON/OFF status of radio frequency (RF) mirrors to create distinct channel fade realizations with a single transmit antenna. Multi RF chain Time successive SSK-M-ary modulation (MRF-TSSM) is a new second-order transmit diversity scheme. The number of antennas needed at the MRF-TSSM transmitter increases exponentially with spectral efficiency as it uses SSK. To overcome this, two system models are proposed in this work. Generalized

TSSM (GTSSM) uses the activation of antenna combinations to reduce the antenna count. The condition on the combination of antennas to achieve second-order transmit diversity, the BER performance and its asymptotic form are derived for GTSSM. MBM based MRF-TSSM (MBM-TSSM) exploits MBM to realize the SSK phase of MRF-TSSM with one antenna per modulator. Further for MBM-TSSM, a mirror activation pattern (MAP) selection criterion is shown and its improved diversity order is analyzed. Simulation results are provided to validate all the analysis. From the results, it is found that GTSSM with a lesser number of active antennas performs better. Moreover, MBM-TSSM is found to provide the same performance as MRF-TSSM. Based on the number of MAPs used for selection, the diversity order of MBM-TSSM is also found to increase.

OTFS: Interleaved OFDM with Block CP

Vivek Rangamgari (IIT Kharagpur, India)
Shashank Tiwari (IIT Kharagpur, India)
Suvra Sekhar Das (IIT Kharagpur, India)
Subhas Chandra Mondal (Wireless & Wipro Technologies, India)

Orthogonal time frequency space modulation (OTFS) is a recently proposed waveform for reliable communication in high-speed vehicular communications. It has better resilience to inter-carrier interference (ICI) as compared to orthogonal frequency division multiplexing (OFDM). In OTFS, information is generated in the Doppler-delay domain as opposed to time-frequency domain in conventional OFDM. In this work, we describe OTFS as block-OFDM with a cyclic prefix and time interleaving. Through this description, we explained the improved performance of OTFS over OFDM. We also compare the performance of OTFS against its contender 5G new radio (NR)'s OFDM configuration of variable subcarrier bandwidth (VSB) while considering practical forward error correction codes and 3GPP high-speed channel model. We have considered practical channel estimates in the demodulation and find

that OTFS outperforms VSB with 5G-NR parameter. We also study the influence of pilot in OTFS in its peak to average power ratio (PAPR).

Performance Analysis of PAM-DMT Under Double Sided Signal Clipping in IM/DD Based Systems

Kishore Vejandla (NIT Warangal, India)
Sai Kiran Kollikonda (NIT Warangal, India)
Venkata Mani Vakamulla (NIT Warangal, India)

Due to the widespread of Light Emitting Diode (LED)s that are ambidextrous in performing simultaneous illumination and communication, Visible Light Communication (VLC) with huge band width has been evolved as a new wireless technology to deliver high data rates. However, these LEDs possess non linear behaviour, come as front end devices in VLC system, and causes clipping on the modulated signal that affects the performance. In this work, the effect of dual side signal clipping in Optical Wireless Communication (OWC) systems based on Pulse Amplitude Modulated-Discrete Multi Tone (PAM-DMT) is investigated. Improper DC biasing and power rating of the front end device decides the amount of clipping. Analytical expression for the clipping noise power and an exact Bit Error Rate (BER) expression under clipping noise are presented. Along with BER performance, Peak-to-Average Power Ratio (PAPR) performance under the impact of uncorrelated clipping noise that arise from dual side clipping for various modulation orders, under different conditions is also examined.

Technical Program-Oral

Speech Classification and Understanding - I

Session Chair : K. S. Rao, IIT Kharagpur
February 22 | 10:00 am – 11:30 am
Moitrayee Auditorium

Language Specific Information from LP Residual Signal Using Linear Sub Band Filters

Siddhartha Soma (IIT Dharwad, India)
Jagabandhu Mishra (IIT Dharwad, India)
Mahadeva Prasanna (IIT Dharwad, India)

In this work, an analysis and comparison of the parameterization methods of excitation source information is demonstrated for the spoken language recognition task. The excitation source information is represented by the features called residual mel frequency cepstral coefficients (RMFCC) and residual linear frequency cepstral coefficients (RLFCC), both derived from the linear prediction residual signal. In general, inspired from the speaker recognition task, perceptually inspired mel-sub band filters are used for the parameterization of LP residual signal (known as RMFCC). In this study, as the LP residual signal is impulsive in nature (i.e. having a flat spectrum) a uniform triangular sub-band filter based parameterization method, called as RLFCC is proposed. From the experimental results, it has been observed that the RLFCC features perform better than RMFCC features. The RLFCC features combined with the MFCC features provide a relative improvement of 20% in terms of average EER over the combined system of MFCC and RMFCC features using DNN-WA architecture.

Technical Program-Oral

An Optimized Signal Processing Pipeline for Syllable Detection and Speech Rate Estimation

Kamini M Sabu (IIT Bombay, India)
Syomantak Chaudhuri (IIT Bombay, India)
Preeti Rao (IIT Bombay, India)
Mahesh Patil (IIT Bombay, India)

Syllable detection is an important speech analysis task with applications in speech rate estimation, word segmentation, and automatic prosody detection. Based on the well-understood acoustic correlates of speech articulation, it has been realized by local peak picking on a frequency-weighted energy contour that represents vowel sonority. While several of the analysis parameters are set based on known speech signal properties, the selection of the frequency-weighting coefficients and peak-picking threshold typically involves heuristics, raising the possibility of data-based optimisation. In this work, we consider the optimization of the parameters based on the direct minimization of naturally arising task-specific objective functions. The resulting non-convex cost function is minimized using a population-based search algorithm to achieve a performance that exceeds previously published performance results on the same corpus using a relatively low amount of labeled data. Further, the optimisation of system parameters on a different corpus is shown to result in an explainable change in the optimal values.

Analysis of Excitation Source Characteristics for Shouted and Normal Speech Classification

Shikha Baghel (IIT Guwahati, India)
S. R. Mahadeva Prasanna (IIT Guwahati, India)
Prithwijit Guha (IIT Guwahati, India)

The present work is aimed at analysing the excitation source characteristics of normal and shouted speech. In this context, we

analyze the Differenced Electroglottogram (DEGG) signal corresponding to different vowels. This work proposes two novel excitation source features that are estimated from DEGG signal. These features are (a) Open Phase Triangle Area (OPTA) and (b) Flatness of Glottal Cycle (FoGC). OPTA captures the effect of open phase duration and slope of DEGG signal. FoGC measures the change in source characteristics due to strength of excitation (SoE) and pitch period. A practical issue in using the proposed features is the unavailability of DEGG signal in most speech processing applications. To overcome this problem, the integrated linear prediction residual (ILPR) signal estimated from speech is considered as an approximation of DEGG. We show that the proposed features can be computed from ILPR signal in the absence of DEGG. It is observed that the proposed features (estimated from either DEGG or ILPR) are successful in discriminating shouted from normal speech.

Classifying Speech of ASD Affected and Normal Children Using Acoustic Features

Abhijit Mohanta (IIIT Chittor, India)
Vinay Kumar Mittal (KL University & KLEF, India)

Children affected with autism spectrum disorder (ASD) produce speech that consists of distinctive acoustic patterns, as compared to normal children. Hence, acoustic analyses can help classifying speech of ASD affected children from that of normal children. In this study, the aim is to identify those discriminating characteristics of speech production that help classification between speech of children with ASD and normal children. Two separate datasets were recorded for this study: the English speech of children affected with ASD and the English speech of normal children. Comparative analyses of acoustic features derived for both datasets are carried out. Changes in the speech production characteristics are examined in three parts. Firstly, changes in the excitation source features F0 and strength of excitation (SoE) are analyzed. Secondly, changes in the vocal tract filter features the formants (F1 to F5) and

dominant frequencies (FD1, FD2) are analyzed. Thirdly, changes in the combined source-filter features signal energy and zero-crossing rate are analyzed. Different combinations of the feature sets are then classified using three different classifiers for validation of results: SVM, KNN and ensemble classifiers. Performance evaluation is carried using different combinations of features sets and classifiers. Results up to 97.1% are obtained for classification accuracy between speech of ASD affected children and normal children, using a combination of feature set with SVM classifier. The results are better than other similar few studies. This study should be helpful in developing an automated system for identifying ASD speech, in future.

Acoustic Features Characterization of Autism Speech for Automated Detection and Classification

Abhijit Mohanta (IIIT Chittor, India)
Prerana Mukherjee (IIT Delhi, India)
Vinay Kumar Mittal (KL University & KLEF, India)

The verbal children affected with autism spectrum disorder (ASD) often shows some notable acoustic patterns. This paper represents the classification of autism speech, i.e., the speech signal of children affected with ASD. In addition, this work specifically aims to classify the speech signals of non-native Indo English speakers (children) affected with ASD. Previous studies, however, have focused only on native English speakers. Hence, for this study purpose a speech signal dataset of ASD children and a speech signal dataset of normal children were recorded in English, and all the children selected for the data collection were non-native Indo English speakers. Here, for the ASD and the normal children, the acoustic features explored for classification are namely, fundamental frequency (F0), strength of excitation (SoE), formants frequencies (F1 to F5), dominant frequencies (FD1, FD2), signal energy (E), zero-crossing rate (ZCR), mel-frequency cepstral coefficients (MFCC), and linear prediction cepstrum coefficients (LPCC). Further, these feature sets

are classified by utilizing different classifiers. The KNN classifier model achieves the highest 96.5% accuracy with respect to other baseline models explored here.

Bio Signal Processing - I

Session Chair : Saswat Chakrabarti, IIT Kharagpur

February 22 | 10:00 am – 11:30 am

NKN Studio, GSSST

A Fusion-Based Approach to Identify the Phases of the Sit-to-Stand Test in Older People

Brajesh Kumar Shukla (IIT Jodhpur, India)
Hiteshi Jain (IIT Jodhpur, India)
Vivek Vijay (IIT Jodhpur, India)
Sandeep Yadav (IIT Jodhpur, India)
David Hewson (University of Bedfordshire, UK)

Automated clinical test that assess quality of exercises like Five-Sit-To-Stands and Time-Up-and-Go are readily being designed to assess the decline in functional ability of elderly. The existing techniques to assess the quality of these physical activities include sensor-based technique including body mounted sensors, force sensors and vision and imaging sensors. These sensors have their own benefits and drawbacks towards the task of clinical assessment. In this work, we introduce a fusion-based technique to combine multiple sensors leveraging advantages of individual sensors, such that the resulting assessment is more accurate. We evaluate our technique for Five-Sit-to-Stands test and fuse force sensors and RGB sensors. It is observed that the proposed fusion technique outperforms the individual sensor assessment.

Technical Program-Oral

Classification of Autism in Young Children by Phase Angle Clustering in Magnetoencephalogram Signals

Kasturi Barik (IIT Kharagpur, India)
Katsumi Watanabe (Waseda University, Japan)
Joydeep Bhattacharya (University of London, UK)
Goutam Saha (IIT Kharagpur, India)

Autism spectrum disorder (ASD) is a complex neurodevelopmental condition that appears in early childhood or infancy, causing delays or impairments in social interaction and restricted range of interests of a child. In this work, our goal is to classify autistic children from typically developing children using a machine learning framework. Here, we have used magnetoencephalography (MEG) signals of thirty age and gender matched children from each group. We perform a spectral domain analysis in which the features are extracted from both power and phase of large-scale neural oscillations. In this work, we propose a novel phase angle clustering (PAC) based feature and have compared its performance with commonly used power spectral density (PSD) based feature. It is observed that with Artificial Neural Network (ANN) classifier, PAC yields better classification accuracy (88.20 ± 3.87 %) than the PSD feature (82.13 ± 2.11 %). To investigate laterality of brain activity, we evaluate the classification performance of each feature type over all channels as well as over individual hemispheres. Using machine learning framework it is found that the discriminating PSD features are mostly from high gamma band i.e. 50-100 Hz frequency oscillations and the PSD features are dominant in right hemisphere. These findings are in line with studies carried before in other framework. However, PAC based feature in our study shows that the whole brain contains important attributes of autism. The discriminating PAC features are mostly from theta band (i.e. 4-8 Hz frequency oscillations) that signifies memory formation and navigation. In this study, it is found that impaired theta oscillations correlate with autistic symptoms. Overall, our findings show the potential of such signal processing and classification based study to aid the clinicians in diagnosis of ASD.

Technical Program-Oral

Correcting Automatic Cataract Diagnosis Systems Against Noisy/ Blur Environment

Turimerla Pratap (IIITDM, Kancheepuram, India)
Priyanka Kokil (IIITDM, Kancheepuram, India)

In this paper, a methodology to improve the performance of existing automatic cataract detection systems (ACDS) in noisy/blur environment is proposed. The presented approach consists of dual-threshold based image quality evaluation module to enhance the performance diminution of ACDS in noisy/blur environment. Initially the first threshold is obtained from naturalness image quality evaluator (NIQE) and then second threshold is achieved through noise level estimation (NLE). In order to ensure robustness, the proposed method is evaluated with artificially created noise and blur datasets in association with existing pre-trained convolution neural network based ACDS. The experiments results show superiority in performance over existing methods in literature.

Synthesis and Classification of Heart Sounds Using Multi-component Oscillatory Model

Samarjeet Das (IIT Guwahati, India)
Samarendra Dandapat (IIT Guwahati, India)

Analysis of heart sounds (HSs) plays a vital role in the early detection and diagnosis of cardiovascular diseases. In this paper, we propose a multi-component oscillatory model for the representation of both normal and pathological heart sound segments. A half-period sine wave is fitted between every two consecutive zero-crossing points to extract parameters for the proposed model. The segment-representation gets improved with the recursive use of multiple half-wave oscillations. The proposed method is tested and validated with the Computing in Cardiology Challenge (CinC) 2016 database, available publicly on the Physionet archive. The efficiency of the model is demonstrated for

the synthesis of HS segments. The performance results of synthesis show that the multi-component oscillatory model provides a highly accurate approximation of the original HS segments. Further, the model parameters are employed for the classification of normal and abnormal HS segments. The proposed method achieves a better performance using support vector machine classifier with RBF kernel.

A Fusion Based Classification of Normal, Arrhythmia and Congestive Heart Failure in ECG

Sudestna Nahak (IIT Kharagpur, India)
Goutam Saha (IIT Kharagpur, India)

In healthcare, Electrocardiogram (ECG) signal is considered important to study life-threatening heart diseases that include arrhythmia (ARR), congestive heart failure (CHF). Mostly, atrial arrhythmia leads to CHF. Previous studies on ARR and CHF are focused on the binary classification of each category against normal sinus rhythm (NSR). So, there is a requirement to study the above disease cases together to detect the severity of the situation and take remedial action accordingly. The goal of this study is to analyse and classify these three different classes of ECG (namely ARR, CHF, and NSR) in an efficient way. We used 30 ECG recordings for each of the classes from the publicly available Physionet database. Since the temporal and spectral features by themselves may be insufficient to distinguish the classes, we sought to combine information across both. Accordingly, we considered feature representations from heart rate variability (HRV) of the ECG signal and wavelet-based features together with auto-regressive coefficients. To leverage complementary information across feature types, we employed feature-level fusion. We examined the performance of individual and fused feature types with multiple classifiers. The highest accuracy of 93.33\% for three-class classification was obtained after feature fusion using Support Vector Machine (SVM). Although the performance of HRV features is relatively poor compared to wavelet-based features, their fusion improved the classification accuracy.

