EECS Symposium-2023

April 3-4, 2023
Indian Institute of Science,
Bengaluru

Book of Abstracts

This was written on April 3-4, 2023
Indian Institute of Science, Bengaluru .

Preface

The EECS Research Students Symposium - 2023 is the fourteenth in the series of annual research students symposia initiated in 2010. The symposium is organized by the following six departments following the best traditions of collaboration:

1. *Computational and Data Sciences (CDS)*
2. *Computer Science and Automation (CSA)*
3. *Electrical Communication Engineering (ECE)*
4. *Electrical Engineering (EE)*
5. *Electronic Systems Engineering (ESE)*
6. *Cyber-Physical Systems (CPS)*

For the EECS 2023 symposium, a team of six faculty members coordinated by Punit Rathore (CPS) and consisting of Utsav Banerjee (ESE), Kiran Kumari (EE), Debdeep Sarkar (ECE), Vaanathi Sundaresan (CDS), and Gugan Thoppe (CSA), and an energetic team of student and staff volunteers, has put in a spectacular effort to organize the event.

As you know, the primary purpose of this event is to showcase the work of our senior research students who are on the threshold of wrapping up their work. These students will present their work in 11 research cluster sessions: Artificial Intelligence and Machine Learning (2 sessions); Brain, Computation and Data Sciences; Cyber-Physical Systems; Microelectronics, RF, and Photonics; Computer Systems, Networking, and IoT; Power Engineering; Security and Privacy; Signal Processing and Communications; Theoretical Computer Science; and Visual Analytics. Several of these sessions also have keynote talks by leading researchers, including industry experts. We are fortunate to get some of the best experts in the world delivering talks in these sessions.

We are fortunate to have a great lineup of plenary speakers – Kevin Buzzard (Imperial College London) and Nivruti Rai (Country Head of Intel India). Another highlight of the symposium is a series of talks by some faculty members who have recently joined IISc. This year, we will have talks by Chirag Jain [CDS]; Sumit Kumar Mandal [CSA]; Viveka K R [ESE]; Samir Hazra [EE]; Balaswamy Velpula [ECE], and Pushpak Jagtap [CPS].

The organizing committee has assembled a splendid technical program for this event – congratulations to them on a superlative effort. We are excited by the excellent response received in registrations for this event. We thank our alumni, industry collaborators, faculty members, and students for registering in such large numbers. We sincerely hope the symposium will facilitate lively interactions among the participants and inspire everyone to attempt and solve intellectually-challenging research problems in EECS and beyond.

Our thanks go out to the sponsors ***Qualcomm (Diamond), Google (Gold), TCS Research (Gold), ARTPARK IISc (Gold), British Telecom India Research Centre (BTIRC), IISc (Silver), Centre for Brain Research IISc (Silver), and Cisco-IISc Centre for Networked Intelligence (Silver)*** *for their generous sponsorship for this event (as on 27 March 2023). Their support is very much appreciated.*

Please interact with them at their outreach posts (ECE) and get to know more about the opportunities available.

This year's symposium is in-person. Please join us and make this a successful event. I urge all of you to exercise caution and care, and follow the norms, while participating in the symposium.

I wish all of you a fruitful symposium.

Rajesh Sundaresan
Dean, Division of EECS,
IISc, Bengaluru.

Contents

1. Organising Committee and Schedule

Committee

1.1 Faculty Organisers

Punit Rathore	CPS	prathore@iisc.ac.in	Overall Co-ordinator, Program Management, Website, Faculty Talks, Cluster- AI/ML
Utsav Banerjee	ESE	utsav@iisc.ac.in	Design, Book of Abstracts, Cluster- Security, Brain, Computation and Data Sciences
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1.2 Student Organisers

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Shashank Telkhade	CSA	shashanktv@iisc.ac.in	–
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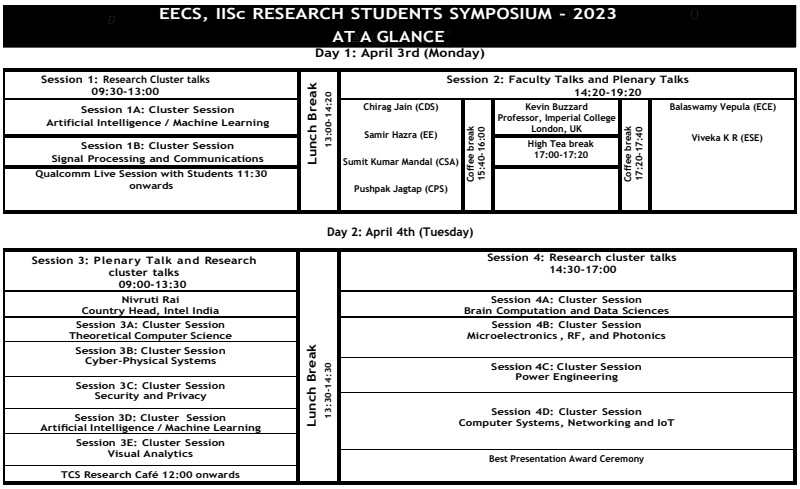
Geethanjali Monto	CDS	geethanjalim@iisc.ac.in	Publicity

1.4 Program at a Glance



2. Day 1: 3th April 2023 (Monday)

2.1 Inauguration

Speaker: Prof. Rajesh Sundaresan, ECE, IISc

2.2 Session 1 | Research Cluster Talks

Location: ECE Building

2.2.1 Session 1A: Artificial Intelligence & Machine Learning

Session Chair: Shalabh Bhatnagar, Aditya Gopalan
Cluster Coordinator: Shalabh Bhatnagar, Aditya Gopalan
Student Organizer: Rankit Kachroo, Naman
Faculty Organizer: Gugan Thoppe
Location: ECE Golden Jubilee Hall

Cluster Overview

Time	Event	Speaker	Affiliation
09:30 – 10:00 AM	Invited Talk 1	Vivek Borkar	EE, IIT Bombay
10:00 – 10:30 AM	Invited Talk 2	Rahul Ghosh	Walmart, India
10:30 – 10:42 AM	Student Presentations	Siddarth Asokan	CPS,IISc
10:42 – 10:54 AM		Chitturi Sidhartha	EE,IISc
10:54 – 11:06 AM		Karthik Girija Ramesan	EE, IISc
11:20 – 11:40 AM	Invited Talk 3	Tushit Jain	Qualcomm Research
11:40 – 12:00 PM	Invited Talk 4	Shourya Roy	Flipkart, India

Time	Event	Speaker	Affiliation
12:00 – 12:12 PM	Student Presentations	Soumya Dutta	EE, IISc
12:12 – 12:24 PM		Prachi Singh	EE, IISc
12:24 – 12:36 PM		Shreyas Ramoji	EE, IISc
12:36 – 12:48 PM		Tanuka Bhattacharjee	EE, IISc

Invited Talk 1: Q-learning for non-Markovian environments

Speaker: Vivek Borkar, IIT Bomabay
Personal Webpage

Abstract

Reinforcement learning algorithms are based on the premise that the underlying controlled dynamics is a Markov Decision Process (MDP). However, in practice this may not always be the case. This talk will address the issue when this assumption fails, using the classical Q-learning as a test case. The talk will describe some recent attempts towards clarifying this issue, including our own. (Joint work with Siddharth Chandak, Parth Dodhia, Pratik Shah).

Bio

Vivek Borkar obtained his B.Tech. from IIT Bombay, M.S. from Case Western Reserve Uni., and Ph.D. from Uni. of California, Berkeley, in 1976, 1977, 1980 respectively. He has worked in TIFR CAM and IISc in Bengaluru and TIFR and IIT Bombay in Mumbai. He is currently an Emeritus Fellow in IIT Bombay. His research interests are stochastic control and optimization, encompassing theory, algorithms and applications.

Invited Talk 2: AI in Retail @ Walmart Scale

Speaker: Rahul Ghosh
Personal Webpage

Abstract

AI is fuelling transformation across all domains of retail such as eCommerce, supply chain and in-store experience. At Walmart, AI technologies empower us to achieve our purpose – helping people save money so they can lead better lives. Across our physical stores and online eCommerce business, AI use cases are increasingly being applied at scale. In this talk, we will illustrate how AI is a game-changer for Walmart and also the future of retail. We plan to dive deep into a few use cases to talk about the end-to-end retail journey and its impact with AI.

Bio

Dr. Rahul Ghosh is Senior Director of Data Science at Walmart Global Tech India. Prior to Walmart, he was with American Express AI Labs, Xerox Research, IBM Research Tushit Jain and Product Groups. Rahul's current research/technical interest is in the intersection of AI and large-scale systems. He is a co-author of 35+ research papers and co-inventor of 42 granted US patents. Rahul received his MS and PhD from Duke University and his BE from Jadavpur University.

Student Presentation 1: The Optimality of Gradient-regularized GANs — Theory and Practices

Siddarth Asokan and Chandra Sekhar Seelamantula

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Generative adversarial networks (GANs) are a deep learning framework consisting of a pair of neural networks, the generator and the discriminator, tasked with modeling the distributions of a target, typically images. GANs excel in generating fake images that are visually indistinguishable from the real ones. Most popular GAN variants are trained by means of a gradient-norm regularizer on the discriminator. In this talk, we will explore the analytical implications of enforcing such penalties, and derive the optimal discriminator in such GANs, from the perspective of variational calculus. From an applications standpoint, we leverage this optimal discriminator to train GAN generators, and develop new GAN evaluation metrics that we leverage to achieve the state-of-the-art performance on widely popular StyleGAN architectures, by means of a novel dataset-to-dataset learning paradigm.

Student Presentation 2: Graduated Non-Convexity (GNC) for Geometric Estimation in Computer Vision

Chitturi Sidhartha and Venu Madhav Govindu

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Geometric estimation tasks in computer vision are often solved via minimization of robust statistical loss functions which account for the presence of outliers in the observations. One such class of problems is the averaging/synchronization problem defined on a graph, wherein each node is characterized by a state, and given the relative ratios (difference) between the states, one need to estimate the unknown states on the nodes. I will first discuss the drawbacks of using popular lp ($0 < p <= 1$) loss functions in the context of synchronization by taking example of rotations averaging, a subproblem in 3D reconstruction, wherein global rotations of cameras are estimated given the pairwise relative rotations. Then, I will describe Graduated Non-Convexity (GNC, also known as annealing), used while minimizing robust parametric loss functions, to avoid convergence to poor

local minima. Existing approaches pay little attention to the annealing schedule resulting in a poor speed-accuracy trade-off. I will describe a principled approach for adaptively annealing the scale of the robust loss function in GNC by tracking the positive definiteness of the Hessian of the cost function and illustrate the approach using the classical problem of pairwise registration of 3D scans given the correspondences.

Student Presentation 3: Scalable Deep Learning models for Inverse Scattering

Karthik Girija Ramesan

Department of Electrical Engineering,
Indian Institute of Science

Abstract

The inverse scattering problem (ISP) deals with the estimation of the internal characteristics of an object using the measured scattered field data obtained when the object is illuminated with a known incident field. Solving the ISP is essential for a wide array of applications which includes medical imaging, seismic imaging, human-computer interaction etc. Traditional methods for inverse scattering can be broadly classified as non-iterative and iterative methods. Non-iterative methods, in general, rely on linear approximations of the otherwise non-linear problem. The use of such approximations makes these methods fast but unsuitable for high contrast reconstruction. Iterative methods, on the other hand, account for the non-linearity and therefore provide higher- quality reconstruction. However, iterative methods are time-consuming. In comparison, state-of-the-art Deep Neural Network (DNN) based methods combine the best of both worlds by providing both fast and reliable reconstructions. However, DNN models are sensitive to the imaging configuration i.e., models trained on one particular configuration do not perform well on other configurations. The imaging configuration includes parameters like the frequency of the incident field, the locations of the transmitters and receivers and their respective directivity patterns etc. Our work focuses on adapting the existing DNN based methods to perform well on arbitrary configurations. To this end, we propose a DNN model for arbitrary transmitter configurations. In addition, both traditional and DNN based methods assume the knowledge of the locations of the transmitters and receivers. The precise knowledge of these locations requires either a careful placement of the transmitters and receivers at specific known locations or placing the transmitters and receivers at arbitrary locations and using an appropriate system to calculate their respective locations. These locations are then fed to the reconstruction algorithm. Having to determine the locations of transmitters and receivers is an additional overhead and reduces the ease of usability of the system. To circumvent this problem, we propose the simultaneous reconstruction of the object as well as localization of the transmitters.

Invited Talk 3: ML-CAD algorithms solutions to redefine the design process of complex SoCsenvironments

Speaker: Tushit Jain, Qualcomm Research
Personal Webpage

Abstract

Traditional algorithms used in computer-aided design (CAD) of complex SoCs require an ever-increasing number of resources in terms of designers, compute, licenses and time. These limitations of algorithm-driven CAD prevent chip design from scaling to higher complexity while maintaining

optimal power, performance and area (PPA). In this talk, we explore the applications of Machine Learning or data-driven CAD to the area of VLSI/SoC design to help scale SoCs to higher complexities.

Bio

Tushit Jain is a Senior Director in Machine Learning Research at Qualcomm. He works on building Machine Learning based tools to improve all aspects of the hardware design process ranging from Design, Verification and Physical Design. The AI/ML models that he and his team have built have been successfully deployed on taped-out chips and have helped improve power, performance, area of these chips while also reducing the engineering effort to build and productize chips at Qualcomm.

Invited Talk 4: Why do we need data science in e-commerce?

Speaker: Shourya Roy, Flipkart, India
Personal Webpage

Abstract

In recent years e-commerce platforms have grown significantly riding on technological advancements, digital spread, and innovative business models. Through this growth, the platforms have been generating an astronomical amount of data and leveraging the same to leapfrog by data-driven insights. Advances in data science in general as well as in specific areas such as deep learning, reinforcement learning, etc. helped scale up their operations as hundreds of thousands of sellers sold millions of products to hundreds of millions of customers by over tens of thousands of pin codes through massive multi-echelon supply chain networks. However, the general understanding of the applicability of data science in e-commerce has been limited to a few popular ones such as recommendations and search. In this talk, I will provide an overview of the expanse and potential of data science in e-commerce, building on some of the recent trends in online shopping in India. For a few use-cases, I will highlight the challenges and research directions from the experiences of solving those in one of the largest e-commerce companies of India and the world. I will conclude by bringing out how the data science landscape is evolving, especially with the advancement of generative AI technologies.