Technical Program-Oral

Channel Estimation

Session Chair : Neelesh B. Mehta, IISc., Bangalore

February 22 | 11:50 pm – 01:00 pm

Gargi Auditorium

Effect of Gaussian Correlated Channel on Uplink Channel Estimation for Massive MIMO with Nested Array at the Base Station

Md. Afaque Azam (IIT Kharagpur, India)
Anirban Mukherjee (IIT Kharagpur, India)
Amit kumar Dutta (IIT Kharagpur, India)

mmWave massive MIMO can support high data rate on account of enhanced spectral efficiency. Uplink channel estimation is an important intermediate problem. Usually channels between the base station and the user equipment is assumed IID, Rayleigh and flat fading. However, the antennas are closely packed together in a massive MIMO and local scatterers are present around the user equipment. This means that a correlated channel model is more realistic. In this paper, a Gaussian one ring scattering model for the channel is used. The uplink Linear Minimum Mean Square Error(LMMSE) channel estimator performance is analyzed, with a pilot reuse factor of L>1. The upper limit of the estimation performance for varying degrees of correlation and pilot length is derived and verified by numerical experiments. In place of usual dense uniform linear array, a sparse nested array is employed at the base station. It is verified experimentally that the sparse array performs better when the channels are highly correlated. However, both arrays showed similar performance for the usual IID case when the correlation is small ($\sigma\phi >> 0.5$).

Technical Program-Oral

BSBL-based Block-Sparse Channel Estimation for Affine Precoded OSTBC MIMO-OFDM Systems

Suraj Srivastava (IIT Kanpur, India)
Manoj Suradkar (IIT KANPUR, India)
Aditya K Jagannatham (IIT Kanpur, India)

This work presents affine precoded superimposed pilot-based sparse channel estimation in orthogonal space-time block coded (OSTBC) multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) systems. A pilot-based block sparse Bayesian learning (P-BSBL) technique is developed initially, which leverages the sparsity as well as the spatial correlation of the MIMO channel for improved estimation. Subsequently, a data aided-BSBL (D-BSBL) technique is presented for joint maximum likelihood (ML) decoding of the symbols and sparse channel estimation, which is shown to lead to a further improvement in the accuracy of the estimated channel. In addition to a significant decrease in the mean squared error (MSE) of estimation, the proposed schemes are also shown to lead to a substantial increase in spectral efficiency over the existing schemes. Moreover, they are also applicable in ill-posed CSI estimation scenarios, where conventional approaches fail due to a large delay spread. The Bayesian Cramér-Rao bounds are derived to analytically benchmark the estimation performance followed by simulation results that show the improved performance of the proposed techniques.

Technical Program-Oral

Superimposed Pilots Based Adaptive Time-Selective Channel Estimation in MU-MIMO Systems

Vikram Singh (IIT Kanpur, India)
Suraj Srivastava (IIT Kanpur, India)
Aditya K Jagannatham (IIT Kanpur, India)

This work proposes symbol and block level adaptive channel estimation schemes, based on the least mean squares (LMS) and block-LMS (BLMS) approaches, respectively, for multiuser-MIMO (MU-MIMO) systems. The proposed schemes do not require knowledge of the first and second order statistics of the time-varying MU-MIMO channel, while also having a lower computational complexity in comparison to the Kalman filter based channel estimation approaches present in the existing literature. Another important aspect of the proposed MU-MIMO framework is that channel estimation is carried out at the base station (BS), which simplifies the receiver architecture. Analytical expressions are derived for the error covariance matrix at each time instant and the asymptotic mean square error (MSE) of the proposed LMS and BLMS frameworks. Further, a superimposed pilot (SIP) framework for MU-MIMO channel estimation been developed, which transmits data symbols to a group of selected users during the training phase, thus leading to a significant improvement in the sum-rate performance. Simulation results are presented to demonstrate the improved sum-rate and MSE performance of the proposed schemes and also to verify the analytical results.

Channel Estimator Designs for Emerging 5G New Radio Cellular Systems

Rakesh Munagala (IIT Kanpur, India)
Rohit Budhiraja (IIT Kanpur, India)

The 5G new radio (NR) cellular system transmits demodulation reference signals (DM-RS) for a user equipment (UE) to estimate the precoded channel. The DM-RS can be optionally transmitted at various

orthogonal frequency division multiplexing (OFDM) symbols. The 5G NR specifications does not explicitly tell how many number of DM-RS should be used, and needs to be decided by the system designers. In this work we design various channel estimators for the DM-RS and numerically analyze their performance. Based on the mean squared error (MSE) performance, we propose an algorithm to decide the number of DM-RS required at a particular UE speed.

Millimeter-Wave and Optical Communication

Session Chair : Adrish Banerjee, IIT Kanpur

February 22 | 11:50 am – 01:00 pm

Moitrayee Auditorium

Design and Analysis of 20-60 GHz Broadband Left Handed Metamaterial

Pallepogu Prasanna Kumar (IIITDM Kancheepuram, India)
Prerna Saxena (IIITDM Kancheepuram, India)

We present the design and characterization of a broadband left-handed metamaterial operating over 20-60 GHz. The proposed metamaterial unit cell comprises of a complementary split ring resonator along with an inverted-T shaped slot structure. The metamaterial cell demonstrates a reflection coefficient (S11) less than -20 dB and a transmission coefficient (S21) approximately 0 dB over the entire broadband frequency range of 20 GHz to 60 GHz. Parameter extraction procedures are used to validate the left-handed nature of the proposed metamaterial unit cell by uniquely determining refractive index, wave impedance, effective permeability, and effective permittivity from the complex S-parameters. The extracted permittivity, permeability and refractive index of the proposed metamaterial are found to be negative over the entire operating frequency range.

Technical Program-Oral

Non-uniform Amplitude Codebooks for MU-MIMO in Millimeter Wave Systems

Silpa Sanal Nair (IIT Madras, India)
Srikrishna Bhashyam (IIT Madras, India)

Beamforming using Discrete Fourier Transform (DFT) based codebooks is widely studied for millimeter wave (mmWave) communication systems. This design requires only phase-control for each antenna element and is therefore motivated by the possibility of lower complexity hardware. While this DFT-based design works well for single-user transmission, significant inter-beam interference is generated in multi-user multiple-input multiple-output (MU-MIMO) transmission. Recently, beamforming based on amplitude tapering has been demonstrated even for mmWave systems. The non-uniform amplitude in this design allows the possibility of significantly reducing inter-beam interference at the cost of slightly reducing the mainlobe gain. Since the amplitude tapering is fixed and designed offline, the additional implementation complexity is not very high. In this paper, we show that Dolph-Chebyshev and Taylor codebook designs can provide significant improvement in performance over DFT-based codebooks in full-dimension MU-MIMO settings. For the MU-MIMO, we also propose a per user power allocation algorithm for maximizing the sum rate under total power and rate constraints. The results show that the proposed algorithm gives high sum rates compared to equal power allocation among users. The simulations are carried out under the 3GPP full-dimension MIMO channel model.

Technical Program-Oral

On Visible Light Communication Using Soft Cancellation Decoder for Polar Codes

Nitin Jain (IIT Kanpur, India)
Adrish Banerjee (IIT Kanpur, India)

Visible light communication (VLC) uses run-length limited (RLL) code to avoid flickering and support different dimming ranges. In this paper, we design an error control coding scheme for VLC using polar code as a forward error correction (FEC) code in serial concatenation with a RLL code. We propose to use soft iterative decoding between RLL code and polar code. Extrinsic information transfer (EXIT) chart is also used to illustrate the proposed serial concatenated scheme's iterative decoding behavior. We will show improvement in bit error rate (BER) performance as compared to the hard decoding based polar code proposed in the literature for VLC.

STPM Based Performance Analysis of Finite-Sized Differential Serial FSO Network

Deepti Agarwal (IIT Jammu, India)

This paper analyzes the performance of serial decode-and-forward (DF) relay assisted free-space-optical (FSO) network with pointing errors and finite-sized receivers employing differential M-ary phase shift keying (DMPSK) data. The atmospheric fading optical links are modeled by unified Gamma-Gamma distribution subject to both heterodyne and intensity modulation/direct detection (IM/DD) techniques. In particular, we derive the average symbol error rate (SER) by utilizing symbol transition probability matrix (STPM) whose entries are the average symbol transition probabilities (ASTPs) of a relay. The ASTPs of single link STPM are then utilized to calculate the SER of serial DF relaying network. Further, the unified outage probability of considered network is obtained. The results indicate that the point receiver performance

is more affected with pointing error as compared to the finite-sized receiver. Further, it is showcased through results that when the number of serial relays increases, the improvement in error performance is more in case of heterodyne as compared to that of IM/DD.

Deep Learning and Pattern Recognition

Session Chair : Jayanta Mukhopadhyay, IIT Kharagpur

February 22 | 03:00 pm – 04:30 am

Gargi Auditorium

Forensic Detection of Median Filtering in Images Using Local Tetra Patterns and J-Divergence

Udayeni A (NIT Rourkela, India)
Manish Okade (NIT Rourkela, India)

This paper presents a novel application of local tetra patterns to the median filtering detection problem. The premise of the proposed method is based on the ability of the local tetra patterns in identifying the streaking fingerprints left over by the application of a median filter on an image. These streaking fingerprints serve as a clue in determining the authenticity of an image towards the application of a median filter. The streaking pixels are identified by establishing the relationship of every pixel with respect to its neighbouring pixels. The relationship is in the form of horizontal and vertical derivative directions and magnitudes followed by the tetra pattern and magnitude assignment. The feature vector generated utilizing the local tetra patterns is reduced by using the J-divergence in-order to keep the computational complexity low. Experimental testing for the proposed method along with comparative analysis carried out with existing state-of-the-art methods show good performance at reduced computational complexity for the proposed method.

Technical Program-Oral

Low-Rank Kernelized Graph-based Clustering Using Multiple Views

Supratim Manna (IIT Kharagpur, India)
Jessy Rimaya Khonglah (IIT Kharagpur, India)
Anirban Mukherjee (IIT Kharagpur, India)
Goutam Saha (IIT Kharagpur, India)

Kernelized methods using multiple kernels have shown better performances in graph-based clustering. But those kernelized methods get affected by the noise present in the data set. Also, only a single view has been used in those kernelized graph-based clustering methods. To address those issues, a novel low-rank multi-view multi-kernel graph-based clustering framework (LRMVMKC) has been proposed in this paper. Where the similarity nature of kernel matrices are exploited by low-rank optimal kernel learning and the clustering performances are boosted by using multiple views that provide different partial information about a given data set. The use of the proposed LRMVMKC framework on different benchmark data sets demonstrates the better performances of the proposed framework over other existing methods.

A Two Way Optimization Framework for Clustering of Images Using Weighted Tensor Nuclear Norm Approximation

Akhil Johnson (NIT Calicut, India)
Jobin Francis (NIT Calicut, India)
Baburaj M (Government College of Engineering Kannur, India)
Sudhish N George (NIT Calicut, India)

Clustering of multidimensional data has found applications in different fields. Among the existing methods, spectral clustering techniques have gained great attention due to its superior performance and low computational complexity. The clustering accuracy in spectral clustering methods depends on the affinity matrix learned from the data.

Technical Program-Oral

Traditional clustering techniques fail to capture the spatial aspects of the images since they vectorize the images. In the proposed approach, the images are stacked as lateral slices of a three-way tensor. Further, a two-way optimization problem is formulated to extract a sparse t-linear combination tensor. Weighted Tensor Nuclear Norm (WTNN) is introduced in the optimization problem for enhancing tensor sparsity, and thereby improving the clustering accuracy. The performance of the proposed method is evaluated on three popular datasets. The evaluation shows that the proposed method has superior performance over the state-of-the-art methods.

Dense Layer Dropout Based CNN Architecture for Automatic Modulation Classification

Dileep P (IIT Guwahati, India)
Dibyajyoti Das (IIT Guwahati, India)
Prabin Kumar Bora (IIT Guwahati, India)

Automatic modulation classification (AMC) is an integral part of signal identification employed in cognitive radio as well as military communication. The problem has been approached traditionally using either likelihood-based or feature-based methods. Since the problem is a classification task, a deep learning (DL) based approach can be an attractive solution. Recently convolutional neural network (CNN) based DL algorithms were introduced for AMC. The complex baseband signals that are represented as In-phase and Quadrature (IQ) samples are applied to train the CNN. We propose a new CNN architecture that significantly improves the classification accuracy over existing results in the literature while keeping the number of trainable parameters low.

Technical Program-Oral

Significance of Phase in DNN Based Speech Enhancement Algorithms

Polemoni Swetha Rani (IIT Hyderabad, India)
Sivaganesh Andhavarapu (IIT Hyderabad, India)
Sri Rama Murty Kodukula (IIT Hyderabad, India)

Most of the speech enhancement methods use the noisy spectrum to estimate the clean spectrum by using either spectral regression or spectral masking. Because of difficulty in processing the unstructured nature of the short time Fourier transform(STFT) phase, speech enhancement methods re-uses the noisy phase to re-synthesis the signal. However, with recent advancement in the deep neural networks (DNNs), phase processing is considered to be more important. In order to show the significance of phase in speech enhancement, we experimented with magnitude masking methods like spectral magnitude mask(SMM) for estimating the magnitude and different phase reconstruction methods like Griffin and Lim, minimum phase, noisy phase and the gold phase(clean phase) for phase reconstruction. The experimental results shows that enhanced magnitude using SMM with gold phase performance is outstanding compared to all of the other methods in all the objective measures. This shows the significance of the phase in the speech enhancement.

Technical Program-Oral

Signal Processing Theory and Methods

Session Chair : Chandra Murthy, IISc, Bangalore

February 22 | 03:00 pm – 04:30 pm

Moitrayee Auditorium

Block-Sparsity-Induced System Identification Using Efficient Adaptive Filtering

Bijit Kumar Das (IIIT Guwahati, India)
Arpan Mukherjee (IIT Kharagpur, India)
Mrityunjoy Chakraborty (IIT Kharagpur, India)

In this paper, we propose an efficient proportionate type block sparse LMS algorithm with a group zero-point attraction (GZA) penalty term for clustered sparse system identification. The proposed algorithm is based on the combination of a mechanism for proportionate gain control, and a mixed l2;0 norm regularization, and outperforms the existing class of block proportionate sparsity-induced algorithms. The performance analysis of the proposed algorithm is then carried out, providing limits to the mean deviation from the original system. We also propose an improved proportionate type block sparse adaptive filtering algorithm with modified gain control mechanism. This one is more robust to the varying degrees of sparsity in the system to be identified than the former. Numerical simulations to identify single and two clustered sparse systems using white, correlated, and speech signals manifest the superiority of the proposed algorithms.