Bio

Dr. Shourya Roy is a Senior Research Director at Flipkart where he had been responsible for AI/ML/Data Science strategy and execution of a number of key initiatives across multiple business units. Currently, he is leading the Supply Chain Planning and Forecasting initiatives managing Product, Engineering, and Data Science teams. Prior to joining Flipkart in 2020, he spent over 18 years in various roles in IBM Research and Xerox Research as well as most recently, heading

the AI Labs at American Express. Shourya's technical expertise is broadly in AI/ML and specifically in NLP where he is a well-known thought leader. He has been granted 30+ patents and his work has led to 80+ publications with about 2500 citations. Shourya is an ACM Distinguished Member and currently serves as the President of the India Chapter of ACM SIGKDD (IKDD). Shourya is a proud alumnus of CSA, IISc where he did his Ph.D. under the supervision of Prof. Y. Narahari.

Student Presentation 4: Emotion Recognition from Multiple Modalities

Soumya Dutta and Sriram Ganapathy

Department of Electrical Engineering,
Indian Institute of Science

Abstract
In this talk, I would speak about the well-known problem of emotion recognition. As human beings perceive emotions from multiple modalities such as speech, vision and text, the talk would focus on the multi-modal aspect of this problem. In the first part, I will talk about the recognition of emotions from speech and text when people are talking with one another and engaging in a conversation. While end-end systems are often used for this task, a hierarchical approach involving stage-wise modeling is shown to perform much better. In the second part of the talk, I would be discussing very preliminary efforts towards recognizing emotions from video data. The talk will conclude with a glimpse of my future work about synthesizing emotional speech.

Student Presentation 5: Supervised Hierarchical Graph Clustering for finding who spoke when in a conversational speech

Prachi Singh and Sriram Ganapathy

Department of Electrical Engineering,
Indian Institute of Science

Abstract
The task of finding who spoke when in a multi-talker conversational speech recording is called speaker diarization. It is an important step in obtaining speaker-specific speech transcription, analyzing turn-taking behavior of doctor and patient in clinical diagnosis. Conventional methods for speaker diarization involve windowing a speech recording into short segments to extract feature vectors also referred as speaker embeddings, followed by an unsupervised clustering of the embeddings. Finally it assigns corresponding cluster/speaker label to each segment of the recording.The main disadvantage of this multi-step approach is that it is not optimized to minimize clustering loss. In this talk, I will discuss a novel Supervised HierArchical gRaph Clustering algorithm (SHARC) for speaker diarization. We introduced a hierarchical structure using Graph Neural Network (GNN) to perform supervised clustering. The supervision allows the model to update the representations and directly improve the clustering performance, thus enabling a single-step approach for diarization. In this work, the input segment embeddings are treated as nodes of a graph with the edge weights corresponding to the similarity scores between the nodes. We also developed an approach to jointly

update the embedding extractor and the GNN model to perform end-to-end speaker diarization (E2E-SHARC). During inference, the hierarchical clustering is performed using node densities and edge existence probabilities to merge the segments until convergence. In the diarization experiments, we illustrate that the E2E-SHARC approach achieves state-of-the-art performance over the baseline systems on benchmark datasets.

Student Presentation 6: Speaker and Language Recognition– Classification, Verification, and Diarization

Shreyas Ramoji

Department of Electrical Engineering,
Indian Institute of Science

Abstract
In the age of artificial intelligence, it is important for machines to figure out who is speaking automatically and in what language - a task humans are naturally capable of doing. Developing algorithms that automatically infer the speaker, language, or accent from a given speech segment are challenging problems that have been researched for over three decades. My doctoral research focused on supervised approaches for language and speaker recognition. In language recognition, we focused on developing robust systems to classify the closely related dialects or accents of one or more language clusters. In speaker recognition, we focused on the open-set verification problem – the binary classification task of determining whether a target speaker is present in a test speech recording, given some enrollment audio of the target speaker. Our ongoing project on a more current, challenging problem called speaker and language diarization is an extension of the recognition problem. It is the task of automatically segmenting multilingual, conversational audio into homogeneous regions based on the speaker identity and the language being spoken. In multilingual societies, conversations between multiple speakers involve code mixing and switching between two or more languages. Current speech technologies are not well equipped to handle such scenarios. Hence, it may be beneficial to explore approaches for speaker and language diarization. In this talk, I will briefly discuss the contributions of my doctoral research and establish the link to our ongoing project on speaker and language diarization, which involves collecting a multilingual conversational dataset, annotating the audio files, exploring various approaches for diarization, and conducting open challenges.

Student Presentation 7: Exploring the Role of Sustained Phonemes In Classifying Healthy Subjects and Patients with Amyotrophic Lateral Sclerosis

Tanuka Bhattacharjee and Prasanta Kumar Ghosh

Department of Electrical Engineering,
Indian Institute of Science

Abstract
Amyotrophic Lateral Sclerosis (ALS) is an incurable and progressive neurodegenerative disease that affects muscle movements. Speech musculature, among others, gets severely affected leading to dysarthria. Around 30% of the ALS patients experience dysarthria as an early sign of the disease with almost all patients developing it in some stage. Different aspects of speech like articulation,

phonation, prosody, respiration and resonance get impaired. These impairments affect even the elementary sustained phoneme utterances. In our work, we analyze sustained vowels and fricatives to identify and interpret the acoustic differentiators between dysarthric speech and the speech of healthy controls. Firstly, we analyze the relative contributions of static and dynamic source and filter cues toward automatic classification of ALS patients and healthy subjects using sustained vowel utterances. Since the production mechanisms of vowels and fricatives are different, these may get affected differently due to dysarthria. We examine different sustained voiceless fricatives, as compared to different sustained vowels, for classifying patients with ALS and healthy controls. Lastly, we perform fusion of vowel and fricative utterances for ALS vs. healthy classification in order to utilize the cues present in both types of sounds.

2.2.2 Coffee break

2.2.3 Sesion 1B: Signal Processing and Communication

Session Chair:Sundeep Prabhakar Chepuri, Neelesh Mehta
Cluster Coordinator: Neelesh B. Mehta, Sundeep Prabhakar Chepuri
Student Organizer: Anand, Yugesh
Faculty Organizer: Debdeep Sarkar
Location: ECE MP-20

Cluster Overview

Time	Event	Speaker	Affiliation
09:30 – 10:00 AM	Invited Talk 1	Krishna Jagannathan	EE, IIT Madras
10:00 – 10:20 AM	Invited Talk 2	Sheshachalam B. S	Department Head, NOKIA
10:20 – 10:34 AM	Student Presentations	V. Arvind Rameshwar	ECE,IISc
10:34 – 10:48 AM		Keerthipriya Sathish	ECE, IISc
10:48 – 11:02 AM		Sai Kiran Kadambari	ECE, IISc
11:20 – 11:40 AM	Invited Talk 3	Nidhin Koshy	Principal Engineer, EdgeQ
11:40 – 11:54 AM	Student Presentations	Siddartha Reddy	ECE,IISc
11:54 – 12:08 AM		Prasobh Sankar	ECE, IISc
12:08 – 12:22 AM		Chirag Ramesh	CPS, IISc
12:22 – 12:36 AM		Banhimitra Kundu	DESE, IISc
12:36 – 12:50 AM		Bhogavalli Satwika	ECE, IISc

Invited Talk 1: Capacity of an Erasure Queue-Channel Without and With Feedback

Speaker: Krishna Jagannathan, IIT Madras
Personal Webpage

Abstract

A queue-channel is a model that captures waiting time-dependent degradation of information bits—a scenario motivated by quantum communications and delay-sensitive streaming. Recent work has characterized the capacity of the erasure queue-channel, and other noise models encountered in quantum communications . In this talk, we first review the capacity results for an erasure queue-channel without feedback and show that the capacity has a simple form that depends on the Laplace transform of the stationary sojourn time distribution. Next, we study an erasure queue-channel with feedback, and ask after the optimal transmission strategy to minimize waiting-induced erasures. Specifically, we assume that instantaneous feedback of queue-length (or of the queue-channel output) is available at the transmitter, which can modulate the rate of Poisson transmissions into the queue-channel. We pose an optimal control problem using HJB-style equations to maximize the information capacity, when the transmitter can choose from a bounded set of transmission rates. We show (under a numerically verifiable condition) that the optimal transmission policy is a single-threshold policy of the bang-bang type. In other words, transmitting at the maximum (minimum) possible rate when the queue is below (above) a threshold, maximizes the information capacity of the erasure queue-channel with feedback.

Bio

Krishna Jagannathan obtained his B. Tech. in Electrical Engineering from IIT Madras in 2004, and the S.M. and Ph.D. degrees in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology (MIT) in 2006 and 2010 respectively. During 2010-2011, he was a visiting post-doctoral scholar in Computing and Mathematical Sciences at Caltech, and an off-campus post-doctoral fellow at MIT. Since November 2011, he has been with the Department of Electrical Engineering, IIT Madras, where he is currently an associate professor. He worked as a consultant at the Mathematical Sciences Research Center, Bell Laboratories, Murray Hill, NJ in 2005, and as an engineering intern at Qualcomm, Campbell, CA in 2007. His research interests lie in the stochastic modeling and analysis of communication networks, network control, and queuing theory.

Invited Talk 2: Overview of Joint Communications and Sensing in 6G

Speaker: Sheshachalam B. S., Department Head, NOKIA
Personal Webpage

Abstract

Similar to Positioning services already integrated in LTE, 5G, and 5G advanced sensing capabilities or "Network as a sensor" are seen as the evolutionary step for inclusion in 6G standardization since positioning is a subset of sensing capabilities. Multiple use cases, apart from the obvious (communication enhancement), justify the expansion of cellular service capabilities to sense objects not connected to the network. Several system design factors favour integrating the design of sensing capabilities into mobile networks as compared to the mere independent co-existence of these two types of networks. However, JCAS systems are in their infancy, and a significant amount of new research over the next few years will enable an optimized, native design for 6G. The challenges include the choice of a power-efficient waveform, channel modeling, radar interference mitigation methods, and sensor fusion, to name a few. However, 6G systems will likely have native AI/ML support and support for Extreme Massive MIMO and D-MIMO that would be welcome tools to be leveraged for processing JCAS signals.

Bio

Sheshachalam is the Department Head at Nokia Standards (Strategy Technology) India He began his career at Motorola (1995) as one of the core developers of CDMA-WILL and RAN products; led CDMA specification team over several years. He currently leads a team of highly motivated researchers primarily in the areas of 3GPP standardization Research for 5G advanced and 6G. At NOKIA he was a member of RAN algorithm innovations team. He has submitted several RAN1 contributions from Nokia and has a few 5G RRM SEPs (Standards Essential Patents) including a GlobeComm Publication on 5G RRM.

He was also recognized as one of the Top 10 inventors of standards-essential patents all-time at Nokia Bangalore center.

Student Presentation 1: Capacity Computation and Coding for Input-Constrained Channels

V. Arvind Rameshwar and Navin Kashyap

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
In data storage and communication systems, the physical limitations of the medium lead to some sequences being more prone to error than others. Constrained coding is a method of alleviating this problem, by requiring that the codewords that are stored or transmitted obey a hard constraint. In this talk, we shall explore constrained coding schemes that are resilient to noise. A well-studied information-theoretic model for a noisy medium is that of the memoryless channel, which corrupts each symbol of the codeword independently. We shall first consider hard input-constrained memoryless channels. For this setting, we shall discuss our bounds on the largest rates of reliable communication (or capacity) of memoryless noisy channels with constrained inputs, present explicit coding schemes that guarantee high-rate, reliable information transfer, and evaluate the performance of well- known codes via a Fourier-analytic lens. We then estimate the resilience of constrained codes to adversarial (or combinatorial) noise, with the aid of an extension of Delsarte's linear program (LP), the bounds obtained using which outperform the state-of-the-art.

Student Presentation 2: Antennas and Receivers for a ground-based detection of CMB spectral distortions

Keerthipriya Sathish and Debdeep sarkar

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
The Cosmic Microwave Background (CMB) radiation is the faint light that permeates the Universe, which is the remnant afterglow from the very early Universe. Theory predicts faint deviations of the CMB spectrum from a blackbody (3 Kelvin). One of the inevitable CMB 'spectral distortions'; is caused by photons emitted by the formation of the first hydrogen and helium atoms over the cosmological 'Epoch of Recombination' (redshifts 900 < z 8000). These 'cosmological recombination lines' span over 100 MHz to 3 THz. Feasibility studies have determined that an octave frequency range over 2-6 GHz is best suited for a ground-based detection of these lines. Over this band the predicted spectral distortion has an amplitude of 10 nK. In addition to the cosmological recombination lines, the GHz frequency range is interesting for studying other astrophysical phenomena, including detecting and studying radio transients and dark-matter annihilation signatures, with a large range in amplitude. These motivate designing and developing a precision radio telescope operating over an octave band in 2-6 GHz, with a custom-designed ultra-wideband dual-polarised antenna and well-calibrated analog receiver. This talk will briefly

outline the antenna and receiver specifications for building precision radiometers, followed by an overview of the developmental activities undertaken in building a prototype receiver with a targeted noise temperature of O(10K) at room temperature.

Student Presentation 3: Product Graph Gaussian Processes for Multi-domain Data Imputation and Active Learning

Sai Kiran Kadambari

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
TBA

Invited Talk 3: Designing algorithms for a soft wireless communications SoC: from radio frequency signals to uplink power control and scheduling.

Speaker: Nidhin Koshy, EdgeQ
Personal Webpage

Abstract
At EdgeQ, we are building a soft wireless communications SoC, optimized for wireless communication workloads. Designing algorithms for wireless communications requires the use of techniques from varied disciplines such as signal processing, coding theory, detection and estimation theory, resource allocation etc. We will discuss a few interesting problems, namely, uplink power control and link adaptation, large parameter estimation under resource constraints for digital pre-distortion compensation, machine learning models for channel estimation and MIMO equalization, and designs for non-terrestrial networks. Each of these problems require different toolsets, and have to be computationally efficient.

Bio
Nidhin Koshy Vaidhiyan is a Principal Engineer at EdgeQ Inc, Bangalore. He obtained his ME and PhD degrees from the Department of ECE, IISc and B.Tech in ECE from College of Engineering, Trivandrum. Prior to EdgeQ, he had stints as a Senior Lead Engineer at Qualcomm Wireless RD, Bangalore and as a Research Manager at the Centre for Networked Intelligence, IISc. At EdgeQ, he is part of the Systems and Simulations team, working on algorithms for 5G and WiFi communication systems.

Student Presentation 4: Clustering with Simplicial Complexes

Thummaluru Siddartha Reddy and Sundeep Prabhakar Chepuri

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
In this talk, we discuss a new clustering algorithm to group nodes in networks based on second-order simplices (aka filled triangles) to leverage higher-order network interactions. We define a simplicial conductance function, which on minimizing, yields an optimal partition with a higher density of filled triangles within the set while the density of filled triangles is smaller across the sets. To this end, we discuss a simplicial adjacency operator that captures the relation between the nodes through secondorder simplices. This allows us to extend the well-known Cheeger inequality to cluster a simplicial complex. Then, leveraging the Cheeger inequality, we propose the simplicial spectral clustering algorithm. We report results from numerical experiments on synthetic and real-world network data to demonstrate the efficacy of the proposed approach.