Technical Program-Oral

SVR-Primal Dual Method of Multipliers (PDMM) for Large-Scale Problems

Lijanshu Sinha (Digital Design Engineer, Intel, India)
Ketan Rajawat (IIT Kanpur, India)
Chirag Kumar (IIT Kanpur, India)

With the advent of big data scenarios, centralized processing is no more feasible and is on the verge of getting obsolete. With this shift in paradigm, distributed processing is becoming more relevant, i.e., instead of burdening the central processor, sharing the load between the multiple processing units. The decentralization capability of the ADMM algorithm made it popular since the recent past. Another recent algorithm PDMM paved its way for distributed processing, which is still in its development state. Both the algorithms work well with the medium-scale problems, but dealing with large scale problems is still a challenging task. This work is an effort towards handling large scale data with reduced computation load. To this end, the proposed framework tries to combine the advantages of the SVRG and PDMM algorithms. The algorithm is proved to converge with rate O(1/K) for strongly convex loss functions, which is faster than the existing algorithms. Experimental evaluations on the real data prove the efficacy of the proposed algorithm over the state of the art methodologies.

RLS-Based Adaptive Time-Varying RCS Estimation and Imaging in MIMO Radar Systems

Archana Rawat (IIT Kanpur, India)
Saumya Dwivedi (Barkhausen Institut gGmbH, Germany)
Suraj Srivastava (IIT Kanpur, India)
Aditya K Jagannatham (IIT Kanpur, India)

This paper presents recursive least squares (RLS)- based adaptive techniques and the pertinent analysis for time-varying radar cross section (RCS) estimation along with 2D imaging in monostatic MIMO

radar systems. Initially, a block-RLS (BRLS) algorithm is developed for RCS estimation and 2D imaging for a scenario with an unknown number of targets present in the radar scanning region with unknown angles and ranges. This is followed by a fast BRLS (FBRLS) scheme, which has faster convergence with improved estimation as well as imaging performances in comparison to the BRLS. Convergence analysis for the resulting mean squared observation and estimation errors, as well as computational complexities of the proposed algorithms, are also presented. Finally, a simulation based comparative study illustrates the improved estimation, convergence and imaging performance of the proposed schemes in comparison to the existing LMS-based schemes, while also validating the analytical results.

Hankel Norm for Nonlinear Digital Systems with Hardware Limitations and External Input

Srinivasulu Jogi (IIITDM Kancheepuram, India)
Priyanka Kokil (IIITDM Kancheepuram, India)

This paper concerns the stability behavior of digital systems associated with hardware limitations and implicit nonlinearity. The proposed criterion can be devoted to nonlinear digital systems using overflow arithmetic and external input with an insight to minimize the unwanted memory effects due to previous actions on future outputs. With the established criterion, the reduction of undesired memory effects (system ringing) can be verified through Hankel norm performance of nonlinear digital systems and also the asymptotic stability without external input. In order to yield the optimum reduction of ringing, the work is formulated in linear matrix inequality (LMI)-constraints as convex optimization problem by using Lyapunov theory and Lipschitz condition. Finally, the efficacy and validity of proposed criterion is verified with a numerical example from real nonlinear physical system such as recurrent neural network.

Technical Program-Oral

Uniformly Most Powerful CFAR Test for Pareto-Target Detection in Pareto Distributed Clutter

John Bob Gali (IIT Kharagpur, India)
Priyadip Ray (IIT Kharagpur, India)
Goutam Das (IIT Kharagpur, India)

In the Radar context, Pareto distribution has been validated for both sea clutter and aircraft target under specific scenarios. Thereby, some heuristic CFAR processors appeared in the literature with the same form of adaptive thresholding that is derived for conventional exponential vs. exponential hypothesis testing (i.e., for detecting Swerling-I target in exponentially distributed clutter). Statistical procedures obtained under such idealistic assumptions cease to be optimal when applied to newer models esp. heavy tail distributions like Pareto. So, even to accommodate a wide range of application scenarios, in addition to Pareto modelled aircraft detection, we solve for heavy tail in Pareto vs. Pareto distributed lots from the composite hypothesis testing framework. Here, we derive the uniformly most power (UMP) test that complies constant-false-alarm-rate (CFAR) property, using the least favorable density (lfd) concept. We further validate CFAR property with respect to tail-index, from extensive simulation results, and attribute that the geometric mean (GM-) CFAR is the optimal test in UMP sense.

Technical Program-Oral

Wireless Networks - I

Session Chair : S. L. Maskara, (Ex.) IIT, Kharagpur

February 22 | 04:50 pm – 06:20 pm

Gargi Auditorium

Methods for Cellular Network's Operation in mmWave Unlicensed Bands

BhanuPrakash Ramisetti (IIT Hyderabad, India)
Abhinav Kumar (IIT Hyderabad, India)

The 3GPP is coming up with 5G New Radio (NR) mmWave based operations that will result in high data rates. To further satisfy the ever-increasing demand for data rates, 5G NR can also be operated on the mmWave unlicensed bands. In this direction, various channel access techniques that consider Listen Before Talk (LBT) and Listen Before Receive (LBR) have been proposed in the literature. However, a thorough comparison of these schemes for fair co-existence with Wireless Gigabit (WiGiG) in different scenarios is needed. Hence, in this paper, we compare the performance of a combination of omni-directional and directional channel access schemes with LBT/LBR/both in presence of a realistic mmWave array antenna pattern, 3GPP mmWave Indoor path loss model, and fixed backoff mechanism for collision avoidance. Through extensive simulations, we show that directional LBT combined with directional LBR and omni-directional LBT techniques perform better than other techniques in terms of sum rate, mean rate, and minimum rate in the system. Whereas, directional LBT performs better in terms of number of channel access and overall fairness in the system.

Technical Program-Oral

Mitigating Jamming Attacks in a MIMO System with Bursty Traffic

Sujatha Allipuram (IIT Kharagpur, India)
Shabnam Parmar (Intel Technology India Pvt. Ltd., Bangalore, India)
Parthajit Mohapatra (IIT Tirupati, India)
Nikolaos Pappas (Linköping University, Sweden)
Saswat Chakrabarti (IIT Kharagpur, India)

In this paper, we study the role of multiple antennas in mitigating jamming attack under Rayleigh fading environment with random arrival of data at the transmitter. The jammer is assumed to have energy harvesting capability with infinite battery size. The outage probabilities under jamming attack are derived for Rayleigh fading scenario with different assumptions on the number of antennas at the transmitter and receiver. The outage probability is also derived for the Alamouti space-time code under the jamming attack. The average service rate and delay performance of the system are characterized with random arrival of data and energy at the transmitter and jammer, respectively. The derived results help to explore the benefits of using multiple antennas in improving average service rate and delay of the system under jamming attack. It is also found that exploitation of space and time diversity with the use of space-time code can improve the performance of the system significantly even under the jamming attack.

Energy-efficient User-centric Dynamic Adaptive Multimedia Streaming in 5G Cellular Networks

Pradip Kumar Barik (IIT Kharagpur, India)
Chetna Singhal (IIT Kharagpur, India)
Raja Datta (IIT Kharagpur, India)

5G multimedia mobile wireless network is designed to support on-demand encoding of rich mobile multimedia content for heterogeneous users. Due to the heterogeneity of the users, adaptive multimedia

services are essential to provide a satisfactory quality of experience (QoE). In this paper, we propose a utility-based dynamic adaptive multimedia streaming scheme, named UDAS, for heterogeneous users that helps in extending the battery life of the low-battery users and also uses the bandwidth of the wireless channel efficiently. At each scheduling interval, the adaptation algorithm considers four utility functions of the user devices, namely, quality utility, power consumption utility, packet error ratio utility, and remaining battery utility to adapt the data rate dynamically. We formulate an optimization problem to maximize a joint utility function of these four utilities. The solution of the problem provides the best adaptive multimedia content that is selected for transmission to the end-users in every scheduling interval. The mobile edge computing (MEC) server situated at the base station performs an on-demand HEVC (high efficiency video coding) encoding of videos and select the best suitable videos for different users. Simulation results verify the improved performance of UDAS in terms of saved battery energy and the number of unserved low-battery users in comparison with state-of-the-art non-adaptive multimedia streaming schemes and a popular scheme ESDOAS from the literature.

Edge Nodes Placement in 5G Enabled Urban Vehicular Networks: A Centrality-based Approach

Moyukh Laha (IIT Kharagpur, India)
Suraj Kamble (IIT Kharagpur, India)
Raja Datta (IIT Kharagpur, India)

The next generation vehicular applications in smart cities, including aided self-driving, require intricate data processing and quick message exchanges. A pragmatic approach to address these requirements is to adopt the edge-computing paradigm from 5G architecture, where storage, computing, and networking resources are brought to the edge of the network, i.e., closer to the end-users. Edge nodes (EN) are geographically overlaid across a region, and therefore, the effectiveness

of the vehicular applications is directly associated with the proper placement of such nodes. However, the deployment of edge nodes on the roadsides presents a challenge of cost-effectiveness. In this paper, we address the efficient deployment of a limited number of edge nodes in an urban scenario under a restricted budget. To this end, we jointly consider the structural properties of the road network using complex-network based centrality metrics and the vehicular traffic distribution to rank the candidate sites for edge node placement. Thereafter, we formulate the problem of edge node deployment as a 0-1 knapsack problem which is a classical NP problem and provide a dynamic programming based solution to it. We evaluate the proposed method in an urban scenario with real traffic and present conclusive proof that our proposed scheme yields a practical solution of the defined problem.

Network Coding Assisted Reliable Multicasting in Multi-Hop Wireless Networks with Two Sources

Prateek Rathore (IIT Guwahati, India)
Kalpana Dhaka (IIT Guwahati, India)
Sanjay Kumar Bose (IIT Guwahati, India)

In this paper, we present a reliable multicasting technique for multi-hop networks when packets from two of the sessions are transmitted simultaneously. Our main aim is to optimally exploit network coding (NC) advantage for efficient packet transmission. For each multicasting session, Multicast Least Cost Anypath Routing (MLCAR) scheme is applied to select the forwarder set. We define a coding window (CW) at the intermediate nodes and packets present in them are combined using NC. These network coded packets formed at a node are then communicated to its neighbouring node such that all the destinations of the respective multicasting session receive the desired packets. The average cost of multicasting is obtained for the proposed Two-Source Multicasting using Network Coding (TSMNC) scheme through extensive simulations. The results are compared with those obtained on

considering the corresponding MLCAR approach. We observe that the considered scheme significantly improves the expected transmission count in a network.

Communication Theory

Session Chair : B. Sundar Rajan, IISc, Bangalore
February 23 | 10:00 am – 11:30 am
Gargi Auditorium

Secrecy at Physical Layer in NOMA with Cooperative Jamming

Shashibhushan Sharma (NIT Durgapur, India)
Sanjay Dhar Roy (NIT Durgapur, India)
Sumit Kundu (NIT Durgapur, India)

We have proposed and analyzed secrecy performance of a network architecture which contains a source, two destinations, a jammer and an eavesdropper (EAV). To jam the EAV in order to secure the confidential information of both users, the jammer sends a jamming signal while the source sends the combined information signal using non-orthogonal multiple access (NOMA) technique to both the users. A known jamming is considered which is known by both the users. Both the users subtract the known jamming from the received signal and then decode the information signal as per the NOMA technique. We analyzed the physical layer security of the network in terms of the secrecy outage probability (SOP) where the two users have different target secrecy rates. A closed form expression of the SOP is developed. We have analyzed the SOP under the impact of several numerical parameters such as: source transmit signal to noise ratio (SNR), jammer transmit SNR, fraction of source transmit power, and different target secrecy rates. For a fixed transmit SNR of the jammer, we obtain an optimal value of the source transmit SNR at which SOP is minimized. These analyzed results are also supported by the MATLAB based simulation results.

Technical Program-Oral

Noisy Deletion, Markov Codes and Deep Decoding

Avijit Mandal (IIT Madras, India)
Avhishek Chatterjee (IIT Madras, India)
Andrew Thangaraj (IIT Madras, India)

Motivated by emerging applications in bioinformatics, we study noisy deletion channels in a regime of practical interest: short code length, low decoding complexity, and low SNR. Our work is inspired by an important insight from information theory and Markov chains: appropriately parametrized Markov codewords can correct deletions and errors (due to noise), simultaneously. We extend this idea to practice by developing a low complexity decoder for short Markov codes, which displays competitive performance in simulations at {low SNRs}. Our decoder design strives to combine the uncanny ability of recurrent neural networks in recovering and predicting stochastic sequences with the assured performance of maximum a posteriori (MAP) decoders like the BCJR decoder.

Index Codes with Minimum Locality for Three Receiver Unicast Problems

Smiju K Joy (IIT Hyderabad, India)
Lakshmi Prasad Natarajan (IIT Hyderabad, India)

An index code for a broadcast channel with receiver side information is ‘locally decodable’ if every receiver can decode its demand using only a subset of the codeword symbols transmitted by the sender instead of observing the entire codeword. Local decodability in index coding improves the error performance when used in wireless broadcast channels, reduces the receiver complexity and improves privacy in index coding. The ‘locality’ of an index code is the ratio of the number of codeword symbols used by each receiver to the number message symbols demanded by the receiver. Prior work on locality in index coding

have considered only single unicast and single-uniprior problems, and the optimal trade-off between broadcast rate and locality is known only for a few cases. In this paper we identify the optimal broadcast rate (including among non-linear codes) for a class of unicast problems with three or fewer receivers when the locality is equal to the minimum possible value, i.e., equal to one. The index code that achieves this optimal rate is based on a clique covering technique which is well known. The main contribution of this paper is in providing tight converse results by relating locality to broadcast rate, and showing that this known index coding scheme is optimal when locality is equal to one. Towards this we derive several structural properties of the side information graphs of three receiver unicast problems, and combine them with information theoretic arguments to arrive at a converse.

Friendly Jammer Localization for Secrecy Enhancement

Ravikant Saini (IIT Jammu, India)
Deepak Mishra (University of New South Wales, Sydney, Australia)

This paper presents a joint resource sharing and jammer placement problem for a simple four node system including a source, a jammer and two untrusted users. Observing that the resource allocation involving subcarrier allocation, power allocation and jammer placement is complex due to their inter-dependence on each other, this work attempts to solve the problem in parts. First of all, key insights on optimal subcarrier allocation which is simply based on channel conditions is presented. Since, jammer has been introduced for secrecy performance improvement, the need for optimal power sharing between source and jammer is highlighted. Due to the consideration of sum power budget, the fraction in which power should be shared between signal and noise for maximizing sum secure rate is an important decision. Utilizing some key concepts, optimal power allocation based on alternating optimizations is presented. Further, insights on optimal placement of

jammer are presented to highlight whether jammer should be placed near the users or somewhere in between on the line joining the two users. All analytical concepts have been numerically verified and performance gain against bench-mark has been highlighted through simulation results.

Communicating with a Strategic Sender

Anuj Vora (IIT Bombay, India)
Ankur A. Kulkarni (IIT Bombay, India)

We consider a communication problem over a noise-less rate limited channel where the sender and receiver have misaligned objectives - the receiver wants to compute a function of the source, but the sender acts to maximize its own utility function. This setting is distinct from source coding since the sender and receiver are strategic agents and hence Shannon theory does not apply. We show that despite this, under certain conditions, reliable communication can be ensured. We pose the problem as a leader-follower game between the sender and receiver. We show that when the receiver is the leader, and the function is incentive compatible, every equilibrium of this game is an optimal code for the source-coding problem. This shows that the Shannon rate is a fundamental threshold for this communication. We show that the incentive compatibility condition, which has its origin in mechanism design theory, is also necessary for reliability. We also show that to ensure reliable communication, it is essential that the receiver is the leader, since the same may not be ensured when the sender is the leader.