Student Presentation 5: Quantized Precoding and RIS-Assisted Modulation for Integrated Sensing and Communication Systems.

Prasobh Sankar and Sundeep Prabhakar Chepuri

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
In this talk, we present a novel reconfigurable intelligent surface (RIS)-assisted integrated sensing and communication (ISAC) system with 1-bit quantization at the ISAC base station. An RIS is introduced in the ISAC system to mitigate the effects of coarse quantization and to enable the co-existence between sensing and communication functionalities. Specifically, we design a transmit precoder to obtain 1-bit sensing waveforms having a desired radiation pattern. The RIS phase shifts are then designed to modulate the 1-bit sensing waveform to transmit M-ary phase shift keying symbols to users. Through numerical simulations, we show that the proposed method offers significantly improved symbol error probabilities when compared to MIMO communication systems having quantized linear precoders, while still offering comparable sensing performance as that of unquantized sensing systems. This is a joint work with my advisor Prof. Sundeep Prabhakar Chepuri. This work has been accepted for presentation at the IEEE ICASSP 2023, Rhodes Islands, Greece.

Student Presentation 6: Random Access for Massive Machine Type Communications

Chirag Ramesh and Chandra R. Murthy

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
Massive machine-type communications (mMTC) is a 6G application expected to serve millions of internet-of-things-type devices within a small area, which require the use of grant-free random access protocols. The performance of overloaded mMTC applications is limited by the multi-user interference. In this work, we propose a random access protocol, in the overloaded mMTC setup, which censors users with poor channel states. This helps in reducing interference and operates the system at the maximum throughput. We also analyze the optimal censoring scenario in which the

uncensored users are all decoded.

Student Presentation 7: Hand-held Low Power Super Resolution Fully Pipelined Ultrasound System for Real time Imaging

Banhimitra Kundu and Chetan Singh Thakur

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract
Portability, convenience, and speed are the key requirements for Point of Care (POC) applications allowing diagnosis at proximity. Ultrasound Imaging (UI) is a crucial POC application that is of immense importance in the medical community for safe and rapid diagnostics. Still, its bulkiness and high-power requirements limit its use in non-resourceful environments. To overcome this challenge, we have designed a low-power, super-resolution handheld ultrasound system using a single Field-Programmable Gate Array (FPGA) on a custom board that consumes < 6 Watts of power. The system features a 64-channel receive beamformer with dynamic focusing capabilities, operating at a frequency of 50 MHz. The front-end, mid-end, and back-end processing have been optimized using specialized interpolation techniques and hardware algorithms, resulting in $< 50\%$ resource utilization. The system can accommodate transducers with varying frequencies and can reconfigure the apodization coefficients, focal, and scan depth. The beamformed data is sent to a commercial host for real-time imaging through a high-speed Universal Serial Bus (USB) 3.0 interface, which also allows for extracting raw ultrasound Radio-Frequency (RF) data for research purposes.

Student Presentation 8: Waveform design to improve the estimation of target parameters using the Fourier transform method in a MIMO OFDM DFRC system

Bhogavalli Satwika and K.V.S. Hari

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
Portability, convenience, and speed are the key requirements for Point of Care (POC) applications allowing diagnosis at proximity. Ultrasound Imaging (UI) is a crucial POC application that is of immense importance in the medical community for safe and rapid diagnostics. Still, its bulkiness and high-power requirements limit its use in non-resourceful environments. To overcome this challenge, we have designed a low-power, super-resolution handheld ultrasound system using a single Field-Programmable Gate Array (FPGA) on a custom board that consumes < 6 Watts of power. The system features a 64-channel receive beamformer with dynamic focusing capabilities, operating at a frequency of 50 MHz. The front-end, mid-end, and back-end processing have been optimized using specialized interpolation techniques and hardware algorithms, resulting in $< 50\%$ resource utilization. The system can accommodate transducers with varying frequencies and can reconfigure the apodization coefficients, focal, and scan depth. The beamformed data is sent to a commercial host for real-time imaging through a high-speed Universal Serial Bus (USB) 3.0 interface, which

also allows for extracting raw ultrasound Radio-Frequency (RF) data for research purposes.

2.2.4 Qualcomm Live Sessionwith Students

Location: ECE 1.09 (11:30 am onwards)

2.2.5 Lunch Break

Location: Main Guest House for all registered attendees(having food coupons*)

2.3 Session 2 | Faculty Talks and Plenary Talks

2.3.1 Faculty Talks

Session Chair: Samar Agnihotri
Student Organizer: Krishna Murthy, Ayushi Kohli, Rohit Raj
Faculty Organizer: Kiran Kumari, Punit Rathore
Location: Faculty Hall, Main Building

Cluster Overview

Time	Event	Speaker	Affiliation
2:20 – 2:40 PM	Faculty Talk 1	Chirag Jain	CDS, IISc
2:40 – 3:00 PM	Faculty Talk 2	Samir Hazra	EE, IISc
3:00 – 3:20 PM	Faculty Talk 3	Sumit Kumar Mandal	CSA, IISc
3:20 – 3:40 PM	Faculty Talk 4	Pushpak Jagtap	CPS, IISc
5:20 – 5:40 PM	Faculty Talk 5	Balaswamy Velpula	ECE, IISc
5:40 – 6:00 PM	Faculty Talk 6	Viveka K R	DESE, IISc

2.3.2 Faculty Talk 1: Graph-theoretic models for de novo genome assembly

Speaker: Chirag Jain, CDS
Personal Webpage

Abstract
The latest breakthroughs in DNA sequencing technologies have made it possible to compute high-quality human genome assemblies at scale, thus providing a more complete picture of human genetic diversity. To move towards a fully automated and robust computational pipeline for deployment in healthcare, it becomes important to develop practically efficient genome assembly algorithms that are also provably-good. Graph-theoretic models play a central role in computing genome assembly. Graph sparsification is commonly used during genome assembly to simplify the graph by removing redundant or spurious edges. However, a graph model must be "coverage-preserving", i.e., it must ensure that the target genome can be spelled as a walk in the graph, given sufficient sequencing depth. Our work highlights that the commonly used string graph model violates

this property, both in theory and practice. We next introduce a novel sparse read-overlap-based graph model that is motivated by theory. Finally, we demonstrate the empirical advantage of this model using human sequencing data. This talk will be based on the following publication: https://doi.org/10.1093/bioinformatics/btad124

Bio

Chirag Jain is an Assistant Professor and Pratiksha Trust Young Investigator in the department of Computational and Data Sciences (CDS) at IISc. He leads the ATCG group (https://at-cg.github.io) which develops scalable algorithms and software tools for data-intensive problems in molecular biology. Prior to his appointment at IISc, he was working as a post-doctoral fellow at the US National Institutes of Health. He had completed his PhD dissertation in 2019 at Georgia Tech, for which he was awarded the College of Computing Dissertation Award.

2.3.3 Faculty Talk 2: Grid-Forming Inverter for Renewable Energy Resource Integration

Speaker: Samir Hazra, EE
Personal Webpage

Abstract

Recently, India accelerated solar power production to cut down coal and oil-based energy consumption. However, with the increase of solar power, the intermittency of the power supply will be high and thus energy storage such as a battery energy storage system (BESS) is required. Although the energy balance can be achieved by BESS, with higher amount of renewable energy resources (RES) including solar and wind generation and BESS integrated into the grid will create new issues. With a small percentage (<30%) of RES of the total power of the grid, traditional current-controlled inverters can be used for integration. In such cases, the large share of synchronous generators (SG) in the network dictates the dynamics of the system and RESs play only the energy balancing role. The large SGs have high inertia and that helps in the stability of the power grid. However, with a higher amount of RES, the dynamics of the grid are no longer dependent on SG as the overall inertia decreases. Also, for the very distributed nature of the RESs the impedance of the power network increases which also deteriorates the stability of the entire power network. A grid-forming (GFM) inverter, a terminal voltage-controlled RES, can offer solutions to integration issues. A GFM can emulate the operation of an SG thus can increase the overall inertia and can operate with a higher point of common coupling (PCC)impedance.

Bio

Samir Hazra received a B.E. (Hons.) degree in power engineering from Jadavpur University, Kolkata, India, in 2005. He received the MTech. degree from the Indian Institute of Technology Kanpur, Kanpur, India, and the Ph.D. degree from NC State University, Raleigh, NC, USA, in 2008 and 2016, respectively, both in electrical engineering. He is currently an Assistant Professor at the electrical engineering

department at IISc. He worked six years after his Ph.D. in EPC Power Corp., Poway, CA, USA, developing high-power converters for grid-tie and motor drive applications. His research interests include SiC device-based high-performance high-power converter design, Grid-tie inverter modeling and control, and Industrial motor drives. Dr. Hazra received the 2017 IEEE PELS TC6 Emerging Technology Best Paper Award and the 2016 IEEE Transactions on Power Electronics Second Prize Paper Award.

2.3.4 Faculty Talk 3: Energy-efficient 2.5D Architectures with Processing-in-memory for Machine Learning Applications

Speaker: Sumit Kumar Mandal, CSA
Personal Webpage

Abstract
rocessing-in-memory (PIM) is a promising technique to accelerate deep learning (DL) workloads. Emerging DL workloads (e.g., ResNet with 152 layers) consist of millions of parameters, which increase the area and fabrication cost of monolithic PIM accelerators. The fabrication cost challenge can be addressed by 2.5-D systems integrating multiple PIM chiplets connected through a network on package (NoP). However, server-scale scenarios simultaneously execute multiple compute-heavy DL workloads, leading to significant inter-chiplet data volume. State-of-the-art NoP architectures proposed in the literature do not consider the nature of DL workloads. In this talk, we will discuss a novel server-scale 2.5-D manycore architecture that accounts for the traffic characteristics of DL applications. Comprehensive experimental evaluations with different system sizes as well as diverse emerging DL workloads demonstrate that the architecture achieves significant performance and energy consumption improvements with much lower fabrication cost than state-of-the-art NoP topologies.

Bio
Sumit Kumar Mandal is currently an Assistant Professor in Indian Institute of Science, Bangalore. He completed his PhD from University of Wisconsin-Madison. He received Best paper award from ACM TODAES in 2020 and ESweek in 2022. His research interest is energy efficient communication architecture for machine learning applications with emerging technologies.

2.3.5 Faculty Talk 4: Formally verified controllers for cyber-physical systems

Speaker: Pushpak Jagtap, CPS
Personal Webpage

Abstract
Due to the increasing level of autonomy and rapid technological advancements in sensing, computing, and communication, nowadays many real-world applications are expected to do complex tasks. These

complex tasks can be formally represented using temporal logic specifications or an (in)finite strings over automata. On the other hand, the modelling complexities in real-world applications, such as combination/interconnection of physical and cyber components, noisy dynamics, dependency on state history, lack of knowledge of the exact mathematical model, interconnection between subsystems, constraints posed by implementing hardware platforms, are increasing. These system-level complexities along with task-level complexities make the formally correct synthesis of control algorithms very challenging. Solving this problem is beyond the scope of conventional control theory and needs to utilize some concepts from computer science. In this talk, I will discuss my research contributions on combining knowledge from different theories of control systems and computer science to synthesize formally verified controllers for complex control systems (i.e., containing the aforementioned modelling complexities) that ensure the satisfaction of complex logical specifications.

Bio
Pushpak Jagtap is an Assistant Professor in the Robert Bosch Center for Cyber-Physical Systems at the Indian Institute of Science (IISc) Bangalore. Before joining IISc, he was a postdoctoral researcher at the KTH Royal Institute of Technology in Sweden. He received PhD in electrical and computer engineering from the Technical University of Munich and an M.Tech. in electrical engineering from the Indian Institute of Technology, Roorkee. His research area focuses on formal analysis and control of autonomous systems, control theory, cyber-physical systems, and learning-based control. He was recently awarded Google India Research Award 2021 for his research works.

2.3.6 Coffee break

2.3.7 Plenary Talks

Session Chair: Siddhartha Gadgil, Rajesh Sundaresan
Student Organizer: Krishna, Ayushi, Rohit Raj
Faculty Organizer: Debdeep Sarkar, Kiran Kumari, Punit Rathore
Location: Faculty Hall, Main Building

2.3.8 Plenary Talk 1: Mathematics and the Computer

Speaker: Prof. Kevin Buzzard, Imperial College London, UK
Personal Webpage

Abstract for decades, mathematicians have been using computers to calculate. More recently there has been some interest in trying to get them to reason. What is the difference? An example of a calculation: "compute the first one million prime numbers". An example of reasoning: "prove that there are infinitely many prime numbers". Tools like ChatGPT can prove things like this, because they have seen many proofs of it on the internet. But can computers help researchers to come up with new mathematics? Hoping that a computer will automatically prove the Riemann Hypothesis is still science fiction. But new tools and methods are becoming available. I will give an overview of the state of the art.

Congress of Mathematicians.

Short Bio

Kevin Buzzard got his PhD from the University of Cambridge in 1995, he was a Miller Research Fellow in Berkeley in the late 90s and a visiting professor at Harvard in the early 2000s; he is currently a professor of pure mathematics at Imperial College in London England. In 2022 he gave a plenary lecture at the International

2.3.9 High Tea break

2.3.10 Coffee break

2.3.11 Faculty Talks

Student Organizer: Sourav Mazumdar, Suraj Mahadev
Faculty Organizer: Utsav Banerjee, Debdeep Sarkar
Location: Faculty Hall, Main Building

2.3.12 Faculty Talk 5: Wavelength agile fiber lasers

Speaker: Balaswamy Velpula, ECE
Personal Webpage

Abstract
Nonlinear effects in laser systems can be both beneficial and detrimental. A specific class of nonlinearities of importance are photon-phonon interactions such as stimulated Raman and Brillouin scattering. Understanding and controlling them is of essential importance to achieve crucial technological developments in laser systems such as enhancing wavelength agility and power scaling. This has been the main theme of my research work. In this talk, I will present beneficial aspects of nonlinear effects, i.e., generation of new frequencies. Specifically, I will present my research work on the design and development of advanced fiber-based laser systems at unconventional wavelengths using "Stimulated Raman Scattering" (SRS) in optical fibers. SRS is a nonlinear effect due to interaction of light with optical phonons of the fiber. Such systems are well suited used for applications such as spectroscopy, characterization of optical components, industrial manufacturing and material processing, free space optical communications etc. Towards the end, I will also present a future research plan on how such wavelength agile fiber lasers enable development of advanced, fiber-based, octave spanning spectrum, called supercontinuum, sources with low intensity noise and low cost for next generation ultra-high resolution (UHR) optical coherence tomography (OCT) systems.

Bio
Dr. Balaswamy Velpula is currently an Assistant Professor in the ECE Department, IISc Bangalore. He did his M.E from ECE and PhD from Centre for Nano Science and Engineering of IISc Bengaluru. His Research interests are Fiber lasers and Amplifiers, Nonlinear optics, optical signal processing and optical fiber communications. His work has produced 1 Indian patent, 15 international journals and 26 peer reviewed international conference proceedings. He was awarded the Visvesvaraya PhD fellowship (Meity), international travel grants from SPIE and Tata Trusts. Currently, he is leading a research program at IISc (with DRDO, IITM) on advancing high coherence, high power fiber lasers.

2.3.13 Faculty Talk 6: Energy-Efficient Computation in Constrained Systems with Machine Learning Workloads

Speaker: Viveka Konandur Rajanna, DESE
Personal Webpage

Abstract

Increasing demand for energy-efficient systems with machine learning workloads requires the exploration of various avenues for lowering consumption in energy-constrained edge devices. Memories, specifically Static Random Access Memories (SRAMs), are essential to today's system on chips (SoCs). In-memory computation (IMC) enables significant improvements in efficiency by combining data storage with computation. An SRAM macro is introduced to support continuous-sensing applications via simultaneous data buffering, always-on energy/area-efficient computing for continuous event detection, as well as reduced bitline activity without the need for any data prediction for energy-efficient bulk read. Secure integrated systems routinely require the generation of keys in the form of dynamic entropy from True Random Number Generators (TRNGs), and static entropy from Physically Unclonable Functions (PUFs). We introduce an SRAM with a unified TRNG and multi-bit PUF for complete in-memory dynamic and static entropy generation for low-cost security, both in terms of area and design. Applications such as sensor-rich robotics, smart surfaces and prosthetics demand electronic skin solutions with human-like tactile receptor density. Such densities are supported using a tactile sensing system with area and energy/receptor suitable for aggregation of thousands of receptors, while keeping sub-0.01mm2/receptor area efficiency and chip power to the mW range for straightforward power distribution over stretchable substrates with tens of cm2 area and long-lived untethered operation, requiring sub-µW/receptor power.

Bio

Dr. Viveka Konandur Rajanna is an Assistant Professor in the Department of Electronic Systems Engineering (DESE) at Indian Institute of Science (IISc), Bangalore. He received his M.Tech. and Ph.D. degrees from IISc in 2007 and 2016 respectively. He worked as research fellow at the National University of Singapore (NUS), before joining the institute in 2022. He worked with Analog Devices Inc, Bangalore, between 2007 to 2010, developing Blackfin DSPs. His research interests include ultra-low power VLSI circuits, in-memory computing, memory design, low-power human sensor interface and secure on-chip computing.

END OF DAY 1

3. Day 2: 4^{th} April 2023 (Tuesday)

3.1 Session 3 | Plenary Talk and Research Cluster Talks

Location: Faculty Hall and ECE Building

3.1.1 Plenary Talk

Session Chair: Bhavana Kanukurthi
Student Organizer: Krishna, Ayushi, Rohit Raj
Faculty Organizer: Kiran Kumari
Location: Faculty Hall, Main Building

3.1.2 Plenary Talk 2: Perspectives on building a successful Systems Foundry

Speaker: Nivruti Rai, Country Head, Intel India
Personal Webpage

Abstract
The emergence of the new open, collaborative semiconductor design and manufacturing ecosystem is advancing the momentum towards building a successful systems foundry. It underlines the need for critical components like IPs, packaging, EDA tools and design services and the role of the semiconductor supply chain ecosystem. Ecosystem collaborations, combined with open standards and a solution mindset can pave the way for foundries to achieve a total addressable market of $180 billion by 2030. Automotive, compute and mobile will be the key drivers of the foundry market.

Bio

Nivruti Rai is Vice President, Intel Foundry Services, at Intel Corporation and Country Head of Intel India. She heads the Automotive Solutions Group for Intel Foundry Services providing design services and custom solutions to foundry customers. Based in Bengaluru, she provides overall engineering and business unit leadership and leads operations for the site, driving innovation, cross-group efficiencies and execution for engineering teams delivering global products and roadmaps. She also leads engagements with national and local governments and policymakers, as well as collaboration with ecosystem players to enable innovation and entrepreneurship.

Nivruti serves as a member of the society board for Council of Scientific and Industrial Research (CSIR), chaired by the Hon. Prime Minister. She was awarded the Nari Shakti Puraskar, on International Women's Day 2022 in recognition of her exceptional contributions towards driving technologies like Artificial Intelligence for India's advancement. She is one of five global business leaders recognized for fostering economic growth and social change, by the Reykjavík Global Forum in the Leading Edge initiative. She is also a recipient of the Women Who Make India award from Makers India for the year 2021.

3.1.3 Coffee break at Faculty Hall and Proceed to ECE building for Research Cluster talks

3.1.4 TCS Research Cafe

Location: ECE 1.05 (12:00 pm onwards)
TCS is organising a Research Café, where many of the TCS Research's scientists will be available for interaction with IISc students on areas of mutual interests.

This will be a great opportunity for students to network with them and get an unparalleled view on career option at TCS Research.

Research Café will open from 12:00 pm onwards. Interested students can make themselves available at this time.

3.1.5 Session 3A: Theoretical Computer Science

Session Chair: Sunil Chandran, Satish Govindarajan
Cluster Coordinator: Arindam Khan
Student Organizer: Meenaly, Jayant
Faculty Organizer: Gugan Thoppe, CSA
Location: ECE 1.07

Cluster Overview

Time	Event	Speaker	Affiliation
10:30 – 11:00 AM	TCS Research Talk	Prasanta Misra	Senior Scientist at Tata Consultancy Services
11:00 – 11:30 AM	Invited Talk 1	Neeldhara Misra	IIT Gandhinagar
11:30 – 12:00 AM	Invited Talk 2	Pandu Rangan Chandrasekaran	Sathish Dhawan Visiting Chair Professor at IISc
12:15 – 12:28 PM	Student Presentations	Tania Sidana	ECE,IISc
12:28 – 11:41 PM		Dalu Jacob	CSA, IISc
12:41 – 12:54 PM		Dhanyamol Antony	CSA, IISc
12:54 – 01:07 PM		Aditya Subramanian	CSA, IISc
01:07 – 01:20 PM		Anand Krishna	CSA, IISc

TCS Research Talk: Agent-based L2O Approach to Electric Vehicle Routing Problem with Vehicle-to-Grid Supply

Speaker: Prasanta Misra, Senior Scientist at Tata Consultancy Services

Abstract

The use of electric vehicles (EV) in the last mile is appealing from both sustainability and operational cost perspectives. In addition to the inherent cost efficiency of EVs, selling energy back to the grid during peak grid demand, is a potential source of additional revenue to a fleet operator. To achieve this, EVs must be at specific locations (discharge points) during specific points in time (peak period), even while meeting their core purpose of delivering goods to customers. This talk will consider the problem of EV routing with constraints on loading capacity; time window; vehicle-to-grid energy supply (CEVRPTW-D); which not only satisfy multiple system objectives, but also scale efficiently to large problem sizes involving hundreds of customers and discharge stations. We present a reinforcement learning based learning to optimize (or RL-L2O) approach for EV routing to overcome these challenges. Using numerical simulations on benchmark datasets, our analysis shows that RL-L2O generates solutions 24 times faster than the genetic algorithm (GA) and MILP baselines; although with approximately 20

Bio

Prasant Misra is a Senior Scientist at Tata Consultancy Services - Research, where he works on intelligent cyber physical systems for smart mobility. His current focus is on the development of mathematical models and the application of operations research methods for the management of electric vehicles, fleets and charging infrastructure. His past research endeavor was in the design of sensing techniques and sensor informatics for energy constrained network embedded systems.

He has published over 60 peer-reviewed scientific and position papers in the fields of cyber physical systems (CPS), Internet of Things (IoT), mobile systems, and electric mobility. He has been felicitated by numerous honors and awards for his work, of which it is noteworthy to mention the MIT TR 35 - India "Top 10 Innovators under the age of 35 in India" (for the development of new technology or creative application of existing technologies to solve problems) and the TCS "Exemplary Contribution Award" (for increasing the brand value of TCS) in 2017; the ERCIM "Alain Bensoussan" and "Marie Curie" Fellowship (for scientific excellence) in 2012; and the Australian Government's AusAID "Australian Leadership Awards" Scholarship (for his potential to make substantial impact on social, economic, and development challenges of the Asia-Pacific region at a leadership level) in 2008. He is a recipient of the Best Paper Award (in the applied data science track) at ACM India CODS-COMADS 2023; and has won the Best Poster Paper Award at ACM SenSys 2016 and EWSN 2013.

Invited Talk 1: A Cheat-Sheet for Hard Problems.

Speaker: Neeldhara Misra, CSE, IIT Gandhinagar
Personal Webpage

Abstract

When we think about designing algorithms, we are usually very demanding in how we go about it: we require our algorithms to be fast and accurate on all conceivable inputs. This is asking for quite a bit, and perhaps it is not surprising that we cannot afford this luxury all the time. The good news is that most of the time we can make meaningful progress by relaxing just one of these demands.

One approach that tackles all of these tradeoffs at once is to take what is now called a "multivariate approach" to the analysis of running times, which essentially involves appreciating that to describe a problem instance just in terms of its size is like describing a movie by a rating, which is unfortunate because there's so much more nuance. And yet we report — and think about — worst-case running times in only terms of the sizes of the instances.

The parameterized approach takes into account problem structure by addressing "secondary" measurements (parameters), apart from the primary measurement of overall input size, that significantly affect problem computational complexity. The central notion of fixed parameter tractability (FPT) is a generalization of polynomial-time based on confining any non-polynomial complexity costs to a function only of these secondary measurements. In this talk, we will introduce this paradigm and illustrate its utility in theory and practice.

Bio

Neeldhara Misra is a Smt. Amba and Sri. V S Sastry Chair Associate Professor of Computer Science and Engineering at the Indian Institute of Technology, Gandhinagar. She completed her PhD from the Institute for Mathematical Sciences in 2012 in Theoretical Computer Science, and was an INSPIRE faculty fellow at the CSA department of IISc between 2013 and 2015. Her research interests include the design and analysis of algorithms in the context of problems that arise in graph theory, combinatorial games, and computational social choice. She is also interested in visualizations and other methods to communicate computational thinking at an elementary level.

Invited Talk 2: Genesis, growth and Future of Blockchains via trilemmas

Speaker: Pandu Rangan Chandrasekaran, Sathish Dhawan Visiting Chair Professor at IISc
Personal Webpage

Abstract

Informally, a trilemma is a situation where you want three things , all the time and all together, but you can not have more than two of them at any time!. And so you compromise bit and manage to get as much as you can... When we started this in the context of a decentralised computation, Blockchain technology is born. It continued to thrive on

other solutions and innovations on dealing with other trilemmas. From genesis to growth to research trends, trilemmas are guiding force behind every innovation in the blockchain technology. I attempt to present the foundation aspects of these trilemmas in a light weight fashion. By the way, some dilemma are easy to resolve: should you choose between honouring an invitation call from your bf/gf/soulmate or to attend this talk.... However, Trilemmas are tricky!!!!

Bio

Prof. Chandrasekaran Pandu Rangan obtained his Master's degree in Mathematics from the University of Madras, Chennai and Doctorate degree from the Indian Institute of Science, Bengaluru. He joined the faculty of Computer Science and Engineering at the Indian Institute of Technology (IIT) Madras in 1982. He served as a distinguished Visiting Professor at the Information and Communications University, Deajon, South Korea. He joined the rank of Professors in 1995 and served as Head of Department from 1998–2001. He was a member of the founding team for IIT Hyderabad (IITH) and served as Inaugural Chair to set up the computer science department at IITH (2008–2011). He has upgraded the unit of the Indian Statistical Institute (ISI) in Chennai to a Centre and served as Inaugural Chair for the ISI, Chennai Centre. He is a Fellow of the Indian National Academy of Engineering (INAE) from 2006. He was honoured as Venky Harinarayan and Anand Rajaraman Chair Professor in 2017. He served at IITM until his retirement and superannuated in 2021. Since August 2021, he is serving at IISc, in the Department of Computer Science and Automation as Sathish Dhawan Visiting Chair Professor.

Pandu Rangan also served in the Board of Directors of the International Association of Cryptology Research (IACR), USA and in the Board of Directors of the Society for Electronic Transactions

and Security (SETS), Chennai. He was also on the editorial board of the Lecture Notes in Computer Science (LNCS) series published by Springer Verlag, Germany. He has developed special outreach programme-related lecture series and customised competency building lecture series at TCS, INFOSYS, IBM Research, Tokyo, Japan, SAMSUNG RD, Seoul, South Korea.

Student Presentation 1: Entanglement-Assisted Quantum Error-Correcting Codes over Local Frobenius Rings

Tania Sidana and Navin Kashyap

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
Quantum error-correcting codes protect quantum states against decoherence caused by the interaction between quantum states and their environment. The stabilizer framework, proposed by Gottesman, is one of the main mechanisms for constructing quantum error-correcting codes. The stabilizer formalism was extended in a different direction by Brun, Devetak, and Hsieh, who gave a method of constructing quantum error-correcting codes (over qubits) from non-abelian subgroups of the Pauli group. The code construction involved the use of a small number of maximally entangled states pre-shared between the transmitter and the receiver. As a consequence, these codes were called entanglement-assisted quantum error-correcting codes. In this talk, we will present some of our recent contributions to this area. Mainly we will discuss a coding-theoretic framework to construct entanglement-assisted quantum error-correcting codes from additive codes over finite commutative local Frobenius rings.

Student Presentation 2: On the anti-Ramsey numbers of star graphs

Dalu Jacob and L. Sunil Chandran

Department of Computer Science and Automation,
Indian Institute of Science

Abstract
The anti-Ramsey number ar(G,H) with input graph G and pattern graph H, is the maximum positive integer k such that there exists an edge colouring of G using k colours, in which there are no rainbow subgraphs isomorphic to H in G. (H is rainbow if all its edges get distinct colours). The concept of anti-Ramsey number was introduced by Erdös, Simanovitz, and Sós in 1973. Thereafter several researchers investigated this concept in the combinatorial setting. Recently, Feng et al. revisited the anti-Ramsey problem for the pattern graph K1,t (for t3) purely from an algorithmic point of view due to its applications in interference modeling of wireless networks. They posed it as an optimization problem, the maximum edge q-colouring problem. For a graph G and an integer q2, an edge q-colouring of G is an assignment of colours to edges of G, such that edges incident on a vertex span at most q distinct colours. The maximum edge q-colouring problem seeks to maximize the number of colours in an edge q-colouring of the graph G. Note that the optimum value of the edge q-colouring problem of G equals ar(G,K1,q+1). In this talk, we discuss ar(G,K1,t), the anti-Ramsey number of stars, for each fixed integer t3, both from combinatorial and algorithmic point of view. The first of

our main results presents an upper bound for ar(G,K1,q+1), in terms of number of vertices and the minimum degree of G. The second one improves this result for the case of triangle-free input graphs. For a positive integer t, let Ht denote a subgraph of G with maximum number of possible edges and maximum degree t. Our third main result presents an upper bound for ar(G,K1,q+1) in terms of |E(Hq1)|. All our results have algorithmic consequences.