Technical Program-Oral

Speech Classification and Understanding - II

Session Chair : T. S. Lamba, (Ex.) IIT Kharagpur

February 23 | 10:00 am – 11:30 am

Moitrayee Auditorium

Self Attentive Context Dependent Speaker Embedding for Speaker Verification

Sreekanth Sankala (RGUKT RK Valley, India)
Shaik Mohammad Rafi (IIT Hyderabad & IIIT RK Valley, RGUKT AP, India)
Sri Rama Murty Kodukula (IIT Hyderabad, India)

In the recent past, Deep neural networks became the most successful approach to extract the speaker embeddings. Among the existing methods, the x-vector system, that extracts a fixed dimensional representation from varying length speech segment, became the most successful approach. Later the c-vector system explicitly models the phonological variations in the x-vector framework and achieves a significant improvement over the x-vector system. Although the c-vector framework utilizes the phonological variations in the speaker embedding extraction process, it is giving equal attention to all the frames using the stats pooling layer. Motivated by the subjective analysis of the importance of nasals, vowels and semivowels for speaker recognition, we extend the work of c-vector system by including a multi-head self-attention mechanism. In comparison with the earlier subjective analysis on the importance of different phonetic units for speaker recognition, we also analyzed the attentions learnt by the network using TIMIT data. To examine the effectiveness of the proposed approach, we evaluate the performance of the proposed system on the NIST SRE10 database and gets a relative improvement of 18.19 \% with respect to the c-vector system on the short-duration case.

Technical Program-Oral

Comparison of Feature-Model Variants for coSpeech-EEG Classification

Rini A Sharon (IIT Madras, India)
Hema A Murthy (IIT Madras, India)

One of the most significant obstacles that must be overcome in pursuing the utilization of brain signals for device control is the formulation of a robust signal processing method that can extract event specific information from real-time EEG signals. Typical Brain Computer Interface systems comprise of signal acquisition, feature extraction and classification modules. The focus in this paper is to experimentally evaluate various feature extraction and classification modules to comparatively determine the best performing feature-model(FM) pair. Few popular FM variants are implemented to classify units from coSpeech-EEG data collected during speech audition, imagination and production. Performance variations across sessions and subjects are also studied to analyse scalability and robustness of the various FM pairs. Simultaneous diagonalization of multi-class common spatial patterns obtained on EEG data coupled with a Gaussian mixture model based Hidden Markov Model proves to be the best FM pair for the task at hand rendering an average accuracy much higher than chance across 30 subjects in a multi-unit classification problem.

Multilingual Speech Mode Classification Model for Indian Languages

Kumud Tripathi (IIIT Allahbad, India)
K. Sreenivasa Rao (IIT Kharagpur, India)

This paper explores the vocal tract and excitation source information for the multilingual speech mode classification (MSMC) task. MSMC is a language independent speech mode classification model that could detect the mode of speech utterance spoken in any language. Here,

we considered data of three broad modes of speech: conversation, extempore, and read from three Indian languages, namely, Telugu, Bengali, and Odia. The vocal tract information is captured using Mel-frequency cepstral coefficients (MFCCs). The pitch contour (PC) processed at the supra-segmental level represents the excitation source information. The MSMC system is developed using multilayer perceptron (MLP). The experimental results show that the vocal tract features provide better overall identification accuracy, compared to excitation source information. Further, an improvement in overall accuracy is achieved by combining the scores obtained by two separate MSMC model based on excitation source and vocal tract features. The results generated using a combined score outperform the model developed using the standard vocal tract feature.

Study on the Effect of Emotional Speech on Language Identification

Priyam Jain (IIIT Hyderabad, India)
Krishna Gurugubelli (IIIT Hyderabad, India)
Anil Kumar Vuppala (IIIT Hyderabad, India)

Identifying language information from speech utterance is referred to as spoken language identification. Language Identification (LID) is essential in multilingual speech systems. The performance of LID systems have been studied for various adverse conditions such as background noise, telephonic channel, short utterances, so on. In contrast to these studies, for the first time in the literature, the present work investigated the impact of emotional speech on language identification. In this work, different emotional speech databases have been pooled to create the experimental setup. Additionally, state-of-art i-vectors, time- delay neural networks, long short term memory, and deep neural network

x-vector systems have been considered to build the LID systems. Performance of the LID system has been evaluated for speech utterances of different emotions in terms of equal error rate and C_avg. The results of the study indicate that the speech utterances of anger and happy emotions degrades performance of LID systems more compared to the neutral and sad emotions.

Spectral Features Derived from Single Frequency Filter for Multispeaker Localization

Sushmita Thakallapalli (IIIT Hyderabad, India)
Sudarsana Reddy Kadiri (Aalto University, Finland)
Suryakanth Gangashetty (IIIT Hyderabad, India)

In this paper, we present a multispeaker localization method using the time delay estimates obtained from the spectral features derived from the single frequency filter (SFF) representation. The mixture signals are transformed into SFF domain from which the temporal envelopes are extracted at each frequency. Subsequently, the spectral features such as mean and variance of temporal envelopes across frequencies are correlated for extracting the time delay estimates. Since these features emphasize the high SNR regions of the mixtures, correlation of the corresponding features across the channels leads to robust delay estimates in real acoustic environments. We study the efficacy of the developed approach by comparing its performance with the existing correlation based time delay estimation techniques. Both, a standard data set recorded in real-room acoustic environments and simulated data set are used for evaluations. It is observed that the localization performance of the proposed algorithm closely matches the performance of a state-of-the-art correlation approach and outperforms other approaches.

Technical Program-Oral

Image and Video Processing

Session Chair : P. K. Biswas, IIT, Kharagpur
February 23 | 10:00 am – 11:30 am
NKN Studio, GSSST

Evaluating the Impact of Region Based Content Popularity of Videos on the Cost of CDN Deployment

Prateek Yadav (IIT Delhi, India)
Subrat Kar (IIT Delhi, India)

We investigate the impact of the content popularity of video streams in a local region and its impact on the CDN deployment cost. We have gathered real-world data from four popular classroom video streaming sites and analyzed the content caching to optimize the CDN deployment. Our traces contain metadata of around 31 thousand educational videos and approximately 100 million views in the education category of YouTube. From this analysis, we assert that region based content (e.g., NPTEL, India) follows Zipf law with low popularity exponent, and it is the region-based content popularity which most significantly impacts the CDN deployment cost.

Exploiting Low Rank Prior for Depth Map Completion

Sukla Satapathy (IIT Kharagpur, India)
Rajiv Sahay (IIT Kharagpur, India)

Occurrence of missing data in depth maps either captured by active sensors or estimated by different passive computer vision algorithms, is unavoidable due to several reasons. The task of depth inpainting from a single degraded depth map is more challenging as compared to using

multiple depth observations or RGB-D data. Recently, low rank techniques have become popular and shown supremacy over several state-of-the-art techniques for image deblurring, denoising, upsampling, etc. Since completion of missing regions in a given degraded depth observation is a severely ill-posed problem, low rank property of the inpainted depth map can be posed as the regularization constraint. We perform several experiments to show the superiority of the proposed method over the state-of-the-art depth inpainting techniques.

Kinect Based Frontal Gait Recognition Using Skeleton and Depth Derived Features

Manasa Gowri Hebbur Sheshadri (NIT Rourkela, India)
Manish Okade (NIT Rourkela, India)

Recognizing humans through gait has been an emanant biometric technology in the recent years owing to the fact that it is unobtrusive since it does not require a subject's cooperation. This paper investigates Kinect based gait recognition of human subjects for surveillance applications especially in narrow corridor and airport scenarios where only the frontal views are available. Two features namely skeleton size feature and projectile motion feature extracted from skeleton data and one feature derived by segmenting the depth data using superpixels followed by SURF descriptor extraction are utilized in a hierarchical framework to obtain the closest matching subject for recognition purposes. The proposed method provides considerable increase in the recognition accuracy along with being computationally efficient in comparison to state-of-the-art gait recognition approaches.

Technical Program-Oral

No-reference Video Quality Assessment (VQA) Using Novel Inter Sub-band 3-D DWT Features

Anish Kumar Vishwakarma (VNIT, Nagpur, India)
Kishore Bhurchandi (VNIT, Nagpur, India)

Major goal of blind video quality assessment (VQA) is to predict visual quality of videos for enhancing the quality of service (QoS) without any reference. However, the conventional VQA model uses video as a two-dimensional image sequence and extracts the features on a frame to frame basis; which completely neglects temporal nature of the video data and the corresponding distortion content as well. In this work, we come up with a novel no-reference VQA model that describes and exploits the inter sub-band statistics of the three-dimensional discrete wavelet transform (3-D DWT) coefficients of video blocks. First, the 3-D DWT transform decomposes the video block of selected size into eight 3-D DWT sub-bands. Then we propose various novel statistical features using the sub-band coefficients. Inter sub-band statistics depicts the spread of the various frequency components and correlation between them. 3-D DWT features automatically take care of the temporal distortions along with spatial distortions and subsequently the support vector regression (SVR) model estimates them to predict the visual quality score of distorted videos. Experimental results on LIVE database demonstrate the superiority of the proposed VQA model over the other state-of-the-art methods.

Technical Program-Oral

On the Latency in Vehicular Control Using Video Streaming over Wi-Fi

Pratik Sharma (IISc Bangalore, India)
Devam Awasare (IISc Bangalore, India)
Bishal Jaiswal (IISc Bangalore, India)
Srivats Mohan (IISc Bangalore, India)
Abinaya N (IISc Bangalore, India)
Ishan Sandeep Darwhekar (IISc Bangalore, India)
Anand Svr (IISc Bangalore, India)
Bharadwaj Amrutur (IISc Bangalore, India)
Aditya Gopalan (IISc Bangalore, India)
Parimal Parag (IISc Bangalore, India)
Himanshu Tyagi (IISc Bangalore, India)

We consider the use of Wi-Fi (IEEE 802.11n/r) network for remote control of a vehicle using video transmission on the uplink and control signals for the actuator on the downlink. We have setup a network with multiple access points (AP) providing indoor and outdoor coverage, which connects an unmanned ground vehicle (UGV) to a remote command center. Additionally, our setup includes a redundant IEEE 802.11p link for sending control messages over downlink with high reliability and low latency. We study the end-to-end communication delay and complete a latency profiling for each sub-component, including the video codec and the Wi-Fi links. Furthermore, we provide guidelines for practical design choices including the optimal configuration of the scanning process during handoffs and the codec parameters for delay optimization. Overall, our proposed configuration reduces the end-to-end delay significantly in comparison with the default configuration.

Technical Program-Oral

Deep Neural Networks

Session Chair : Anirban Mukherjee, IIT Kharagpur
February 23 | 11:50 am – 01:20 pm
Gargi Auditorium

Frontal Facial Expression Recognition Using Parallel CNN Model

Sagar Deep Deb (IIT Patna, India)
Fazal Ahmed Talukdar (NIT Silchar, India)
Manish Sharma (NIT Silchar, India)
Chandrajit Choudhury (NIT Silchar, India)
Rabul Hussain Laskar (NIT Silchar, India)

Facial expression recognition is one of the very important research topics in computer vision. Studies on nonverbal communication have shown that 55% of intentional information is conveyed through facial expressions. Expression recognition has recently found a lot many applications in medical and advertising industries. In this paper we have proposed a parallel Convolutional Neural Network (CNN) structure for detection of expression from frontal faces. The CNNs are trained on two most important sub facial patches. The overall feature vector will be the features concatenated from the parallel models. We have experimentally found applying such a strategy provides better results than the models which take the entire facial image. We have also compared our performance with other benchmark CNN structures like AlexNet and VGG16.

Technical Program-Oral

MIC-GAN: Multi-view Assisted Image Completion Using Conditional Generative Adversarial Networks

Gagan Kanojia (IIT Gandhinagar, India)
Shanmuganathan Raman (IIT Gandhinagar, India)

Consider a set of images of a scene captured from multiple views with some missing regions in each image. In this work, we propose a convolutional neural network (CNN) architecture which fills the missing regions in one image using the information present in the remaining images. The network takes the set of images and their corresponding binary maps as inputs and generates an image with the completed missing regions. The binary map indicates the missing regions present in the corresponding image. The network is trained using an adversarial approach and is observed to generate sharp output images qualitatively. We evaluate the performance of the proposed approach on the dataset extracted from the standard dataset, MVS-Synth. To the best of our knowledge, we propose the first learning-based technique which utilizes information from multiple views for image completion.

Semantic Segmentation Based Hand Gesture Recognition Using Deep Neural Networks

H Pallab Jyoti Dutta (IIT Guwahati, India)
Debajit Sarma (IIT Guwahati, India)
Manas Kamal Bhuyan (IIT Guwahati, India)
Rabul Laskar (NIT Silchar, India)

The ability to discern the shape of hands can be a vital issue in improving the performance of hand gesture recognition. Segmentation itself is a very odd problem having various constraints like illumination variation, complex background etc. The objective of the paper is to incorporate the perception of semantic segmentation into a classification problem and make use of the deep neural models to achieve improved results.

This paper utilizes the UNET architecture to obtain the semantically segmented mask of the input, which is then given to a VGG16 model for classification. Here the top classifier layer of the VGG16 model is replaced with a classifier designed specifically for classifying the gestures at hand. The Brazilian Sign Language database used in the paper contains about 9600 images. Data augmentation process is used in preprocessing to generate sufficient number of training images for the aforementioned CNN-based models. A significant and improved average recognition rate of 98.97% is achieved through inherent feature learning capability of CNN and refined segmentation for 34 classes."

Underwater Image Recognition Detector Using Deep ConvNet

Dhana Lakshmi M (SSN College of Engineering, India)
Sakthivel Murugan Santhanam (SSN College of Engineering, India)

Underwater navigation and intelligent object recognition require robust machine learning algorithms to operate in turbid water. Modern life created the man-made pollution in oceans, rivers, and lakes, which contaminate our water resources. Despite environmental regulations solid waste in the form of trash, litter and garbage are thrown directly into sea spoiling the existence of underwater living creatures. The underwater vehicle can be used for survey purposes. The key challenge of underwater image-based localization comes from the unstructured nature of the seabed terrain. So, there is a need for robust detection of the features in such environments is essential. Hence, this paper proposes the automated multi-class underwater image recognition detector for submersible imagery. We train a Convolutional neural Network (ConvNet) to classify input 64 × 64 images and considered the classifier as an object feature detector. The features of the image from background underwater-bed can be extracted and forward into a network. The output of the three-layer ConvNet with deeply connected network results in a probability distribution over N classes. A Stochastic gradient descent with ADAM optimizer uses the squared gradients to

scale the learning rate and reduces the difference between the actual and predicted output. The evaluations are done on the precision, recall, F-Score, Macro and Weighted Average accuracy for both the detectors. It is observed that our proposed network, achieved an overall accuracy of 93.9 % for correct detections with a binary detector and 90.1% with a multiclass detector compared to existing detectors.