Student Presentation 3: On Subgraph Complementation to H-free graphs

Dhanyamol Antony and L. Sunil Chandran

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

A significant number of interesting computational problems emerging from both theory and applications can be formulated as graph modification problems. For a graph class G, a graph modification problem refers to the problem of modifying the input graph G into a graph that belongs to G. Among the various graph modification problems, vertex deletion problems and edge modification problems have been studied for many years. The complete P versus NP-Complete dichotomies of vertex deletion and basic edge modification (edge addition, edge deletion, and edge editing) problems have been established. In this talk, we discuss the computational complexity of a kind of edge modification problem, namely, Subgraph Complementation, in which the modified edges satisfy some additional structural constraints.

For a class G of graphs, SUBGRAPH COMPLEMENTATION TO G is the problem to find whether one can identify a subset S of vertices of the input graph G such that complementing the subgraph induced by S in G results in a graph G S that belongs to G. The talk outlines the results we have obtained for this interesting operation introduced by Kamin´ski et al. (Discret. Appl. Math. 2009). Specifically, the talk covers the P versus NP-Complete dichotomies of SUBGRAPH COMPLEMENTATION TO H-free graphs for H being a complete graph, or a 5-connected graph with specific properties, or a tree, or a cycle. These results and techniques could be of use for an eventual computational complexity dichotomy of SUBGRAPH COMPLEMENTATION TO H-free graphs for any graph H.

3.1.6 Coffee break

Student Presentation 4: Online and Dynamic Algorithms for Geometric Set Cover and Hitting Set

Aditya Subramanian and Arindam Khan

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

Set cover and hitting set are fundamental problems in combinatorial optimization which are well-studied in the offline, online, and dynamic settings. We study the geometric versions of these problems and present new online and dynamic algorithms for them. In the online version of set cover (resp. hitting set), m sets (resp. n points) are given and n points (resp. m sets) arrive online,

one by one. In the dynamic versions, points (resp. sets) can arrive as well as depart. Our goal is to maintain a set cover (resp. hitting set), minimizing the size of the computed solution. For online set cover for (axis-parallel) squares of arbitrary sizes, we present a tight $O(\log n)$-competitive algorithm. In the same setting for hitting set, we provide a tight $O(\log N)$-competitive algorithm, assuming that all points have integral coordinates in $[0,N)^2$. No online algorithm had been known for either of these settings, not even for unit squares (apart from the known online algorithms for arbitrary set systems).

For both dynamic set cover and hitting set with d-dimensional hyperrectangles, we obtain $(\log m)^{O(d)}$-approximation algorithms with $(\log m)^{O(d)}$ worst-case update time. This partially answers an open question posed by Chan et al. [SODA'22]. Previously, no dynamic algorithms with polylogarithmic update time were known even in the setting of squares (for either of these problems). Our main technical contributions are an *extended quad-tree approach* and a *frequency reduction* technique that reduces geometric set cover instances to instances of general set cover with bounded frequency.

Student Presentation 5: Achieving Envy-Freeness with Limited Subsidies under Dichotomous Valuations

Anand Krishna and Siddharth Barman

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

We study the problem of allocating indivisible goods among agents in a fair manner. While envy-free allocations of indivisible goods are not guaranteed to exist, envy-freeness can be achieved by additionally providing some subsidy to the agents. These subsidies can be alternatively viewed as a divisible good (money) that is fractionally assigned among the agents to realize an envy-free outcome. In this setup, we bound the subsidy required to attain envy-freeness among agents with dichotomous valuations, i.e., among agents whose marginal value for any good is either zero or one. We prove that, under dichotomous valuations, there exists an allocation that achieves envy-freeness with a per-agent subsidy of either 0 or 1. Furthermore, such an envy-free solution can be computed efficiently in the standard value-oracle model. Notably, our results hold for general dichotomous valuations and, in particular, do not require the (dichotomous) valuations to be additive, submodular, or even subadditive. Also, our subsidy bounds are tight and provide a linear (in the number of agents) factor improvement over the bounds known for general monotone valuations.

3.1.7 Session 3B: Cyber-Physical Systems

Session Chair: Pushpak Jagtap, Shishir N Y
Cluster Coordinator: Pushpak Jagtap, Pavankumar Tallapragada
Student Organizer: Suraj, Harsh
Faculty Organizer: Kiran Kumari, EE
Location: ECE MP-30

Cluster Overview

Time	Event	Speaker	Affiliation
10:30 – 11:00 AM	Invited Talk 1	Manjesh Hanawal	IEOR, IIT Bombay
11:00 – 11:12 AM	Student Presentations	Anusree Rajan	EE,IISc
11:12 – 11:24 AM		Rohit Chowdhury	CDS, IISc
11:24 – 11:36 AM		Vishal Kushwaha	RBCCPS, IISc
10:44 – 11:48 AM		Abishek Chandrasekhar	RBCCPS, IISc
10:44 – 12:00 PM		Pankaj Mishra	RBCCPS, IISc
12:15 – 12:35 PM	Invited Talk 2	Naveen Arulselva	CTO, Ati Motors
12:35 – 12:47 PM	Student Presentations	P S V S Sai Kumar	RBCCPS, IISc
12:47 – 12:59 PM		Ananta Kant Rai	ECE, IISc
12:59 – 01:11 PM		Amit Kumar	CPS, IISc
01:11 – 01:23 PM		Kumar Ankit	CPS, IISc

Invited Talk 1: Learning Optimal Exit in Early-Exit Neural Networks.

Speaker: Manjesh Hanawal, IEOR IIT Bombay
Personal Webpage

Abstract

Deep Neural Networks (DNNs) have shown impressive performance in various tasks, including image classification and natural language processing (NLP). However, their deployment on resource-constrained devices remains challenging due to energy consumption and delay overheads. Early-exit DNNs (EE-DNNs) have been proposed to address these challenges, which leverage side branches at intermediate layers for early inferences. How to decide which layer to exit is a question one needs to address in the EE-DNNs. Also, the optimal exits may depend on the specific application and need to be learned. We develop models and learning algorithms using the Multi-Arm Bandit framework to learn exit points that optimally tradeoff between latency and accuracy. We demonstrate how one can significantly reduce the inference latency in pre-trained models from NLP and Image classification applications with only a small drop in accuracy.

Bio

Manjesh K. Hanawal received the BTech degree in ECE from NIT, Bhopal, in 2004, the M.S. degree in ECE from the Indian Institute of Science, Bangalore, India, in 2009, and the Ph.D. degree from INRIA, Sophia Antipolis and University of Avignon, France, in 2013. After two years of postdoc at Boston University, he joined

Industrial Engineering and Operations Research at the Indian Institute of Technology Bombay, Mumbai, India, where he is an associate professor now. During 2004-2007 he was with CAIR, DRDO, working on various security-related projects. His research interests include communication networks, machine learning, cybersecurity, and 5G security. He is a recipient of Inspire Faculty Award from DST and the Early Career Research Award from SERB. He has received several research grants like MATRIX from SERB and Indo-French Collaborative Scientific Research Programme from CEFIPRA.

Student Presentation 1: Event-Triggered Parameterized Control for stabilization of Linear Systems

Anusree Rajan

Department of Cyber-Physical Systems,
Indian Institute of Science

Abstract

Event-triggered control is a popular control method in the field of networked control systems due to the advantage of efficient utilization of resources while simultaneously achieving the control objective. Many of the papers in event-triggered control literature consider the case where the control input is applied to the plant in a zero-order-hold (ZOH) manner. Resource usage in networked control systems can be further reduced by using event-triggered control based on non-ZOH. With this motivation, in this work, we propose an event-triggered parameterized control method for stabilization of linear systems. We show that the proposed event-triggered control system guarantees global asymptotic stability of the origin of the closed loop system. We ensure the absence of Zeno behaviour by showing the existence of a uniform positive lower bound on the inter-event times. We illustrate our results through numerical examples.

Student Presentation 2: Intelligent Onboard Routing in Stochastic Dynamic

Rohit Chowdhury

Department of Cyber-Physical Systems,
Indian Institute of Science

Abstract

Autonomous marine agents find extensive applications in environmental data collection, naval security, and exploration of harsh ocean regions. As intelligent agents, they must perform onboard routing, collect data about their surroundings and update their route to minimize mission travel time, energy, or data collection. While Markov Decision Processes (MDPs) and Reinforcement Learning (RL) are often used for path planning, they are computationally expensive for onboard routing as they need in-mission re-planning. In the present paper, we develop a novel, deep learning method based on the decision transformers for optimal path planning and onboard routing of autonomous marine agents. The transformer architectures convert the RL-based optimal path planning problem into a supervised learning problem via sequence modeling. Before the mission, during the offline planning phase, the environment is first modeled as a stochastic dynamic ocean flow with dynamically orthogonal flow equations. A training dataset for the transformer model is created by solving the stochastic dynamically orthogonal Hamilton-Jacobi level set partial differential

equations or a dynamic programming solution for MDPs. These paths are then processed to obtain sequences of states, actions and returns for our transformer models, where the agent's state is typically its spatio-temporal coordinate and other collectible data. We propose and analyze multiple state modeling choices against the agent's state estimation capabilities and scenarios with multiple target locations. We demonstrate that (i) a trained agent learns to infer the surrounding flow and perform optimal onboard routing when the agent's state estimation is accurate,(ii) specifying the target locations (in case of multiple targets) as a part of the state enables a trained agent to route itself to the correct destination, and (iii) a trained agent is robust to limited noise in state transitions and is capable of reaching target locations in completely new flow scenarios. We extensively showcase end-to-end planning and onboard routing in various canonical and idealized ocean flow scenarios. We analyze the predictions of the transformer models and explain the inner mechanics of learning through a novel visualization of self-attention of actions and states on the trajectories.

Student Presentation 3: A Generalized Collaboration Model for Rideshare and Transit Service Providers to Facilitate First- and Last-Mile Services

Vishal Kushwaha

Department of Cyber-Physical Systems,
Indian Institute of Science

Abstract

The rideshare service providers (RSPs), e.g., Ola, Uber, Lyft etc., are gaining popularity among travelers because of their special service structure. The features of their services include online booking facility, ride personalization flexibility, end-to-end connectivity for travelers etc. However, due to this increasing popularity, the city transportation planners are concerned that the congestion levels on the roads may increase leading to an increase in travel times. On the other hand, the public transit (e.g., bus, metro etc.) agencies are observing a decline in ridership. The transit stops may be located far away from travelers' homes or activity locations which discourages public transit use. Due to these issues, efforts are being made to make the RSPs and public transit agencies collaborate. In such collaboration frameworks, the RSPs will provide connectivity from transit stops to travelers' home and activity locations. The transit agencies will provide connectivity on the long-haul part of the journey. In this regard, we propose a tri-level game theory, discrete mode choice theory, and route choice theory based model to determine optimal travel prices for such a travel mode. The model is applied to a part of the Bangalore traffic network. The simulation results show a significant increase in profits and market shares of the RSPs and the bus agency. The collaborative travel mode turns out to be an attractive option for the travelers in terms of travel price and travel time. A system-wide reduction in travel times and carbon dioxide emissions is also observe.

Student Presentation 4: Neuro-adaptive learning for Artificial Pancreas Systems

Abishek Chandrasekhar

Department of Cyber-Physical Systems,
Indian Institute of Science

Abstract

Type-1 Diabetic Mellitus is a condition where the insulin producing cells in their body are destroyed by the immune system. The people affected by Type-1 Diabetes are unable to regulate their blood sugar levels naturally and require insulin. They follow strict dietary restrictions and take multiple shots of insulin every day. However, this leads to several inaccurate doses and causes several health complications due to hypoglycemia and hyperglycemia (low and high blood sugars).

The Artificial Pancreas is the most effective solution for such patients. It is a safety-critical control system that includes an insulin pump, a continuous glucose monitor (CGM) and a powerful computer at the centre. A sophisticated control algorithm calculates the amount of insulin to be delivered to ensure glucose is maintained within target ranges at all times. The Model Predictive Control technique from Optimal Control is one of the best control methods for this application because it utilizes a mathematical model to predict system behaviour and optimizes control input. MPC has constraint handling capabilities and is robust because of the feedback loop. Mathematical Modeling of glucose-insulin dynamics of these patients is an essential component of the design and development of Artificial Pancreas Systems. These model parameters, which exhibit significant inter-patient variability, are identified for each individual T1DM patient through standard tolerance tests. However, in addition to the inter-patient variability, each patient's model parameters vary according to the circadian rhythm. Therefore, the blood glucose response to a meal is different at breakfast, when compared to lunch and dinner. In addition to this, the glucose-insulin dynamics vary when the T1DM patient exercises or during any physical activity. To account for these intra-patient variabilities and the variability due to exercise, a neuro-adaptive learning scheme is proposed in this work. The uncertainties are approximated as a product of a weight and a meaningful basis function. The model uncertainties are learned during meals and idle activity, whereas exercise learning requires an announcement from the patient and is only learned when the patient is exercising. This neuroadaptive learning scheme can prove to be of vital importance in designing model-based control laws for blood glucose regulation in Type-1 Diabetic patients.

Student Presentation 5: Approximation-free control of unknown nonlinear systems with prescribed performance and input constraints

Pankaj Mishra and Pushpak Jagtap

Department of Cyber-Physical Systems,
Indian Institute of Science

Abstract

Researchers in academia and industry have devised various approaches for designing controllers for nonlinear systems. Despite these developments, designing controllers for systems subject to constraints and unknown time-varying disturbances is still challenging. In most practical control systems, constraints appear in different forms, such as performance, saturation, physical stoppages, and safety specifications. For such systems, while designing controllers, constraints are ineludible. In the talk, we will explore a tracking control problem for an unknown control-affine nonlinear systems with prescribed performance constraints (PPC) and prescribed input constraints (PIC). We will look for the following question in the talk: 1.) How to specify time-domain design specifications (settling time, steady-state error, overshoot,...) in modern control? 2.) Can we prescribe PPC and PIC arbitrarily? 3.)How to design an approximation-free control for the unknown systems?

Invited Talk 2: Designing Autonomous mobile robots ground-up.

Speaker: Naveen Arulselvan, CTO, Ati Motors
Personal Webpage

Abstract

Using Ati's Sherpa as a template, we will look at the building blocks of an Autonomous mobile robot and the design decisions the robotics engineer has to make across the stack.

Bio

Naveen Arulselvan is currently the CTO of Ati Motors. His previous stints include Motorola (now part of Nokia), Altiostar (now part of Rakuten), and Artpark, with his work spanning across wireless communications and robotics.

Student Presentation 6: Autonomous Soft Landing of UAVs using Minimum Jerk based Guidance Strategy

P S V S Sai Kumar and Radhakant Padhi

Department of Aerospace Engineering,
Indian Institute of Science

Abstract

Autonomous soft landing is an essential requirement for various autonomous missions of Unmanned Aerial Vehicle (UAV), especially when transporting sensitive or fragile components. These demand precise strategies for generating trajectories for landing. Hard constraints on terminal position, velocity, and acceleration are necessary for accurate soft landing. An explicit constraint on attitude is required for a vertical landing. Moreover, autonomous soft-landing needs to be accurately carried out even with the limited capability of the onboard computer. Towards this objective, a jerk minimization-based optimal control problem is formulated to generate the trajectory. The guidance is formulated in a fixed final time optimal control framework, where the final time selection is typically a tuning parameter. Thus, an acceleration minimization-based cost function is formulated alongside the guidance to select the final time. The developed method generates the solution in a closed form, reducing the computational load on the flight computer. The acceleration constraints also facilitate smooth transfer between successive segments along the trajectory. Terminal acceleration constraints enforce constraints on the attitude for the vertical landing of UAV. Moreover, the acceleration minimization cost function translates to minimal control effort. Additionally, the

generated commands are corrected for aerodynamic forces to obtain an accurate solution for thrust, which is commanded to the inner loop attitude controller of the UAV. Software in the loop simulation is performed for a quadrotor drone in PX4-ROS (Robot Operating System) environment. Simulation results show that this method produces smooth trajectories to soft-land on the desired target. The performance of the guidance is also studied when disturbances like the wind are introduced. Extensive flight trials are conducted to verify the performance of the developed method in the real-world.

Student Presentation 7:Design of Resilient Linear Dynamical Systems

Ananta Kant Rai and Vaibhav Katewa

Department of Cyber-Physical Systems,
Indian Institute of Science

Abstract
The networks in the cyber-physical world have a blend of virtual and physical entities connected by communication links. With the advent of technology, the performance of these systems is improving, but it also makes the system vulnerable to malicious attacks on devices and communication links. It may result in data breaches, privacy violations of users and instability of the whole network. Thus, there is a need to develop safety mechanisms and countermeasures against such attacks. In this work, we focus on designing the topology of these networks modelled as linear dynamical systems that are inherently resilient against such destabilizing attacks. In this work, the metrics to study the robustness measure and vulnerability to malicious attacks of a system are utilized to design resilient systems. When a system is under attack, the system matrices get perturbed, and thus the behaviour of the system gets affected. This work presents the countermeasures at the operators' end to mitigate such malicious attacks.

Student Presentation 8: Barrier Coverage using Unmanned Aerial Vehicles

Amit Kumar and Debasish Ghose

Department of Aerospace Engineering,
Indian Institute of Science

Abstract
Barrier coverage of a protected region refers to the sensor network deployment, which ensures that there are no paths for intruders to go undetected when it passes through the borders of that region. UAVs that are equipped with downward-facing cameras act as mobile sensors and can be used for barrier coverage. In this work, we study the barrier coverage problem using such UAVs. Given an arbitrary placement of UAVs over a rectangular belt, we propose a deterministic placement strategy to maximize the barrier coverage based on the number of sensors and the maximum and minimum height of flight allowed for UAVs. Further, we formulate an energy and resolution-based optimization problem that secure barrier coverage for arbitrary placement of UAVs in the rectangular belt. Further, We define a cost function that determines the resolution of the overall network. Given an already barrier-covered network, we improve the quality of the belt based on the cost function. In cases, when the deployment is arbitrary, and the region is not barrier covered, we optimize the position of each UAV to achieve barrier coverage with improved quality. Moreover, we show that

our method can be applied to monitor the borders of various shapes by confining them within a combination of rectangular belts. Additionally, we propose a fault tolerance model that ensures uninterrupted barrier coverage in case of faulty UAVs in the network. The model considers nearby UAVs to compensate for the gaps. We determine the neighbors for each faulty UAV and preserve barrier coverage while maintaining the overlap constraints. We validate our result with simulation on different example scenarios.

Student Presentation 9: Multi-agent Collaborative Framework for Automated Agriculture

Kumar Ankit and Debasish Ghose

Department of Aerospace Engineering,
Indian Institute of Science

Abstract

In agricultural scenarios, Unmanned Aerial Vehicles hover close to biomass to capture high-quality images for inspection purposes. In this work, we propose a centralized framework capable of handling a heterogeneous mixture of UAVs and UGVs to efficiently cater to the needs of automating agriculture. The framework's core is a novel heuristic decision module that creates new tasks by visually analyzing the farm and optimally solving a vehicle routing problem to allocate it to agents. We also address the issue of finding trajectories around the biomass that enable UAVs to inspect it proximally without compromising its safety. We also outline the complete pipeline from data collection and preprocessing to generating proximal waypoints. We test our pipeline by collecting data from a farm and evaluating the trajectory using a UAV.

3.1.8 Session 3C: Security and Privacy

Session Chair: Navin Kashyap, Chaya Ganesh
Cluster Coordinator: Vaibhav Katewa, Bhavana Kanukurthi and Navin Kashyap
Student Organizer: Moumita, Abhishek
Faculty Organizer: Utsav Banerjee
Location: ECE Golden Jubilee Hall

Cluster Overview

Time	Event	Speaker	Affiliation
10:30 – 10:50 AM	Invited Talk 1	Kapaleeswaran Viswanathan	Siemens, India
10:50 – 11:02 AM	Student Presentations	Puspabeethi Samanta	ECE, IISc
11:02 – 11:14 AM		Debottam Mukherjee	CPS, IISc
11:14 – 11:26 AM		Varkey M John	ECE, IISc
11:26 – 11:56 AM	Invited Talk 2	Satyam Lokam	Microsoft Research, India
12:15 – 12:35 PM	Invited Talk 3	Jaideep Reddy	Trilegal, India
12:35 – 12:47 PM	Student Presentations	Shravani Patil	CSA, IISc
12:47 – 12:59 PM		Varsha Bhat	CSA, IISc
12:59 – 01:11 PM		Nishat Koti	CSA, IISc
01:11 – 01:23 PM		Protik Paul	CSA, IISc

Invited Talk 1: Towards trustworthy sensors, devices and systems

Speaker: Viswanathan Kapaleeswaran, Siemens India
Personal Webpage

Abstract At Siemens, we believe that the following mega-trends will affect all technology generation, deployment and business activities in the next few years. Increased Digitalization Automation, Climate Change, Urbanization, Globally aging population, Sustainability as a core proposition. Within such a context, we shall motivate an RD greenfield called trustworthy sensing, trustworthy devices and trusted cyber-physical systems. The terminology for trust and trustworthiness shall be introduced in theory and the applicability of the theory to the practice of designing and developing a new class of sensors, devices and systems shall be briefly explored.

Bio

Kapali Viswanathan is a Senior Key Expert at the Cybersecurity Trust research group in the Technology Organization of Siemens in India. He analyzes, designs, and develops secure and trustworthy distributed systems. Since recently, he is focused on incubating the field of trusted sensors and trustworthy devices as an important field of technology development.

Student Presentation 1: A DNA-based Secure Communication Scheme

Puspabeethi Samanta and Navin Kashyap.

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

In DNA-based data storage, the desired information is encoded into the quaternary sequence of synthetic DNA molecules, called oligos. We focus on secure communication via information-containing oligos in the usual three-party setting, where Alice and Bob are legitimate communicators and Eve is an eavesdropper. Our scheme for secure DNA-based communication is two-fold: First, we store secret data in synthetic DNA molecules in a properly designed oligo pool of suitably high dilution. The oligo pool comprises information-containing oligos mixed up with background genomic DNA cleaved into strands of the same length as the useful oligos. Designing oligos for storing data involves the design of a library of primer pairs and a code book specific to this set of primers, that satisfy constraints on homopolymer run length, GC content, primer-primer dissimilarity, and primer-sequence dissimilarity. The differential knowledge of the designed primer pairs allows Bob to retrieve most of the information-containing DNA molecules after carrying out sufficient rounds of PCR amplification on the diluted oligo pool. In contrast, Eve is not able to access the stored information owing to her lack of any prior knowledge of the primer pairs. Next, we develop a coding scheme to improve upon the security of this technique. We design an index-based secrecy coding scheme for the DNA-storage wiretap channel, where Bob's knowledge of primers results in a substantially lower number of erasures in the main channel, as compared to Eve's channel, which suffers a large number of erasures (loss of molecules). We show that our coding scheme achieves the secrecy capacity of the resulting wiretap system with strong secrecy.

Student Presentation 2: Detection of local false data injection attacks in renewable integrated modern smart grids

Debottam Mukherjee and Dr. Vaibhav Katewa.

Department of Cyber Physical Systems,
Indian Institute of Science

Abstract

The modern power sector has rapidly incorporated renewables and electric vehicles to cater the ongoing power demand. This requires an efficient monitoring of the power grid under all circumstances and requires advanced industrial internet of things (IIOT) technology. State estimation techniques at the control centre furnish an efficient solution to the aforesaid problem. These advanced IIOT devices although may lead to a more reliable and efficient working of the power grid, but it can be effectively undermined by attackers to develop critical scenarios. This work demonstrates that with minimal network and parameter information, local false data injection attacks targeting the power system state estimates can be formulated which may lead to maloperations in the grid. For an

efficient detection of such attacks within the set of acquired measurements, this work has undertaken a state forecasting based anomaly detection scheme which is based on the error covariance matrix. The developed state forecasting models incorporate nonlinear deep learning structures that furnish a minimal set of error indices with an optimal set of parameters. The developed detection scheme furnishes a robust, real-time attack detection framework under varying range of noise and attack margins. All the aforesaid propositions are verified over the standard IEEE 14 bus test bench.

Student Presentation 3: Opacity and its Trade-offs with Security in Linear Dynamical Systems

Varkey M John and Dr. Vaibhav Katewa.

Department of Cyber Physical Systems,
Indian Institute of Science

Abstract
Opacity is notion of privacy that is well-studied in computer science and discrete-event systems. In our work, we extend the opacity notion to linear dynamical systems. Opacity describes an eavesdropper's inability to estimate a system's "secret" states by observing the system's outputs. We show how opacity is fundamentally connected with certain subspaces of the linear system. Further, we establish that a trade-off exists between opacity and security in the system. We show this in two ways – (i) we prove that an opaque system always permits undetectable attacks, (ii) we show that expanding the set of opaque states in the system always expands the set of undetectable attacks. Our work is the first to study opacity in such generality for linear dynamical systems, and provides necessary mathematical foundation for system designers to develop and build opaque systems, while ensuring adequate security.

Invited Talk 2: Lower Bounds for Reconstruction Attacks on Differentially Private Learning.

Speaker: Satya Lokam, Principal Researcher at the Microsoft Research lab in Bangalore
Personal Webpage

Abstract Differential Privacy (DP) has evolved to be the de facto standard for privacy in machine learning. However, the mathematical guarantees of DP are often difficult to interpret in terms of their resilience to specific attacks on learning algorithms. We continue the line of work that attempts to understand the semantics of DP by quantifying the level of protection offered by DP-learners against specific classes of attacks. In this talk, we will consider training data reconstruction attacks by informed adversaries. For such attacks, we derive concrete lower bounds on the adversary's reconstruction error in terms of DP parameters, data dimension, and the adversary's query budget. Our results improve and generalize previous asymptotic bounds due to Guo et al. (Bounding training data reconstruction in private (deep) learning, ICML 2022). [Joint work with Prateeti Mukherjee]

Bio

Satya Lokam is a Principal Researcher at the Microsoft Research lab in Bangalore, India. His research interests include Cryptography, Privacy, Complexity Theory, and Theoretical Computer Science in general. Before moving to Microsoft Research, Satya was a faculty member at the University of Michigan, Ann Arbor. He received his Ph.D. from the University of Chicago and held postdoctoral positions at the University of Toronto and at the Institute for Advanced Study (IAS) in Princeton, NJ.

Invited Talk 3: Crypto-assets: Law and policy issues.

Speaker: Jaideep Reddy, Trilegal, India

Abstract This talk will focus on the policy and regulatory aspects around crypto-assets. There is no specific statute regulating crypto-asset intermediaries today, unlike, for instance, the securities market. The industry has been evolving through a process of self-regulation and interpretation of existing laws. Recently, a specific tax was introduced on virtual digital assets. Intermediaries were also called on to follow anti-money laundering reporting norms. In 2020, the Supreme Court invalidated a Reserve Bank of India circular denying banking access to crypto companies. The talk will discuss why it has been challenging to evolve a clear-cut regime and will explore the potential paths forward.

Bio

Mr. Jaideep Reddy is a Counsel at Trilegal. He is a technology lawyer, qualified to practice in India and California, U.S.A., whose areas of practice include crypto and blockchain, payments, privacy and data, e-commerce, and gaming. Since 2016, he has developed a deep specialization in the law relating to crypto and blockchain technology. He has provided Indian law advice to nearly all the leading Indian and international crypto and blockchain platforms. He led his previous firm's successful representation of the Internet and Mobile Association of India, the lead petitioner, in the landmark 2020 Supreme Court case which set aside a central bank restriction on virtual Currencies. He has written and been quoted extensively on crypto and blockchain technology and other emerging technology issues, and is a visiting faculty at the National Law School of India University, Bengaluru. He has been recognised as a Rising Star by Legal500 (Legalease) and as a notable practitioner by Chambers and Partners Fintech Guide.

Student Presentation 5: Asymptotically Free Broadcast in Constant Expected Time via Packed VSS

Shravani Patil and Arpita Patra.

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

In the classical notion of multiparty computation (MPC), an honest party learning private inputs of others, either as a part of protocol specification or due to a malicious party's unspecified messages, is not considered a potential breach. Several works in the literature exploit this seemingly minor loophole to achieve the strongest security of guaranteed output delivery via a trusted third party, which nullifies the purpose of MPC. Alon et al. (CRYPTO 2020) presented the notion of Friends and Foes (FaF) security, which accounts for such undesired leakage towards honest parties by modelling them as semi-honest (friends) who do not collude with malicious parties (foes). With real-world applications in mind, it's more realistic to assume parties are semi-honest rather than completely honest, hence it is imperative to design efficient protocols conforming to the FaF security model.