Aerial Multi-Object Tracking by Detection Using Deep Association Networks

Ajit Jadhav (IIIT Sri City, India)
Prerana Mukherjee (IIT Delhi, India)
Vinay Kaushik (IIT Delhi, India)
Brejesh Lall (IIT Delhi, India)

A lot a research is focused on object detection and it has achieved significant advances with deep learning techniques in recent years. Inspite of the existing research, these algorithms are not usually optimal for dealing with sequences or images captured by drone-based platforms, due to various challenges such as view point change, scales, density of object distribution and occlusion. In this paper, we develop a model for detection of objects in drone images using the VisDrone2019 DET dataset. Using the RetinaNet model as our base, we modify the anchor scales to better handle the detection of dense distribution and small size of the objects. We explicitly model the channel interdependencies by using ""Squeeze-and-Excitation"" (SE) blocks that adaptively recalibrates channel-wise feature responses. This helps to bring significant improvements in performance at a slight additional computational cost. Using this architecture for object detection, we build a custom DeepSORT network for object detection on the VisDrone2019 MOT dataset by training a custom Deep Association network for the algorithm.

Technical Program-Oral

Bio Signal Processing - II

Session Chair : Sudipta Mukhopadhyay, IIT Kharagpur

February 23 | 11:50 am – 01:20 am

Moitrayee Auditorium

Application of Kohonen-Self Organizing Map to Cluster Drug Induced Ca2+ Response in Hippocampal Neurons at Different Drug Dose

Abha Saxena (IIT Hyderabad, India)
Vaibhav Dhyani (IIT Hyderabad, India)
Soumya Jana (IIT Hyderabad, India)
Lopamudra Giri (IIT Hyderabad, India)

Recent advancement in neuronal imaging leads to an accurate measurement of cellular activity after treatment with drugs. However, neuronal activity obtained by dynamic imaging being complex temporal patterns, the prediction of activity level corresponding to drug level remains challenging. In this context, we apply SOM to estimate the drug dose according to the neuronal activity level in four different time windows. Here we cluster the neuronal activity pattern and classify the activity pattern with drug dose. We also implement supervised SOM to predict the drug dose corresponding to the activity pattern. The advantage of using SOM is that it is a great visualization and prediction tool to analyze high-dimensional data onto a low-dimensional (1D or 2D) SOM grid. Such a computational tool can be used to classify unknown neuronal responses according to the extent of the drug level present in the system.

Technical Program-Oral

P300 Based Stereo Localization of Single Frequency Audio Stimulus

Sidharth Aggarwal (IIT Madras, India)
Rini A Sharon (IIT Madras, India)
Hema A Murthy (IIT Madras, India)

P300 is widely used for developing Brain-Computer Interfaces (BCIs) and also in clinical applications for research and diagnosis. In this study, a novel way of performing oddball paradigm by stereo-localization of single frequency audio stimulus is proposed. In the proposed stereo oddball technique, a single frequency audio stimulus is presented to the subject in alternating ears with one ear being the target and the other non-target. Non-target is presented more often than target. The experiments are conducted for two configurations, left (target) - right (non-target) and right (target) - left (non-target). Non- invasive Electroencephalogram (EEG) signals are collected for the above mentioned protocol and the P300 component is detected using event-related potentials (ERPs) and analyzed. The proposed Stereo oddball technique is also compared with classical (target and non-target are beeps of different frequency) oddball technique, where the stimulus is presented simultaneously to both ears. The P300 responses are also analyzed using both temporal regions individually. Despite differing inputs(single frequency and dual frequency), similar P300 responses are observed for stereo localized and binaural stimuli presentations.

Technical Program-Oral

Twin Deep Convolutional Neural Network Based Cross-spectral Periocular Recognition

Sushree Sangeeta Behera (IIT Bhubaneswar, India)
Bappaditya Mandal (Keele University, UK)
Niladri Puhan (IIT Bhubaneswar, India)

Recognition of individuals using periocular information has received significant importance due to its advantages over other biometric traits such as face and iris in challenging scenarios where it is difficult to acquire either full facial region or iris images. Recent surveillance applications give rise to a challenging research problem where individuals are recognized in cross-spectral environments in which a probe infra-red (IR) image is matched with a gallery of visible (VIS) images and vice versa. Cross-spectral recognition has been studied mostly for face and iris traits over the past few years; however, the performance of periocular biometric in the cross-spectral domain still needs to be improved. In this paper, we propose a twin deep convolutional neural network (TCNN) with shared parameters to match VIS periocular images with those of near IR (NIR) ones. The proposed TCNN finds the similarity between the VIS and NIR image pairs applied at its input rather than classifying them into a certain class. The learning mechanism involved in this network is such that the distance between the images corresponding to the genuine pairs is reduced and that of the imposter pairs is maximized. Based on the experimental results and analysis on three publicly available cross-spectral periocular databases, the TCNN achieves the state-of-the-art recognition results.

Technical Program-Oral

Design of a 3-Bit Chipless RFID Tag Using Circular Split-Ring Resonators for Retail and Healthcare Applications

Durga Prasad Mishra (NIT Rourkela, India)
Tanmaya Kumar Das (NIT Rourkela, India)
Santanu Kumar Behera (NIT Rourkela, India)

Chipless radio frequency identification (RFID) has emerged as an advanced, wireless, non-line-of-sight, data capturing and tracking radio communication technology. Now tagging technology is getting more efficient than optical barcodes. RFID technology has appeared as a promising alternative to replace optical barcodes. Based on the presence of application specific integrated circuit (ASIC), it is classified as chipped and chipless RFID. Till now chipless RFID systems cannot compete with chipped RFID in terms of information storage capability, size, and tracking distances. One of the most valid reason that hinders the mass production of RFID tag is its cost which is due to the semiconductor unit present in the tag. Therefore, research has been focused on developing low-cost chipless RFID tags. Here circular split-ring resonator (SRR) based 3-bit chipless RFID tag is proposed, fabricated and analyzed. The performance characteristics are obtained through design and simulation using CST Microwave Studio and validated through measurements. Based on measurement results, the tag can provide a maintenance-free environment for wireless applications, viz. goods tracking, identity detection and healthcare applications.

Technical Program-Oral

Biomedical CT Image Retrieval Using 3D Local Oriented Zigzag Fused Pattern

Rakcinpha Hatibaruah (Tezpur University, India)
Vijay Nath (Tezpur University, India)
Deepika Hazarika (Tezpur University, India)

In this paper, we introduce a new feature descriptor 3D local oriented zigzag fused pattern (3D-LOZFP) for retrieval of medical CT images. The existing local patterns such as local binary pattern (LBP), local tetra pattern (LTrP) etc. captures the relationship between the reference and its surrounding pixels in a circular fashion in a 2D plane. The proposed descriptor encodes the relation between the reference pixel and its neighbouring pixels using three unique 3D zigzag patterns in four different directions in a 3D plane. Therefore a total of 12 effective 3D zigzag patterns are introduced to capture the relationship between the reference and its neighbours in a 3D plane. The 3D plane is constructed by passing the input image through a Gaussian filter bank producing multiple filtered images containing multi-scale information. The feature dimensions are reduced using quantization and a fusion based scheme. The retrieval performance of the proposed descriptor is investigated by conducting experiments on two benchmark CT image datasets and then compared it with several recent techniques. The experimental results in terms of average retrieval precision (ARP) and average retrieval recall (ARR) across two databases validate the retrieval supremacy of the proposed descriptor over other techniques in CT image retrieval.

Technical Program-Oral

Wireless Networks - II

Session Chair : S. L. Maskara, (Ex.) IIT, Kharagpur
February 23 | 11:50 am – 01:20 pm
NKN Studio, GSSST

Outage Analysis of mmWave Integrated Device-to-Device Communication System Under Nakagami Fading Channel

Ratnakant Govenker (BITS Pilani Goa, India)
Atharva Phatak (BITS Pilani Goa, India)
Rahul Bajpai (BITS Pilani Goa, India)
Naveen Gupta (BITS Pilani Goa, India)

Millimeter-wave (mmWave) communication has emerged as a promising candidate to meet the capacity demand in highly dense indoor environments for the next-generation cellular networks. Utilization of directional mmWave for D2D communication systems provides low powered, high data rate transmission with manageable interference. In this paper, the rate and outage probability for mmWave integrated D2D communication system under Nakagami-m fading channel are derived. The performance of the model is analyzed by obtaining the closed-form expressions for the outage probability of a D2D user, wherein multiple cellular or D2D users are interfering with a mmWave integrated D2D transmission. The impact of various system parameters such as sectored beamforming gain probabilities and distance from interfering nodes on D2D outage probability are also investigated. Results show that the D2D outage probability decreases with an increase in main lobe gain, whereas increases with an increase in side lobe gain.

Technical Program-Oral

Performance Analysis of Cooperative NLOS UVC System with Receiver Diversity

Kamal K Garg (IIT Indore, India)
Vimal Bhatia (IIT Indore, India)

Ultraviolet (UV) communication with its ability to operate non-line-of-sight (NLOS) mode offers several advantages as compared to the conventional optical wireless communication systems (OWC). NLOS UV communication (UVC) relaxes the pointing, acquisition and tracking (PAT) requirement; and also experiences extremely less background noise at earth surface due to the absorption of solar radiation by the ozone layer. Due to very small wavelength, UV signal strongly interacts with atmospheric particles and aerosols, thereby resulting in strong scattering and NLOS connectivity. The NLOS UVC, however, suffers with very high path loss and turbulence induced fading whose effects become more severe for large communication distance. In this work, we address these challenges by introducing a NLOS UVC system which incorporates relay to extend the communication distance and multiple receiver branches at the destination to mitigate the effect of fading. Performance analysis of the considered system model leads to deriving novel closed-form expressions for the outage probability and average symbol error rate. We evaluate the system performance for different configuration parameters and modulation formats. Correctness of the derived analytical expressions is validated through Monte-Carlo simulations.

Technical Program-Oral

Throughput of an Energy-Harvesting UAV Assisted Cognitive Radio Network

Abhijit Bhowmick (VIT Vellore, India)
Sanjay Dhar Roy (NIT Durgapur, India)
Sumit Kundu (NIT Durgapur, India)

The performance of an unmanned aerial vehicle (UAV) assisted energy harvesting cognitive radio (CR) network is studied in this paper. The UAV is a CR enabled device, rotates around a primary user (PU) at a certain height for sensing the PU channel and forwards the information of a CR source to the corresponding CR destination in absence of PU. One rotation period of the UAV is divided in three sub-periods: harvesting period, sensing period and transmission period. The functionalities (sensing and information forwarding) of the UAV depend on the harvested energy from radio frequency (RF) signal of the CR source while a dedicated battery is used to take care of its mobility. The performance of the UAV is investigated for two schemes: (i) without cooperation of the ground node and (ii) with cooperation from the ground node. Novel analytical expressions for the overall sensing decisions, and throughput are developed. The performance is investigated in terms of false alarm, detection probability and throughput for several parameters such as velocity of CR, and radius of the UAV trajectory.

Technical Program-Oral

Outage Performance of Cognitive Relay Networks with Optimal Relay and Antenna Selection

Priyanka Das (IIIT Bangalore, India)

Cooperative relaying and multiple-input multiple-output (MIMO) transmission technologies exploit spatial diversity to improve the performance of the secondary users in an underlay cognitive radio network. We consider a multiple-relay cognitive MIMO network that is subject to a peak interference power constraint and a peak transmit power constraint. We present an optimal relay and antenna selection scheme, which jointly selects a relay between a secondary source and a destination, a transmit antenna at the source, and a receive antenna at the destination to maximize the end-to-end signal-to-interference-plus-noise ratio (SINR) at the destination. To demonstrate the advantages of our proposed framework, we derive exact closed-form expression for the outage probability of the secondary network under non-identically distributed Rayleigh fading channels. We also derive insightful expressions for the asymptotic outage probability for high SINR. Several important design insights are reached when both fixed and proportional interference power constraints are employed to limit the interference at the primary user's receiver. Under the proportional interference power constraint, the full diversity order is achieved. Under the fixed interference power constraint, the diversity gain is lost. We then consider a practical scenario in which the secondary users have only the mean channel power gains of the interference links to the primary receiver. The secondary source and the selected relay control their transmit powers in order to satisfy an interference outage constraint for the primary receiver. Under this scenario, we also provide an expression for the outage probability of the secondary network for the optimal relay and antenna selection scheme. Our analytical results, which are validated with simulations, show the effective impact of the proposed model on enhancing the overall system performance.

Technical Program-Oral

Average Rate of Optimal Incremental Relaying with Selection: Analysis and Insights

Priyanka Das (IIIT Bangalore, India)

Incremental relaying (IR) has been widely studied in the cooperative communications literature in order to trade-off between the improved signal-to-noise-ratio (SNR) and spatial diversity provided by a relay, and the additional time required by it to forward data to a destination. When multiple relays are present, several variants of IR with relay selection (RS) have been proposed and analyzed. These select one among the available relays to forward data only if the SNR of the source-to-destination (SD) link is either less than a threshold or less than the end-to-end SNR of at least one of the relays. However, an in-depth analysis of the average rate of the rate-optimal RS rule for IR, which turns out to be a non-linear function of the SNR of the SD link, and insights into its behavior are not available in the literature. We derive novel, closed-form expressions for this important performance metric. We further develop an insightful asymptotic analysis that helps to quantify the rate gain over direct transmission and characterizes the effect of various system parameters. We also extensively benchmark the performance of the rate-optimal RS rule against several IR variants proposed in the literature. We present numerical results to verify the analysis and show the impact of imperfect channel state information.

Technical Program-Oral

Microwave Communication

Session Chair : Ajoy Chakraborty, (Ex.) IIT, Kharagpur
February 23 | 02:20 pm – 03:50 pm
Gargi Auditorium

Design of a Modified Inscribed Square Fractal Antenna for Wideband Wireless Applications

Rupa Samyuktha Kotla (NIT Rourkela, India)
Tanmaya Kumar Das (NIT Rourkela, India)
Santanu Kumar Behera (NIT Rourkela, India)

This paper investigates a modified inscribed square fractal antenna dedicated to wideband wireless applications. The proposed antenna consists of a fractal monopole radiator with a defected ground structure fabricated on a low-cost FR4 epoxy substrate. A prototype has been fabricated to verify the wide operating band of the proposed design (5 GHz-13.7 GHz). The simulated 2D radiation patterns exhibit omnidirectional characteristics throughout the wide operating band. The proposed design is having a dimension of 0.32λ×0.21λ×0.026λ (λ represents the wavelength at the lowest cut off frequency) and is found compact related to some recent designs. With the peak realized gain of 5.23 dBi, the proposed design can be suitable for ISM band, WLAN, X-band, and UWB applications.

Technical Program-Oral

A Compact Circularly Polarized Antenna for Human Activity Classification

Neha Y Joshi (VNIT, Nagpur, India)
Paritosh Peshwe (VNIT, Nagpur, India)
Ashwin Kothari (VNIT, Nagpur, India)

In the present work, a dual feed, compact circularly polarized antenna is designed for activity classification purpose. It consists of a circular ring on the top of the substrate which acts as the radiating patch. The ground plane exactly compliments the patch and thus is a circle with radius equal to inner radius of the ring. A rectangular stub is added to the ground plane for impedance matching. The antenna has been fabricated and the measured results are in very good agreement with the simulations. Excellent circular polarization performance is observed in the antenna which is highly desirable for the intended application. The transmission and reflection co-efficient of the antenna are a function of motion activities. This is due to specific obstruction of EM waves by the antenna when involved in performing daily human activities. Datasets have been collected by actual activity performance involving the fabricated antenna. Specific and distinct signatures of S11 parameter have been obtained for different activities. Thus, the antenna can be used for activity classification purpose.