Our contributions are not only motivated by the practical viewpoint, but also consider the theoretical aspects of FaF security. We prove the necessity of semi-honest oblivious transfer for FaF-secure protocols with optimal resiliency. On the practical side, we present QuadSquad, a ring-based 4PC protocol, which achieves fairness and GOD in the FaF model, with an optimal corruption of 1 malicious and 1 semi-honest party. QuadSquad is, to the best of our knowledge, the first practically efficient FaF secure protocol with optimal resiliency. Its performance is comparable to the state-of-the-art dishonest majority protocols while improving the security guarantee from abort to fairness and GOD. Further, QuadSquad elevates the security by tackling a stronger adversarial model over the state-of-the-art honest-majority protocols, while offering a comparable performance for the input-dependent computation. We corroborate these claims by benchmarking the performance of QuadSquad. We also consider the application of liquidity matching that deals with highly sensitive financial transaction data, where FaF security is apt. We design a range of FaF secure building blocks to securely realize liquidity matching as well as other popular applications such as privacy-preserving machine learning (PPML). Inclusion of these blocks makes QuadSquad a comprehensive framework.

Student Presentation 6: Find Thy Neighbourhood: Privacy-Preserving Local Clustering

Varsha Bhat Kukkala and Arpita Patra

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

Identifying a cluster around a seed node in a graph, termed local clustering, finds use in several applications, including fraud detection, targeted advertising, community detection, etc. However, performing local clustering is challenging when the graph is distributed among multiple data owners, which is further aggravated by the privacy concerns that arise in disclosing their view of the graph. This necessitates designing solutions for privacy-preserving local clustering and is addressed for the first time in the literature. We propose using the technique of secure multiparty computation

(MPC) to achieve the same. Our local clustering algorithm is based on the heat kernel PageRank (HKPR) metric, which produces the best-known cluster quality. En route to our final solution, we have two important steps: (i) designing data-oblivious equivalent of the state-of-the-art algorithms for computing local clustering and HKPR values, and (ii) compiling the data-oblivious algorithms into its secure realisation via an MPC framework that supports operations over fixed-point arithmetic representation such as multiplication and division. Keeping efficiency in mind for large graphs, we choose the best-known honest-majority 3-party framework of SWIFT (Koti et al., USENIX'21) and enhance it with some of the necessary yet missing primitives, before using it for our purpose. We benchmark the performance of our secure protocols, and the reported run time showcases the practicality of the same. Further, we perform extensive experiments to evaluate the accuracy loss of our protocols. Compared to their cleartext counterparts, we observe that the results are comparable and thus showcase the practicality of the designed protocols.

This is a joint work with Pranav Shriram, Nishat Koti, Arpita Patra and Bhavish Raj Gopal which was accepted to PoPETS 2023.

Student Presentation 7: Ruffle: Rapid 3-party shuffle protocols

Nishat Koti and Arpita Patra

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

Secure shuffle is an important primitive that finds use in several applications such as secure electronic voting, oblivious RAMs, secure sorting, to name a few. For time-sensitive shuffle-based applications that demand a fast response time, it is essential to design a fast and efficient shuffle protocol. In this work, we design secure and fast shuffle protocols relying on the techniques of secure multiparty computation. We make several design choices that aid in achieving highly efficient protocols. Specifically, we consider malicious 3-party computation setting with an honest majority and design robust protocols. Our shuffle protocols provide a fast online (i.e., input-dependent) phase compared to the state-of-the-art for the considered setting.

To showcase the efficiency improvements brought in by our shuffle protocols, we consider two distinct applications of anonymous broadcast and secure graph computation via the GraphSC paradigm. In both cases, multiple shuffle invocations are required. Hence, going beyond standalone shuffle invocation, we identify two distinct scenarios of multiple invocations and provide customised protocols for the same. Further, we showcase that our customized protocols not only provide a fast response time, but also provide improved overall run time for multiple shuffle invocations. With respect to the applications, we not only improve in terms of efficiency, but also work towards providing improved security guarantees, thereby outperforming the respective state-of-the-art works. We benchmark our shuffle protocols and the considered applications to analyze the efficiency improvements with respect to various parameters. This is a joint work with Pranav Shriram, Varsha Bhat Kukkala, Arpita Patra, Bhavish Raj Gopal and Somya Sangal, and was accepted to PoPETS 2023.

Student Presentation 8: Attaining GOD Beyond Honest Majority with Friends and Foes

Protik Paul and Arpita Patra

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

In the classical notion of multiparty computation (MPC), an honest party learning private inputs of others, either as a part of protocol specification or due to a malicious party's unspecified messages, is not considered a potential breach. Several works in the literature exploit this seemingly minor loophole to achieve the strongest security of guaranteed output delivery via a trusted third party, which nullifies the purpose of MPC. Alon et al. (CRYPTO 2020) presented the notion of Friends and Foes (FaF) security, which accounts for such undesired leakage towards honest parties by modelling them as semi-honest (friends) who do not collude with malicious parties (foes). With real-world applications in mind, it's more realistic to assume parties are semi-honest rather than completely honest, hence it is imperative to design efficient protocols conforming to the FaF security model.

Our contributions are not only motivated by the practical viewpoint, but also consider the theoretical aspects of FaF security. We prove the necessity of semi-honest oblivious transfer for FaF-secure protocols with optimal resiliency. On the practical side, we present QuadSquad, a ring-based 4PC protocol, which achieves fairness and GOD in the FaF model, with an optimal corruption of 1 malicious and 1 semi-honest party. QuadSquad is, to the best of our knowledge, the first practically efficient FaF secure protocol with optimal resiliency. Its performance is comparable to the state-of-the-art dishonest majority protocols while improving the security guarantee from abort to fairness and GOD. Further, QuadSquad elevates the security by tackling a stronger adversarial model over the state-of-the-art honest-majority protocols, while offering a comparable performance for the input-dependent computation. We corroborate these claims by benchmarking the performance of QuadSquad. We also consider the application of liquidity matching that deals with highly sensitive financial transaction data, where FaF security is apt. We design a range of FaF secure building blocks to securely realize liquidity matching as well as other popular applications such as privacy-preserving machine learning (PPML). Inclusion of these blocks makes QuadSquad a comprehensive framework.

3.1.9 Session 3D: Artificial Intelligence & Machine Learning

Session Chair: Pankaj Dayama
Cluster Coordinator: Yadati Narhari
Session Chair: Pankaj Dayama **Student Organizer**: Rankit, Rohit Prasad
Faculty Organizer: Punit Rathore
Location: ECE 1.08

Cluster Overview

Time	Event	Speaker	Affiliation
10:30 – 11:00 AM	Invited Talk 1	Suparna Bhattacharya	Hewlett-Packard Enterprise, India
11:00 – 11:20 AM	Invited Talk 2	Sunayana Sitaram	Microsoft Research, India
11:20 – 11:32 AM	Student Presentations	Dibyajyoti Nayak	CDS, IISc
11:32 – 11:44 AM		Mayank Ratan Bhardwaj	CSA, IISc
11:44 – 11:56 AM		Rahul NR	ECE, IISc
12:15 – 12:35 PM	Invited Talk 3	Ramasuri Narayanam	Adobe Research
12:35 – 12:47 PM	Student Presentations	Sravanthi Gurugubelli	ECE, IISc
12:47 – 12:59 PM		Thivin Anandh	CDS, IISc
12:59 – 01:11 PM		Satyapreet Singh Yadav	ESE, IISc
01:11 – 01:23 PM		Abhipsa Basu	CDS, IISc

Invited Talk 1: Towards a Data Centric Foundation for AI: Teaching AI to Solve its own Data Problem

Speaker: Suparna Bhattacharya, HPE Fellow
Personal Webpage

Abstract
AI models and pipelines are growing in sophistication with phenomenal advances that eclipse previous solutions. However, the real-world impact and trustworthiness of AI heavily depends on the data behind these models. Data centric AI is an emerging discipline that accounts for this reality, provoking us to rethink how we build AI systems by shifting attention to techniques that systematically improve the data instead of iterating on models while keeping the data fixed.

Selecting and tuning the most valuable data for improving model performance, efficiency and trust metrics can be very laborious and challenging - a complex optimization problem in a high- dimensional space of possible data characteristics and hyperparameters across all many pipeline stages including data collection, selection, labelling, augmentation, feature selection, domain adaptation, model training, fine tuning, testing and refinement. This space is even more intricate in "AI for Science" pipelines that often include multiple models applied in sequence, or models built incrementally as new data is collected from simulation or experimental facilities.

This talk describes a Self-Learning Data Foundation that captures and learns from AI pipeline metadata and data characteristics, enabling a new layer of data centric intelligence towards addressing these challenges.

Bio

Suparna is an HPE Fellow in the AI Research Lab at Hewlett Packard Labs, where she currently focuses on data-centric and trustworthy AI, and has a passion for realizing innovations that blend insights from diverse computing domains. She has deep experience in several areas of systems software development and research, spanning many layers of data-processing systems, and the storage stack. This includes several enjoyable years of open-source contributions to the Linux kernel, 29 granted patents, 30 publications, and a book on Resource Proportional Software Design for Emerging Systems.

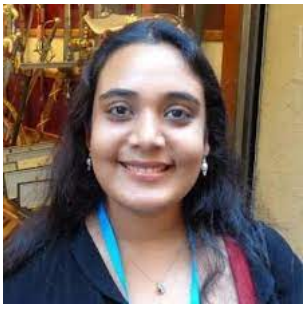
Suparna holds a B.Tech in Electronics and Electrical Communication Engineering from IIT Kharagpur (1993) and a late-in-life PhD in Computer Science with a best-thesis award from the Indian Institute of Science (2013). She was elevated to IEEE Fellow in 2022 for her contributions to the Linux kernel for the enterprise and advanced data processing systems. She is also a Fellow of the India National Academy of Engineering. She received the HPE Women's Excellence Award in 2017 and 2022, the IEEE India Council Woman Technologist of the Year award in 2020, the IISc Prof S. K Chatterjee Award for Outstanding Woman Researcher in 2019, the Zinnov Next Generation Women Leaders Award in 2019 and the Economic Times and Femina Inspiring Women-in-Tech award in 2023.

Invited Talk 2: Large Language Models – Strengths and Opportunities

Speaker: Sunayana Sitaram, Senior Researcher at Microsoft Research India
Personal Webpage

Abstract

In this talk, I will present a benchmarking view of understanding the capabilities of LLMs by discussing some recent results from large scale holistic benchmarking across many dimensions, including accuracy, fairness, bias, robustness and inclusivity.



Bio

Sunayana Sitaram is a Senior Researcher at Microsoft Research India. Her research goal is to enable inclusive universal empowerment through technology. Her current area of research is on making Large Language Models useful to everyone on the planet by improving their multilingual performance and infusing local culture and values. Sunayana also serves as the director of the MSR India Research Fellow program, which exposes bright young researchers to a world-class research environment and prepares them for careers in research, engineering and entrepreneurship. Prior to joining MSRI as a Post Doc Researcher, Sunayana completed her MS and PhD at the Language Technologies Institute, Carnegie Mellon University in 2015. Sunayana's research has been published in top NLP and Speech conferences including ACL, NAACL, EMNLP, Interspeech, ICASSP and she regularly serves in the program committee of these conferences. In 2023, she will be serving as Industry track

co-chair and Senior Area Chair for ACL 2023. She as organized special sessions and workshops on under-resourced languages, code-switching, multilingual evaluation and speech for social good. She has also led the creation of several benchmarks and datasets in code-switching, speech recognition and speech synthesis that have been used by research groups all over the world.

Student Presentation 1: A co-kurtosis based dimensionality reduction with neural network based reconstruction of chemical kinetics in reacting flows

Dibyajyoti Nayak and Konduri Aditya

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract
Dimensionality reduction seeks to reduce the feature space of high-dimensional data while effectively retaining the information and dynamics of the original system. The widely used principal component analysis (PCA) achieves this for combustion data by transforming the original thermo-chemical state space into a low-dimensional manifold with eigenvectors of the covariance matrix of the input data. However, this may not effectively capture the stiff chemical dynamics when the reaction zones are localized in space and time. Alternatively, a co-kurtosis PCA (CoK-PCA), wherein the principal components are obtained from the singular value decomposition (SVD) of the matricized co-kurtosis tensor, demonstrated greater accuracy in capturing the stiff dynamics. However, both methods incur significant errors due to a linear reconstruction of data onto the original manifold. Nonlinear methods such as artificial neural networks (ANNs) can greatly improve reconstruction accuracy over linear methods, thereby allowing further dimensionality reduction of the original manifold. We investigate the efficacy of our approach, i.e., CoK-PCA-ANN, relative to PCA-ANN in two cases, namely, homogeneous reactor data of premixed ethylene-air and ethylene-air freely-propagating premixed laminar one-dimensional flame by comparing errors in the reconstruction of the thermo-chemical state, species production rates, and heat release rates. Our results show that, while ANN outperforms linear reconstruction in general, the proposed CoK-PCA-ANN captures the stiff dynamics better than PCA-ANN.

Student Presentation 2: Algorithmic Agriculture based on Game Theory and Artificial Intelligence Techniques

Mayank Ratan Bhardwaj and Yadati Narahari

Department of Computer Science and Automation,
Indian Institute of Science

Abstract
India is the second largest producer of farm products, and approximately 50% of the Indian workforce is involved in agriculture. Yet, agriculture in India accounts for only 17-18% of the gross domestic product of the nation. A major reason behind this discrepancy is the fact that most farmers in India are small farmers without the wherewithal to access technologies for making optimal decisions. Our project attempts alleviating this problem, by designing game theoretic and AI-based solutions for input procurement, crop selection, helping decide the harvest time, and for selling the final produce

in the market. In this direction we have designed PREPARE, ACRE, PROMISE, PROSPER, and CROPS. PREPARE uses deep learning models to predict the accurate price of crops, which helps the farmer decide the exact time of harvest. ACRE uses this information along with other factors such as expected yield to recommend optimal crops, for sowing, to the farmer. Once the decision to invest in a certain crop is made, the farmer or farmer collective can use PROMISE to procure inputs efficiently. PROSPER can be used to auction the produce so as to enhance the farmers' revenue.

Student Presentation 3: Sequential Transfer in Reinforcement learning through Upper Confidence Reinforcement Learning with Known Dynamics

Rahul NR

Deaprtment of Cyber Physical Systems,
Indian Institute of Science

Abstract
Sequential RL is a framework where an RL agent, for example, an autonomous robot is given a series of tasks to learn one after the other. The naive approach is to apply some RL algorithm on each task separately. This is not a good approach always. When the tasks are related we can leverage this information to aid in the learning of tasks. In this talk, first I will discuss some of the algorithms in the literature of sequential transfer in RL and then propose a new algorithm that is a variant of UCRL.