Design and Development of 6 dB Microstrip Directional Coupler at C-Band Using Defective Ground for Tracking Application

Nupur Sood (DRDO, India)
Umesh Bahuguna (DRDO, India)
Pinaki Sen (DRDO, India)

This paper describes the design and development of 6 dB microstrip directional coupler at C-band using Defective Ground Structure (DGS). The required defective ground effect has been implemented using floating ground structure along with stubs for optimization of coupling

as well as return loss over 200 MHz of bandwidth. The measured results show that the designed coupler achieved a coupling of approximately 7 dB at 4.5 GHz with an isolation of ≥ 25 dB and return loss of ≥ 25 dB over 200 MHz bandwidth. This coupler has been used for tracking application in monopulse scan converter with the provision of scanning in azimuth direction.The measured modulation depth for the scan converter was ≥ 75% with variation less than 18% for 200 MHz of bandwidth.

A Comparative Analysis Between Circuit Analog and Capacitive Circuit Based Broadband Absorbers

Gaurav Singh (IIT Indore, India)
Saptarshi Ghosh (IIT Indore, India)

This paper presents two broadband absorber structures based on circuit analog (CA) and capacitive circuit (CC) concepts. Each of the proposed designs is made of multiple resistive layers separated by an air spacer and terminated by a ground plane. The CA structure employs square resistive loops printed on dielectric substrates, whereas square resistive patches are being used in the CC geometry. The proposed CA absorber exhibits 142.08% absorption bandwidth (for absorptivity > 90%) at the expense of a large thickness (0.296 times lambda, lambda being the wavelength corresponding to the centre absorption frequency). On the other hand, the CC absorber provides 76.41% absorption bandwidth corresponding to a thinner substrate (0.135 lambda). Both the designs are polarization-independent and angularly stable, despite having small profile, low resistance, and simple design. A comparison has also been made between the CA and CC concepts, thereby highlighting their performances over one another.

Technical Program-Oral

A Polarization-Independent Frequency Selective Surface Based Switchable Absorber / Rasorber

Vishal Rathore (IIT Indore, India)
Saptarshi Ghosh (IIT Indore, India)

This paper presents a frequency selective surface (FSS) based active design, which exhibits switchability between an absorber and a rasorber structure. Active components p-i-n diodes are symmetrically mounted in the geometry to realize the switching activity. For absorption, it adopts the concept of a circuit analog absorber during ON state, whereas for rasorber, an additional transmission window along with the broadband absorption is obtained during OFF state. The absorption band lies from 5.04 to 11.38 GHz for both the states, covering C and X bands in the spectrum, while the OFF-state transmission band is appearing at 2.82 GHz in the rasorber. Further, the proposed topology is four-fold symmetric and exhibits polarization-insensitive responses, unlike the earlier switchable rasorber structures. A possible realization of the proposed geometry, through establishment of the biasing network, has also been provided.

Technical Program-Oral

Network Application

Session Chair : S. S. Pathak, IIT Kharagpur
February 23 | 02:20 pm – 03:50 pm
Moitrayee Auditorium

Performance Analysis of NOMA Aided Cooperative Relaying over \(alpha-eta-kappa-mu\) Fading Channels

Brijesh Soni (School of Engineering and Applied Science, Ahmedabad University, India)
Dhaval Karshanbhai Patel (School of Engineering and Applied Science-Ahmedabad University, India)
Yong Liang Guan (Nanyang Technological University, Singapore)
Sumei Sun (Institute for Infocomm Research, Singapore)
Yoong Choon Chang (Universiti Tunku Abdul Rahman, Malaysia)
Joanne Mun Yee Lim (Monash University, Malaysia)

In this paper, we investigate the outage analysis of Millimeter wave (mmWave) non-orthogonal multiple access (NOMA) based cooperative relaying system. We consider that the source communicates with user equipment with the aid of decode and forward relay using power domain downlink NOMA, and by sending messages in two time slots. Moreover, the \(alpha-eta-kappa-mu\) fading channel is considered between source, relay and user equipment, which is recently proposed in literature as a good fit model for mmWave communication. To this end, we derive the analytical expression for outage probability in terms of channel fading parameters. In order to gain insights at high SNR, asymptotic analysis for outage probability is carried out. Furthermore, analysis of achievable sum rate is also studied. Findings suggest that the considered channel model provides comparative diversity gain than the other fading channels. Proposed analytical expressions are verified by Monte Carlo simulations. We observe that at high SNR, diversity order depends only on the number of the scattered clusters and on the non linearity of the medium i.e. diversity order is (\alpha.\mu /2\).

Technical Program-Oral

Internet of Things-Enabled Overlay Satellite-Terrestrial Networks in the Presence of Interference

Pankaj Kumar Sharma (NIT Rourkela, India)
Budharam Yogesh (NIT Rourkela, India)
Deepika Gupta (DSPM IIIT, Naya Raipur, Chhattisgarh, India)

In this paper, we consider an overlay satellite-terrestrial network (OSTN) where an opportunistically selected terrestrial IoT network assist primary satellite communications as well as access the spectrum for its own communications in the presence of combined interference from extra-terrestrial and terrestrial sources. Hereby, a power domain multiplexing is adopted by the IoT network by splitting its power appropriately among the satellite and IoT signals. Relying upon an amplify-and-forward (AF)-based opportunistic IoT network selection strategy that minimizes the outage probability (OP) of satellite network, we derive the closed-form lower bound OP expressions for both the satellite and IoT networks. We further derive the corresponding asymptotic OP expressions to examine the achievable diversity order of two networks. We show that the proposed OSTN with adaptive power splitting factor benefits IoT network while guaranteeing the quality of service (QoS) of satellite network. We verify the numerical results by simulations.

Subpacketization in Coded Caching with Demand Privacy

Aravind V R (IIT Madras, India)
Pradeep K Sarvepalli (IIT Madras, India)
Andrew Thangaraj (IIT Madras, India)

Coded caching is a technique where we utilize multi-casting opportunities to reduce rate in cached networks. One limitation of coded caching schemes is that they reveal the demands of all users to their peers. In this work, we consider coded caching schemes that assure privacy for user demands with a particular focus on reducing subpacketization. For

the 2-user, 2-file case, we present a new linear demand-private scheme with the lowest possible subpacketization. This is done by presenting the scheme explicitly and proving impossibility results under lower subpacketization. When only partial privacy is required, we show that subpacketization can be significantly reduced when there are a large number of files.

Demand-Private Coded Caching and the Exact Trade-off for N=K=2

Sneha Kamath (Qualcomm, India)
Jithin Ravi (Universidad Carlos III de Madrid, Spain)
Bikash K Dey (IIT Bombay, India)

The distributed coded caching problem has been studied extensively in the recent past. While the known coded caching schemes achieve an improved transmission rate, they violate the privacy of the users since in these schemes the demand of one user is revealed to others in the delivery phase. In this paper, we consider the coded caching problem under the constraint that the demands of the other users remain information theoretically secret from each user. We first show that the memory-rate pair (M, min{N, K}(1-M/N)) is achievable under information theoretic demand privacy, while using broadcast transmissions. We then show that a demand-private scheme for files. We characterize the exact memory-rate trade-off for this case. To show the achievability, we use our first result to construct a demand-private scheme from a non-private scheme satisfying a restricted demand subset that is known from an earlier work by Tian. Further, by giving a converse based on the extra requirement of privacy, we show that the obtained achievable region is the exact memory-rate trade-off.

Technical Program-Oral

Dynamic Routing and Spectrum Allocation in Elastic Optical Networks with Minimal Disruption

Sadananda Behera (IIT Kharagpur, India)
Goutam Das (IIT Kharagpur, India)

Fragmentation is considered as a major bottleneck for Elastic Optical Networks (EON) resulting in poor spectrum utilization. A defragmentation scheme can be employed to tackle this fragmentation issue. Often defragmentation schemes involve complex procedures and disruption to existing connections. As disruption of connections is paramount for defragmentation schemes in flex-grid EONs, we propose a novel Routing and Spectrum Allocation (RSA) framework in EON that employs controlled disruption for dynamic traffic scenarios. First, we propose a Mixed Integer Linear Program (MILP) model for a sample network which jointly optimizes delay-bandwidth product, fragmentation, and link congestion. Then, a heuristic algorithm for realistic networks is also proposed. We show the benefits of our formulation with existing studies in terms of blocking probability and fragmentation.

Technical Program-Poster

Poster Session - I

February 22 | 3:00 pm – 04:30 pm
Vikramshila Foyer

Performance of Spatially Coupled LDPC Codes over Underwater Acoustic Communication Channel

Sravan Kumar Padala (NIT Karnataka, India)
John D'Souza (NIT Karnataka, India)

Underwater acoustic (UWA) channel is complex because of its multipath environment, Doppler shift and rapidly changing characteristics. UWA communication-based applications demand high data rates and reliable communication. The orthogonal frequency division multiplexing (OFDM) system is very effective in UWA channels and provides high data rate with low equalization complexity. It is a challenging taskto achieve reliability over these channels. We have studied by simulation, the performance of protograph based spatially-coupled low-density parity-check (SC-LDPC) codes over shallow water acoustic environment. The results show that SC-LDPC codes give 1 dB performance improvement over LDPC codes at a Bit Error Rate (BER) of 10^(-3) for the same latency constraints.

On the Polarizing Behavior and Scaling Exponent of Polar Codes with Product Kernels

Manan Bhandari (IIIT Hyderabad, India)
Ishan Bansal (IIIT Hyderabad, India)
V. Lalitha (IIIT Hyderabad, India)

Polar codes, introduced by Arikan, achieve the capacity of arbitrary binary-input discrete memoryless channel W under successive

cancellation decoding. Any such channel having capacity I(W) and for any coding scheme allowing transmission at rate R, scaling exponent is a parameter which characterizes how fast gap to capacity decreases as a function of code length N for a fixed probability of error. The relation

between them is given by $N >= \alpha/(I(W) - R)^{\mu}$. Scaling exponent for kernels of small size up to L = 8 have been exhaustively found. In this paper, we consider product kernels T_L obtained by taking Kronecker product of component kernels. We derive the properties of polarizing product kernels relating to number of product kernels, self duality and partial distances in terms of the respective properties of the smaller component kernels. Subsequently, polarization behavior of component kernel T_l is used to calculate scaling exponent of $T_L = T_2 \otimes T_l$. Using this method, we show that $\mu(T_2 \otimes T_5) = 3.942$. Further, we employ a heuristic approach to construct good kernel of L = 14 from kernel having size l = 8 having best μ and find $\mu(T_2 \otimes T_7) = 3.485$.

Outage Analysis of Adaptive Combining Scheme for Hybrid FSO/ RF Communication

Siddharth Mokkapati (IIT Indore, India)
Suyash Shah (IIT Indore, India)
Swaminathan Ramabadran (IIT Indore, India)

In this paper, we analyse the outage performance of an adaptive combining scheme for hybrid free space optics (FSO) / radio frequency (RF) system considering both terrestrial communication and uplink satellite communication (SATCOM) scenarios Adaptive combining involves keeping the FSO link active all the time and activating the RF link based on the quality of the FSO link. The outage analysis has been carried out by modeling the atmospheric turbulence of FSO link using Gamma-Gamma distribution. Further, Nakagami-m and Ricean distributions are used for modeling the small-scale fading of RF link for terrestrial communication and SATCOM scenarios, respectively. The

exact expression of outage probability for the adaptive-combining-based hybrid FSO/RF system has been derived. Further, a range for optimum switching threshold has been determined. Asymptotic analysis along with the calculation of diversity gain has also been carried out for both scenarios. The outage performance of adaptive combining scheme is compared with that of hard switching scheme and single-link FSO system.

ABEP of SSK with SWIPT at Relay and Generalised Selection Combining at the Destination over Rayleigh Fading

Hemanta Sahu (IIT Bhubaneswar, India)
Pravas Ranjan Sahu (IIT Bhubaneswar, India)
Jeevan Mishra (Orissa Engineering College, India)

A cooperative communication system with space shift keying (SSK) modulation and simultaneous wireless information and power transfer (SWIPT) scheme is analyzed over Rayleigh fading channel. SSK is a simple modulation technique that enhances data rate, minimize inter-channel interference, inter-antenna synchronization, and number of radio frequency chains whereas SWIPT extends battery life at the relays. Average bit error probability (ABEP) using partial relay selection and generalised selection combining (GSC) schemes at the receiver are investigated for Rayleigh fading channels. ABEP expression is derived with single amplify and forward (AF) relay selection, from multiple relays, and using selection combining of signals from multiple antennas. Numerical and computer simulation results are presented with the discussion.

Technical Program-Poster

Performance Analysis of a Li-Fi System Under Ambient Light Conditions

Jayashree Pradhan (NIT Rourkela, India)
Kappala Vinod Kiran (NIT Rourkela, India)
Santos Kumar Das (NIT Rourkela, India)

Light Fidelity (Li-Fi) is a high-speed data trans-mission to transmit data in the visible light spectrum (350 nm to 750 nm) using light-emitting diodes (LEDs). Li-Fi can be a complementary wireless technique to high speed traffic in an indoor environment. Li-Fi system is limited in operation due to ambient noise from different illumination sources. The main sources of ambient noise are conventional fluorescent light, incandescent lamps, and sunlight. Photo-detectors are exposed to these sources degrading the overall performance of the link. This work highlights the performance of Li-Fi communication under different modulation techniques and using various ambient noise sources. An experimental Li-Fi testbed is designed and tested to analyze the performance."

Microstrip Quasi-Elliptic Low Pass Filter in Multilayer Topology

Ananya Parameswaran (PES University, India)
Singaravelu Raghavan (NIT Tiruchirappalli, India)

A quasi-elliptic low pass filter using modified dielectric is proposed in this work. A quasi- elliptic stepped impedance Butterworth low pass filter without disturbing the stepped impedance sections is presented for the first time in this paper. The dielectric is modified using plated hole vias and is implemented with double layer topology. The pitch should be 0.22λg and the height of the artificial dielectric should be three times the other dielectric to result in quasi-elliptic characteristics. The presented technique resulted in transmission zero at the stop band edge of slow wave Butterworth filter with 78 dB attenuation and

is higher compared to the works reported. For proof of concept, the filter is fabricated and performance is validated with measurement. The simulated and measured results showed good mutual agreement with each other.

Adaptive Energy Harvesting with Relay Selection Schemes in an Ordered NOMA Network

Soumen Mondal, Sanjay Dharroy, Sumit Kundu
(NIT Durgapur, India)

An adaptive energy harvesting relay based Non-Orthogonal Multiple Access (NOMA) network is investigated where three schemes of energy harvesting adaptations utilizing power splitting relaying (PSR) are proposed. A comparative study of proposed adaptive PSR schemes, employing partial relay selection in NOMA relaying network is carried out. The proposed adaptive energy harvesting schemes outperform fixed PSR based energy harvesting in NOMA network as per priority of signals. It is observed that the imperfection of successive interference cancellation can significantly degrade the performance of strong signal (x2). The statistics of power splitting coefficients in proposed adaptive energy harvesting is also presented. A closed-form expressions on outage performance of two users NOMA network is developed which is verified by MATLAB based simulation.

Technical Program-Poster

A Robust Low-Complexity Real-Time Vehicle Counting System for Automated Traffic Surveillance

Arun Varghese (NIT Calicut, India)
Sreelekha G (NIT Calicut, India)

This paper presents a real-time video based vehicle counting system, the key feature of which is its low computational complexity. The counting algorithm is tailored to be able to run on a low cost hardware platform like Raspberry Pi as part of a smart camera system. Background subtraction forms the basis of day time vehicle counting while night time counting is based on headlight detection and pairing. Both operations are performed only on a pre-specified virtual detection region within each frame. When tested on public traffic datasets, the method outperforms other more complex algorithms under various weather and traffic conditions.

ROC Analysis for Detection of Epileptical Seizures Using Haralick Features of Gamma Band

Mustafa Sameer (NIT Patna, India)
Chinmay Chakraborty (BIT Mesra, India)
Akash Gupta (BIT Mesra, India)
Bharat Gupta (NIT Patna, India)

In this study, gamma band (30-60 Hz) is used for detection of epileptical seizures using Haralick features. Most of the previous methods is based on the whole frequency spectrum for detection. This work use only high frequency electroencephalogram (EEG) subband for seizure detection using image descriptors. To convert one dimensional EEG data into image Short time fourier transform (STFT) has been used. Gamma band is cut from the time frequency (t-f) plane and Haralick features is used as

image descriptors to fed in the decision tree classifier. The results have been evaluated using receiver operating characteristic (ROC) analysis. Maximum area under curve (AUC) of 0.96 is obtained to classify between seizures and healthy. Advantage of this work is rather using whole frequency band it utilizes only a particular band which reduces computational load. It also shows the utility of gamma band in seizure detection.

Ensemble Algorithms for EEG Based Emotion Recognition

Nalini Pusarla (DSPM IIIT, Naya Raipur, Chhattisgarh, India)
Anurag Singh (DSPM IIIT, Naya Raipur, Chhattisgarh, India)
Shrivishal Tripathi (DSPM IIIT, Naya Raipur, Chhattisgarh, India)

Emotion recognition using Electroencephalogram (EEG) signal has grabbed the attention of researchers recently due to its widespread applications. This study employed empirical mode decomposition (EMD) to process EEG signals of different channel profiles and obtains various intrinsic mode functions. Sample Entropy (Samp En) is computed for the first four intrinsic mode functions, which are used as feature vectors for emotion recognition. To identify three categories of human emotions namely negative, neutral and positive, random forest (RF) and Extreme Gradient Boosting (XGBoost) classifiers are fed with the extracted feature vectors. This algorithm achieved maximum accuracy of 88% and 96% with Random forest and XGBoost classifiers on a publicly available database SEED by considering all 62 channels of EEG.

Technical Program-Poster

Investigating Target Set Reduction for End-to-End Speech Recognition of Hindi-English Code-Switching Data

Kunal Dhawan (IIT Guwahati, India)
Ganji Sreeram (IIT Guwahati, India)
Kumar Priyadarshi (IIT Guwahati, India)
Rohit Sinha (IIT Guwahati, India)

End-to-end (E2E) systems are fast replacing the conventional systems in the domain of automatic speech recognition. As the target labels are learned directly from speech data, the E2E systems need a bigger corpus for effective training. In the context of code-switching task, the E2E systems face two challenges: (i) the expansion of the target set due to multiple languages involved, and (ii) the lack of availability of sufficiently large domain-specific corpus. Towards addressing those challenges, we propose an approach for reducing the number of target labels for reliable training of the E2E systems on limited data. The efficacy of the proposed approach has been demonstrated on two prominent architectures, namely CTC-based and attention-based E2E networks. The experimental validations are performed on a recently created Hindi-English code-switching corpus. For contrast purpose, the results for the full target set based E2E system and a hybrid DNN-HMM system are also reported.

Substate Detection Based Confidence Scoring in Speech Recognition

Punnoose A K (Flare Speech Systems, Bangalore India)

This paper discusses an approach for confidence scoring at the phoneme level. Various features derived from multi layer perceptron(mlp) posteriors that indicates the strength of a phoneme detection are introduced. The capability of these features to discriminate between

true positive and false positive phoneme detection is shown. Appropriate distributions are fit on these features. These distributions are combined to derive the posterior odds ratio, which signals the confidence of a phoneme detection. Finally, a simple thresholding on the posterior odds ratio is used to classify a detected phoneme as a true/false positive. Relevant real world datasets are used to benchmark the proposed approach.

Discriminating High Arousal and Low Arousal Emotional Speech Using Mahalanobis Distance Among Acoustic Features

S S S Kalyan (KL University, India)
John Philip Bhimavarapu (KL University, India)
Vinay Kumar Mittal (KL University & KLEF, India)

Emotion classification from emotional speech continues to be a challenging research domain. Few research studies have attempted to discriminate amongst a set of emotions, and categorize for valence, activation and dominance. Discriminating between high-arousal and low-arousal emotions is itself challenging, but discriminating emotions within each subcategory is further challenging problem. In this study, a new approach is proposed to discriminate between high and low arousal emotions, and also amongst emotions within each subcategory. Mahalanobis distances amongst acoustic feature vectors of emotional speech w.r.t. normal speech are examined. The approach, involving speech production features, has been validated on three databases: German (Berlin EMO-DB), English (RAVDESS) and Telugu (IITKGP-SESC). A common set of five emotions Angry, Happy, Fear, Disgust and Sad are examined with reference to normal speech. The excitation source feature F0, vocal-tract filter features Mel-frequency cepstral coefficients (MFCCs), and combined source-filter features signal energy, zero-crossing rate and duration are used. A 2D projection of Mahalanobis distance for one emotion, w.r.t. normal, onto another emotion is

observed to discriminate amongst emotions within each high/low-arousal sub-category. The Angry and Happy emotions are discriminated in high-arousal emotions sub-category, whereas Fear, Disgust and Sad are discriminated in low-arousal emotions sub-category. Encouraging results are achieved. This study should be helpful in further classifying emotions within each sub-category of high/low arousal emotions in emotional speech.

A TfidfVectorizer and SVM Based Sentiment Analysis Framework for Text Data Corpus

Vipin Kumar, Basant Subba (NIT Hamirpur, India)

E-commerce and social networking sites are very much dependent on the available data which can be analyzed in real time to predict their future business strategies. However, analyzing huge amount of data manually is not possible in time context of business. Therefore, automated sentimental analysis, which can automatically determine the sentiments from the text data corpus plays an important role in today's world. Many sentimental analysis frameworks with state of the art results have been proposed in the literature. However, many of these frameworks have low accuracy on the textual data corpus contains emoticons and special texts. In addition, many of these frameworks are also energy and computation intensive with which puts limitation in their real time deployment. In this paper , we aim to address these issues by proposing a novel sentimental analysis framework based on Support Vector Machine (SVM). The proposed framework uses a novel technique to tokenize the text documents, wherein stop words, special characters, emoticons present in the text documents are eliminated. In addition, words with similar meanings and annotations are clubbed together into one type, using the concept of stemming. The pre-processed tokenized documents are then vectorized into n-gram integers vectors using the 'TfidfVectorizer' for use as input to the SVM based machine learning

classifier model. Experimental results on the Amazon's electronics item review dataset and IMDB's movie review data corpus show that the proposed sentimental analysis framework achieves high performance compared to other similar frameworks proposed in the literature.

Generalized Fractional Matched Filtering and its Applications

Peeyush Sahay (IIT Bombay, India)
Ameya Anjarlekar (IIT Bombay, India)
Shubham Anand Jain (IIT Bombay, India)
P. Radhakrishna (DRDO, India)
Vikram M. Gadre (IIT Bombay, India)

Time domain matched filtering is a classic method used in radar and sonar applications to maximize signal to noise ratio (SNR) gain, estimate time delay, and improve range resolution. Fractional Fourier transform, and fractional Fourier domain matched filtering are used extensively to overcome the drawbacks of time domain matched filtering and are shown to have improved performance for a linear chirp. This paper presents a generalized fractional matched filtering (GFMF) for estimating higher order chirp parameters with known time delay. It is shown to provide SNR gain equivalent to time domain matched filtering. As an application of GFMF, a novel method to minimize SNR gain degradation due to the range-Doppler coupling effect of quadratic chirps is presented. For a higher order chirp with unknown time delay, another method using generalized fractional envelope correlator (GFEC) is proposed, which performs joint estimation of time delay and higher order chirp parameters using a double quadratic chirp.

Technical Program-Poster

Poster Session - II

February 23 | 11:50 am – 01:20 pm
Vikramshila Foyer

Blind Channel Coding Identification of RS Encoder Using Neural Networks

Naveenta Gautam (IIT Delhi, India)
Brejesh Lall (IIT Delhi, India)

Forward error correcting (FEC) codes are used to improve the reliability of digital communication systems. They introduce redundancy in the signal which helps the receiver to correct errors without requesting for re transmission. FEC codes can be classified into two categories : Convolutional codes and linear block codes (LBCs). Reed-Solomon (RS) codes lie in the category of LBCs. For non-cooperative communication applications such as adaptive modulation and coding (AMC), military applications and cognitive radio, the channel encoder has to be identified blindly for decoding the received signal. In this study, we propose a scheme for blind identification of convolutional and RS codes. We have used the pattern recognition properties of a neural network (NN) to identify the encoder from a candidate set. NNs have not been used for this purpose, to the best of our knowledge. Performance of the proposed classifier has been evaluated for both the noiseless and the noisy case. To show the application of the proposed approach we present the performance results for the two most common use cases namely the terrestrial wireless and the satellite communication channels. Experimental results have shown that the proposed classifier can identify the encoder with high accuracy in low signal-to-noise ratio.

Technical Program-Poster

Machine Learning Enabled Detection for QPSK-PD-NOMA System Employing Single Mode Fiber

Debi Pada Jana (IIT Patna, India)
Sumanta Gupta (IIT Patna, India)

In this paper, we propose a Successive Interference Cancellation (SIC) technique which uses k-means clustering for a standard single mode fiber based non return to zero (NRZ)- quadrature phase shift keying (QPSK) transmission system that employs power division non-orthogonal multiple access (PDNOMA) scheme to enhance the capacity. Results obtained from the numerical simulation confirm that for an aggregated transmission of 20 Gbps signal for two users, each transmitting a data rate of 10 Gbps over standard single mode fiber (SSMF), a BER value of 10^-5 is achievable with an OSNR penalty of 2 dB for a far user, which is situated 100 km away from the transmitter and utilizes NOMA. The proposed system doesn't include any compensation technique for mitigating fiber induced impairments. Simulation results also reveal that, a 1:7 power division ratio is required between the two users for optimum performance."

Spectral Analysis of a Nonlinear WOLA-OFDM System with DPD

Mohd Hamza Naim Shaikh (IIIT Delhi, India)
Vivek A Bohara (IIIT Delhi, India)
Anand Srivastava (IIIT Delhi, India)

Orthogonal frequency division multiplexing (OFDM) has been a universal choice for modulation scheme for most of the wireless standards such as long-term evolution (LTE). However, OFDM is prone to large out-of-band (OOB) emission due to slower decay of its side-lobes. Weighted overlap and add OFDM (WOLA-OFDM) have been proposed for mitigating the out-of-band (OOB) emission by improving faster sidelobe

decay. However, the presence of nonlinear high power amplifier (HPA) worsens the OOB performance of OFDM, even though the windowing reduces the noise floor considerably. In this work, we have proposed an architecture based on digital predistorter (DPD) to reduce the impact of non-linearity in WOLA-OFDM in the presence of HPA. The results show that the stated benefits of WOLA-OFDM can only be attained through employing DPD in the nonlinear WOLA-OFDM systems.

Simultaneous Measurement of Atmospheric Turbulence Induced Intensity and Polarization Fluctuation for Free Space Optical Communication

Abhishek Mani Shukla (IIT Patna, India)
Sumanta Gupta (IIT Patna, India)

The performance of free space optical (FSO) communication link is highly sensitive towards the intensity, phase and polarization fluctuations, which are induced by turbulent atmosphere. In order to study the impact of atmosphere induced turbulence on the optical signal, which propagates through it, it is essential to know the statistics of intensity, phase and polarization fluctuations. In this paper we report an experimental investigation that categorically measures the statistics of intensity and polarization fluctuations in terms of their probability density functions (PDFs) using a single setup uses 210 cm link length and takes measurement under various turbulent conditions. Experimental results show that for all turbulent conditions considered in this paper log-normal and Gaussian distribution are closely matches with measured PDF for intensity and polarization angle fluctuations, respectively.

Technical Program-Poster

On Performance of SWIPT Enabled Two-Way Relay System with Non-Linear Power Amplifier

Parvez Shaik (IIT Indore, India)
Deepak Kumar (IIT Indore, India)
Vimal Bhatia (IIT Indore, India)

In this work, we examine a dual-hop amplify-and-forward two-way relay system over independent and non-identically distributed Nakagami-m fading channels with integer values of fading parameter. We consider a three-node half-duplex relaying system with two source nodes and a relay node. To address the needs of present day energy constraint battery enabled relay nodes, we employ simultaneous wireless information and power transfer (SWIPT) for energy harvesting (EH) from ambient resources through time-switching protocol. Further, since a low-cost and low-complexity relay node has a non-linear power amplifier, we consider the impact of the same in the analysis. Framework, for outage probability of SWIPT enabled two-way relay system with non-linear amplifier is presented. Additionally, throughput analysis is performed and affect of non-linearity, EH and relay power over the system is analyzed. Accuracy of the derived expressions and impact of non-linear power amplifier over the SWIPT system are verified through the Monte-Carlo simulations.

Technical Program-Poster

A Low Profile Wideband Planar Antenna for 5G Wireless Communication Applications

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This paper presents a low profile wideband planar antenna for 5G applications. The designed antenna consists of a circular patch element and a partial ground plane with two rectangular edge elements and has a compact size of 20 × 35 × 0.8 mm3. The antenna with the optimized dimension of the patch element and the ground plane is able to excite for a wide bandwidth of 2900 MHz (2.99 - 5.89 GHz) which cover all the lower 5G bands between 3 GHz to 5 GHz at reflection coefficient, S11 < -10dB. Due to its simple structure, smaller size, symmetric radiation pattern and stable gain, the proposed antenna could be a potential competitor to be used in 5G wireless devices.

A Novel NOMA Scheme for Uplink Heterogeneous Network Using QR Decomposition Based Projection

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This paper proposes a novel non-orthogonal multiple access (NOMA) scheme for the uplink heterogeneous network (HetNet) using QR decomposition. In a HetNet employing NOMA, femtocell users (FUs) share the same spectrum as that of the macrocell users (MUs). While it increases the system capacity, this reuse results in new cases of cross-tier and co-tier interference. Cross-tier interference at the femtocell causes severe performance degradation due to the high transmit

power of undesired macrocell users (MUs). Hence efficient interference management is essential to garner the benefits promised by NOMA-HetNet combination. In the proposed NOMA scheme, the cross-tier interference in the femtocell is mitigated by QR decomposition-based decoding. This decomposition carried out at the femtocell base station (FBS) extracts the desired NOMA users' signal from the received composite signal. In contrast to the NOMA schemes in literature based on successive interference cancellation (SIC), the proposed scheme does not require any user pairing or power control schemes on the user equipment (UE) to decode FUs' data at the FBS. Besides, it does not require any information exchange to the transmitter (UE) side for decoding, thereby significantly reducing the computational complexity as well as the signaling overhead at the FBS. Performance of the proposed scheme is evaluated through simulation studies and also compared with a prevailing SIC algorithm to establish its superiority.

Data Adaptive Compressed Sensing Using Deep Neural Network for Image Recognition

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Vinay Kaushik (IIT Delhi, India)

Compressive sensing (CS) using deep learning for recovery of images from measurements has been well explored in recent years. Instead of sensing/sampling full image, block or patch based compressive sensing is chosen to overcome memory and computation limitations. The drawback of this block based CS sampling and recovery is that it does not capture global context and focuses only on the local context. This results in artifacts at the boundary of two consecutive image blocks. Random Gaussian or random Bernoulli matrix are commonly used as

sensing matrices to sample an image block and generate corresponding linear measurements. Although, random Gaussian or random Bernoulli matrices exhibits Restricted Isometry property (RIP), which is a guarantee for good quality reconstructed image, its two main disadvantages are: 1) large memory and computational requirements and 2) their encoded measurements doesn't generalize well to a large-scale dataset. In this paper, we propose a data adaptive CS based on deep learning framework for image recognition where 1) sampling is done considering the global context and 2) encoding to obtain measurements is learned from data, so as to achieve the generalization over large-scale dataset.

Ocular Artifact Elimination from EEG Signals Using RVFF-RLS Adaptive Algorithm

Sridhar Chintala (IIT Dhanbad, India)
Jaisingh Thangaraj (IIT Dhanbad, India)

Ocular Artifacts (OAs) have a significant impact on the performance of Electroencephalogram (EEG) activities in the frontal region because of its higher amplitude. In this paper, Robust Variable Forgetting Factor (RVFF) and Recursive Least Square (RLS) based RVFF-RLS algorithm is implemented for the removal of OAs from the raw EEG signal. Reference signals such as horizontal electro-oculogram and vertical electro-oculogram are recorded and then processed through the finite impulse response filter, whose coefficients are adaptively updated using the RVFF-RLS algorithm. Thereafter, obtained signals are subsequently subtracted from the raw EEG signal to obtain an EEG signal, which is free from OAs. The performance of the proposed technique is compared with conventional techniques such as numerical variable forgetting factor RLS, fixed step size normalized least mean squares, fixed forgetting factor- RLS. The proposed technique shows the least mean square error under a dynamic environment.

Technical Program-Poster

Binaural Spatial Audiometry Screening Using Android Mobile Device Audio I/O Facility

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T V Sreenivas (IISc Bangalore, India)

The localization of acoustic sources in hearing impaired (HI) listeners is known to be less satisfactory than normal hearing (NH) listeners and the performance worsens in the presence of interfering sources or noise. Hence, in the recent trend for hearing aid applications, providing for speech enhancement using multi-channel signal processing and preserving spatial cues for binaural presentation has become important. Also, there is need to keep the clinical facility/cost accessible and affordable; hence, new hearing assistance technologies based on mobile-phone and its accessories are being developed and standardized. In this work, we propose a methodology to evaluate spatial perception of listeners using a novel MUSHRA-like experimental setup on Android mobile phone. We propose evaluation of multiple random stimuli for their perceptual localization accuracy, relative to explicitly presented spatial anchors. The test implemented on Android mobile platform and bluetooth earplugs, along with pre-stored directional interference stimuli, provides a means for the test to be administered at any remote location, without the necessity of expensive clinical facilities. We also propose schemes for different methods of rendering binaural audio for further mobile phone based hearing assistance

Technical Program-Poster

Effective Combination of Multiple Evidences for I-vector Based Limited Data Speaker Verification

Krishna Dutta (NIT Nagaland, India)
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The performance of automatic speaker verification (ASV) system always depends upon the amount of information (speech sample) used in the process. ASV system's performance suffers when the information provided to the system is limited, even though the methodology is remain same. The issue of limited information can be resolved to some extend by using multiple evidences. In general, score level combination scheme is widely used to combine the effect of multiple evidences, where a decision is made based on the independent opinions of the evidences.

We conjecture that the collectively contributed decisions may be more effective and propose a new combination scheme for limited data speaker verification task. In the proposed work, we have used mel frequency cepstral coefficient (MFCC) and residual

MFCC (RMFCC) as representation of the vocal tract and excitation source information. The experiments are conducted with well-known NIST-2003 speaker recognition evaluation (SRE) database.

The score level combination scheme provide a relative improvement of 14.93% in extremely limited data condition (‘ 2 sec), on an average 15.57% for all limited data conditions. In comparison, the proposed scheme provides 28.40% and 29.02%, respectively. Thus proposed method provides a relative gain of 13.47% for extremely limited data condition and on an average 13.42% for other limited data conditions. These experimental results signify the importance of using proposed combination scheme over the popular score level combination scheme.

Technical Program-Poster

IITG-Indigo Submissions for NIST 2018 Speaker Recognition Evaluation and Post-Challenge Improvements

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Rohit Sinha (IIT Guwahati, India)
Shreyas Ramoji (IISc Banglore, India)
Sriram Ganapathy (IISc Bangalore, India)

This paper describes the submissions of team Indigo at Indian Institute of Technology Guwahati (IITG) to the NIST 2018 Speaker Recognition Evaluation (SRE18) challenge. These speaker verification (SV) systems are developed for the fixed training condition task in SRE18. The evaluation data in SRE18 is derived from two corpora: (i) Call My Net 2 (CMN2), and (ii) Video Annotation for Speech Technology (VAST). The VAST set is obtained by extracting audio from video having high musical/noisy background. Thus, it helps in assessing the robustness of the SV systems. A number of sub-systems are developed which differ in front-end modeling paradigms, back-end classifiers, and suppression of repeating pattern in the data. The fusion of sub-systems is submitted as the primary system which achieved actual detection cost function (actDCF) and equal error rate (EER) of 0.77 and 13.79%, respectively, on the SRE18 evaluation data. Post-challenge efforts include the domain adaptation of the scores and the voice activity detection using deep neural network. With these enhancements, for the VAST trails, the best single sub-system achieves the relative reductions of 38.4% and 11.6% in actDCF and EER, respectively.

Technical Program-Poster

Kernelized Graph-based Multi-view Clustering on High Dimensional Data

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Kernelized graph-based learning methods have gained popularity because of its better performances in the clustering task. But in high dimensional data, there exist many redundant features which may degrade the clustering performances. To solve this issue, we propose a novel multi-view kernelized graph-based clustering (MVKGC) framework for high dimensional data that performs the clustering task while reducing the dimensionality of the data. The proposed method also uses multiple views which help to improve the clustering performances by providing different partial information of a given data set. The extensive experiments of the proposed method on different real-world benchmark data sets show a better and efficient performance of the proposed method than other existing methods.

An Efficient Malware Detection Technique Using Complex Network-based Approach

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System security is becoming an indispensable part of our daily life due to the rapid proliferation of unknown malware attacks. Recent malware found to have a very complicated structure that is hard to detect by the

traditional malware detection techniques such as antivirus, intrusion detection systems, and network scanners. In this paper, we propose a complex network-based malware detection technique, Malware Detection using Complex Network~(MDCN), that considers Application Program Interface Call Transition Matrix (API-CTM) to generate complex network topology and then extracts various feature set by analyzing different metrics of the complex network to distinguish malware and benign applications. The generated feature set is then sent to several machine learning classifiers, which include naive-Bayes, support vector machine, random forest, and multi-layer perceptron, to comparatively analyze the performance of MDCN-based technique. The analysis reveals that MDCN shows higher accuracy, with lower false-positive cases, when the multi-layer perceptron-based classifier is used for the detection of malware. MDCN technique can efficiently be deployed in the design of an integrated enterprise network security system.

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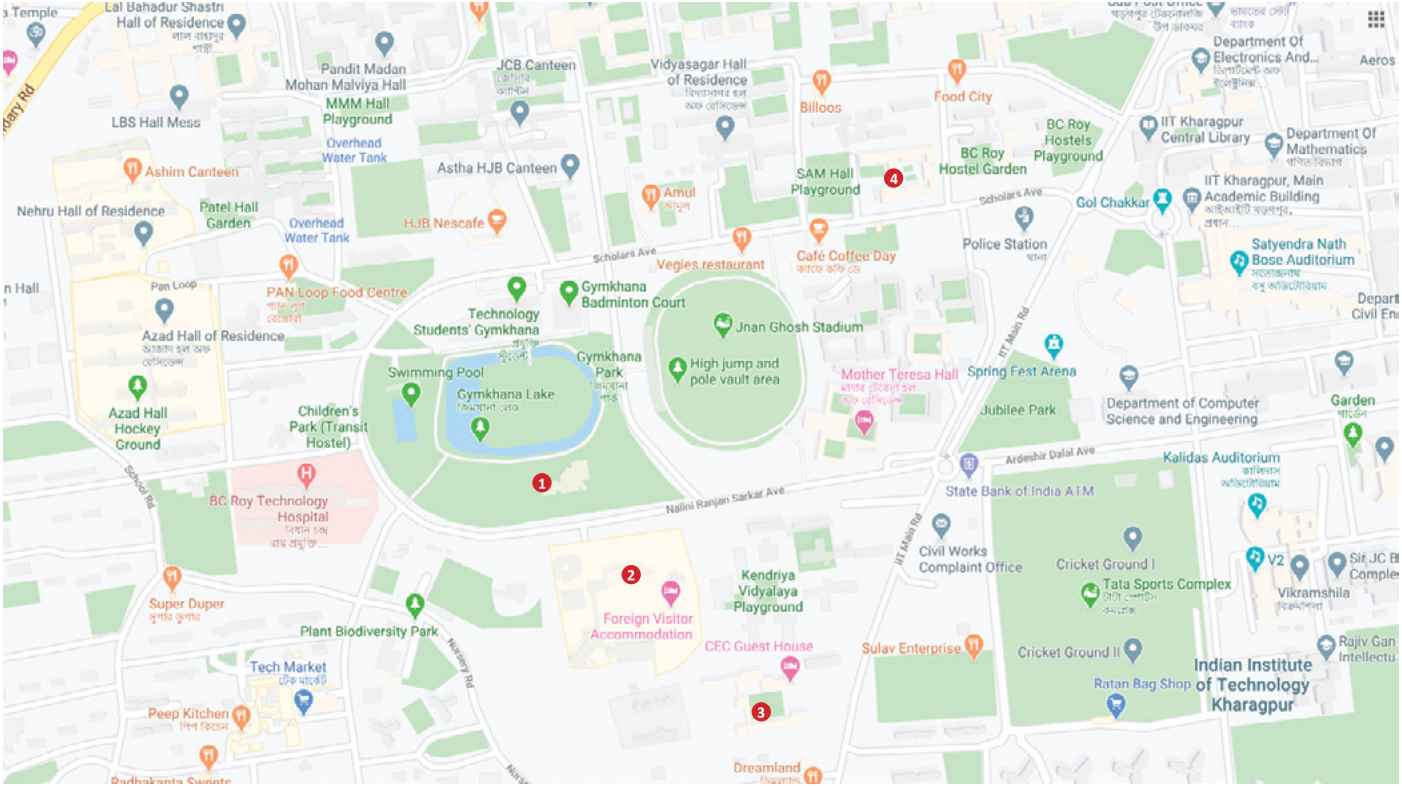

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2. Technology Guest House
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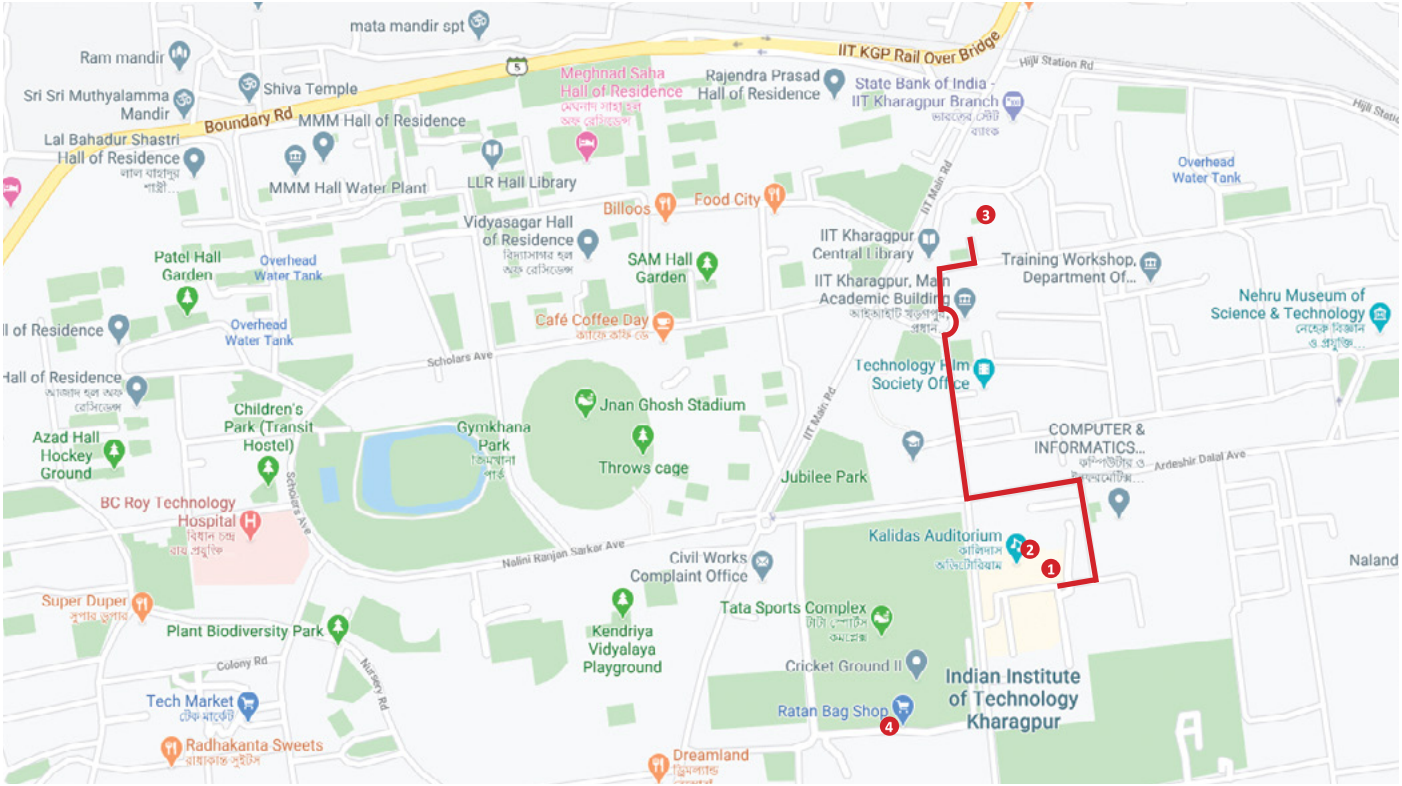
Conference Hall Map



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