Invited Talk 3: Adobe Experience Platform (AEP) - Capabilities and Challenges

Speaker: Ramasuri Narayanam, Adobe Research
Personal Webpage

Abstract
Adobe Experience Platform is purpose-built for capturing, processing and actioning data in real time, enabling enterprises to deliver rich and relevant experiences to their customers. This talk first provides the basic architecture of AEP along with its capabilities. Then it highlights several large-scale data science problems associated with AEP and many of these problems require innovative AI solutions.

Bio
Ramasuri Narayanam is currently a Senior Research Scientist at Adobe Research - India. Prior to this, he was a Senior Research Scientist at IBM Research - India and IBM Master Inventor. Before joining IBM Research in 2011, he obtained his Master's and Ph.D. degrees both in computer science, in 2006 and 2010 respectively, from the Department of Computer Science and Automation, Indian Institute of Science, Bangalore, India. His research interests include Data Analytics, Federated Machine Learning, Computational Network Science, Computational Game Theory, and Multi-Agent Decision Making. He has published about 35 peer-reviewed research articles in several premier computer science conferences such as AAAI, AAMAS, IJCAI, ECAI, ECML, ICPR, etc. He has about 32 Granted Patents from USPTO to his credit. He received IBM's prestigious 'Outstanding

Technical Achievement Award (OTAA)' FOUR times for his work in the areas of social media and business analytics, graph mining and game theory. He also received the 'Best Ph.D. Thesis' award from Computer Society of India (CSI), 2012.

Student Presentation 4: Scalable Simplicial-aware Neural Networks

Sravanthi Gurugubelli and Sundeep Prabhakar Chepuri

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
Simplicial neural networks (SNNs) are deep models for higher-order graph representation learning. SNNs learn low-dimensional embeddings of simplices in a simplicial complex by aggregating features of their respective upper, lower, boundary, and coboundary adjacent simplices. The aggregation in SNNs is carried out during training. Since the number of simplices of various dimensions in a simplicial complex is significantly large, the memory and training-time requirement in SNNs is enormous. In this work, we propose a scalable simplicial- aware neural network (SaNN) model with a constant run-time and memory requirements independent of the size of the simplicial complex and the density of interactions in it. SaNN is based on preaggregated simplicial-aware features as inputs to a neural network, so it has a strong simplicial-structural inductive bias. We provide theoretical conditions under which SaNN is provably more powerful than the Weisfeiler-Lehman (WL) graph isomorphism test and as powerful as the simplicial WeisfeilerLehman (SWL) test. We also show that SaNN is permutation and orientation equivariant and satisfies simplicial-awareness of the highest order in a simplicial complex. We demonstrate via numerical experiments that despite being computationally economical, the proposed model achieves state-of-the-art performance in predicting trajectories, simplicial closures, and classifying graphs.

Student Presentation 5: A Deep learning framework coupled with reduced order modelling for real time monitoring of fluid flows

Thivin Anandh and Prof.Sashikumaar Ganesan

Department of Electrical Engineering,
Indian Institute of Science

Abstract
Simulation-based Digital Twins of continuous systems, for example those featuring fluid flows, are often difficult to realize due to the high computing costs associated with accurate simulation of the continuous systems. We propose a Deep-Learning framework comprising of a Physics Informed Neural Network and a Reduced Order Model (ROM) based on Dynamic Mode Decomposition (DMD) for real-time simulation of such systems. The framework is targeted for realizing a Digital Shadow of continuous systems. The PINN works as the primary physics driver, whereas the DMD-ROM is responsible for the short-term prediction of the system trajectory. Further, the ROM component of the system is lightweight and can be deployed on an edge computing device. The proposed framework is mainly targeted for applications in fluid dynamics, however, it can be easily

extended to other continuous systems. We demonstrate the accuracy of our approach with the help of benchmark problems.

Student Presentation 6: TinyRadar for fitness: A radar-based contactless activity tracker for edge computing

Satyapreet Singh Yadav and Chetan Singh Thakur

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

Exercising regularly is essential for maintaining a healthy lifestyle. Studies have shown that knowing parameters such as calories burnt, step counts, and miles traveled helps track fitness goals and maintain motivation. Modern fitness trackers aim to provide these metrics in real-time, with features like ubiquitous y and lightweight. Most fitness trackers are either wearables or camera-based. Wearable fitness trackers can cause discomfort during exercise, and exchanging users' data over the internet poses a privacy threat. The camera-based fitness trackers also often pose a privacy risk. Certain works prevent this by hiding the face of users through complex algorithms, adding to the computation cost requiring high-end processing computers to make readings available in real time. We propose tinyRadar as a contactless fitness tracker which identifies the exercise performed by the user and computes its repetition counts. It comes in a small form factor and preserves the user's privacy as it provides point cloud data, making it a suitable choice for a fitness tracker in a smart home setting. tinyRadar comprises a Texas Instruments (TI) IWR1843 mmWave radar board as a sensing and processing modality and an ESP32 module for results transmission to the user's smartphone through Bluetooth Low Energy (BLE). The mmWave radar processes the information received from the target environment to create a Velocity-Time map which contains unique signatures for different human activities. A three-layered Convolutional Neural Network (CNN) deployed on the radar board classifies the exercise performed by the user with the Velocity-Time map as input in one of the following eight categories: Crossover toe touch, Crunches, Jogging, Lateral squats, Lunges, Hand rotation, Squats, and Rest. The repetition count algorithm runs parallelly on board to compute the repetition counts. It provides a real-time subject-independent classification accuracy of 97%, and repetition counts with an accuracy of 96%.

Student Presentation 7: RMLVQA: A Margin Loss Approach For Visual Question Answering with Language Biases

Abhipsa Basu

Department of Computational and Data Science,
Indian Institute of Science

Abstract

Visual Question Answering (VQA) is the task of answering natural language questions based on any image. In this talk, I will speak about the problem of language biases that the VQA models suffer from, where models learn a correlation between the 'question type' and the answer, ignoring the image completely. In this regard, I will present an adaptive margin loss approach having two components – one addressing the concern of class imbalances in the training data, the other

considering per sample complexity. While traditional margin losses are effective in overcoming the language biases, they are not robust to in-domain test data. The proposed approach, Robust Margin Loss for Visual Question Answering (RMLVQA) generalizes to both in-distrbution and out-of-distribution data. It improves upon the existing state-of-the-art results when compared to augmentation-free methods on benchmark VQA datasets suffering from language biases, while maintaining competitive performance on id data, making this method the most robust one among all comparable methods. I will conclude the talk with a glimpse of my future work about detecting geographical biases in text-to-image models, as well as discovering unknown biases from models without any apriori information on the training data.

3.1.10 Session 3E: Visual Analytics

Session Chair: Chandra Sekar Seelamantula, Rajiv Soundararajan
Cluster Coordinator: Venkatesh Babu, Anirban Chakraborty
Student Organizer: Subhadeep, Sourav Mazumdar
Faculty Organizer: Vanathi Sundaresan
Location: ECE MP-20

Cluster Overview

Time	Event	Speaker	Affiliation
10:30 – 11:00 AM	Invited Talk 1	Subrahmanyam Murala	EE, IISc
11:00 – 11:20 AM	Invited Talk 2	Pradeep Shenoy	Google
11:20 – 11:40 AM	Invited Talk 3	Debdoot Mukherjee	Meesho
11:40 – 11:57 AM	Student Presentations	Alokendu Mazumdar	CPS, IISc
12:15 – 12:32 PM		Mohit Sharma	CSA, IISc
12:32 – 12:49 PM		Aditay Tripathi	CDS, IISc
12:49 – 01:06 PM		Harsh Rangwani	CDS, IISc
01:06 – 01:23 PM		Rishubh Parihar	CDS, IISc

Invited talk 1: Burst Restoration and Enhancement using Transformers

Speaker: Prof. Subrahmanyam Murala, IIT Ropar
Personal Webpage

Abstract

Burst image processing is becoming increasingly popular in recent years. Burst mode, also known as continuous shooting mode is a feature available in iPhones, and Samsung Galaxy Note3 that allows capturing multiple shots continuously in a fraction of a second. However, it is a challenging task since individual burst images undergo multiple degradations and often have mutual misalignments resulting in ghosting and zipper artefacts. Existing burst restoration methods usually do not consider the mutual correlation and non-local contextual information among burst frames, which tends to limit these approaches in challenging cases. Another key challenge lies in the robust up-sampling of burst frames. The existing up-sampling methods cannot effectively utilize the advantages of single-stage and progressive up-sampling strategies with conventional and/or recent up-samplers at the same time. To address these challenges, we come up with a novel transformer-based approach named as Gated Multi-Resolution Transfer Network (GMTNet) to reconstruct a spatially precise high-quality image from a burst of low-quality raw images. GMTNet consists of three modules optimized for burst processing tasks: Multi-scale Burst Feature Alignment (MBFA) for feature denoising and alignment, Transposed-Attention Feature Merging (TAFM) for multi-frame feature aggregation, and Resolution Transfer Feature Up-sampler (RTFU) to up-scale merged features and construct a high-quality output image. In this talk, I will be discussing burst superresolution, burst denoising, and burst low-light enhancement, with more focus on super-resolution application.

Bio

Dr. Subrahmanyam Murala is an Associate Professor in the Department of Electrical Engineering, Indian Institute of Technology Ropar, Rupnagar, Punjab, India. Dr. Murala joined the institute as an Assistant Professor in July, 2014 and received his M.Tech. and Ph.D. from the Department of Electrical Engineering, Indian Institute of Technology Roorkee, India, in 2009 and 2012, respectively. He was a Post-Doctoral Researcher in the Department of Electrical and Computer Engineering at the University of Windsor, Windsor, ON, Canada from July 01, 2012, to June 30, 2014. He is a senior member of IEEE and the recipient of the Faculty Research and Innovation Awards 2019-2020. His major fields of interests are Computer Vision, Medical Image Processing, and Object Detection. At IIT Ropar, Dr. Murala leads the Computer Vision and Pattern Recognition Laboratory (CVPR Lab) which actively focuses on deep generative models, adversarial robustness of deep neural networks, and learning-based applications like Human Action Recognition, Image Enhancement (Haze Removal), Moving Object Segmentation for videos, Image Depth Estimation, Image/Videos Inpainting, Image/Videos Super-resolution, Motion magnification, and Multi-weather Restoration. His research has resulted in many publications in several top conferences and journals including CVPR, WACV, TIP, etc. Besides contributing actively to his research group, Dr. Murala is currently handling several challenging projects in collaboration with renowned industries and the Department of Science and Technology (DST), India. Apart from this, Dr. Murala has been the Conference chair of CVIP-2021, 2022 and the Organizing member of ICVGP-2023. Being Head of the Electrical Engg. Department at IIT Ropar, Dr. Murala has also contributed to the department's making by leading on several fronts including both technical and non-technical. Further information about Dr. Murala and his research group can be found at https://www.iitrpr.ac.in/subbumurala/.

Invited talk 2: Robust learning in computer vision–by design, and by optimization

Speaker: Dr. Pradeep Shenoy, Google India
Personal Webpage

Abstract

This talk will cover two recent sets of results – one on using inductive biases (i.e., design) in the development of robust, efficient computer vision systems, and the other on learned reweightings of training loss (i.e., optimization) for achieving a range of robustness properties in classifiers. In the first half, we look at how simple, well-chosen inductive biases can significantly impact accuracy of vision models, with case studies in object categorization and multi-object multi-part segmentation. The second half will cover the paradigm of learned reweighting using meta-learning for robust classification. We will cover recent developments in this framework for tackling learning under concept drift, selective classification, and domain generalization.

Bio

Pradeep Shenoy leads the Cognitive modeling Machine Learning team at Google Research India, which aims to build expressive, robust ML systems, drawing functional and algorithmic inspiration

from human cognition. Pradeep also works on modeling human behavior cognition, with applications in personalization and human-AI interfaces. Recent work has focused on robust learning via instance reweighting, and its application to a range of problem settings in applied ML. Pradeep has a Ph.D. in Computer Science from the University of Washington post-doctoral research experience at UC San Diego, where he worked in neuro-engineering, computational neuroscience cognitive science. He has previously led machine learning teams at Microsoft Bing, developing and supporting large-scale production models that predict user behavior (clicks, conversions, audience segmentation, etc.) in sponsored search.

Student Presentation 1: Self-Supervised Approach for Cluster Assessment of High-Dimensional Data

Alokendu Mazumdar

Department of Cyber Physical Systems,
Indian Institute of Science

Abstract
Estimating the number of clusters k in a data set is a very important problem. As real-world data is very high-dimensional and complex, the classical clustering algorithms don't perform very well on them. VAT/iVAT is one such algorithm, it is a visual technique for determining the potential cluster structure and the possible number of clusters in numerical data. Both VAT and iVAT have also been used in conjunction with a single-linkage (SL) hierarchical clustering algorithm. However, VAT/iVAT fails badly on high-dimensional data due to the curse of dimensionality as they heavily rely on the notion of closeness and farness of data points. We propose a two-stage framework that makes use of deep learning architectures with dimensionality reduction techniques to generate low-dimensional feature embeddings of data, to improve VAT/iVAT for complex data sets (i.e image data sets). The first stage of our framework generates the embeddings from a deep network, in the second stage those low-dimensional embeddings are fed to VAT/iVAT algorithms. In this whole process, we made sure not to use any prior for the number of clusters (i.e k). We present our results on four real-life image data sets and conclude that our framework outperforms the conventional VAT/iVAT family algorithms in terms of improved clustering accuracy and NMI.

Student Presentation 2: Topological Structures for Bivariate Data Visualization

Mohit Sharma

Department of Computer Science and Automation,
Indian Institute of Science

Abstract
Data from science and engineering disciplines is often represented as a single or multiple scalar fields defined over a geometric domain. In recent years, the importance of studying a collection of fields, represented as a multivariate field has been highlighted with applications in chemistry, medical imaging, climate science, and material science. Topological structures provide an abstract and

succinct representation of features in the data. Jacobi sets, fiber surfaces and continuous scatterplots (CSP) are few structures used for multivariate data analysis. In this talk, I will discuss our works on these structures for bivariate fields. Specifically, I will describe our contributions on using the Jacobi set for computing individual components of a fiber surface. I will also talk about CSP operators which help to execute application specific queries on CSPs. Finally, I will show the applicability of CSP operators to study electronic transitions in molecules.

Invited Talk 3: Democratizing E-Commerce with AI @ Meesho

Speaker: Debdoot Mukherjee, Chief Data Scientist at Meesho
Personal Webpage

Abstract

Meesho is on a journey to democratize internet commerce in India, where it is connecting the next generation of internet users from tier 3-4 towns and villages to the millions of sellers, who are also new to online commerce and sell the long tail of unbranded products. This talk provides an overview of how AI is used to power every pillar of the e-commerce marketplace and showcases interesting research challenges therein. At Meesho, there is a machine learning model working at every step in a user's shopping journey - be it nudging you to open the app via personalized push notifications, a personalized home page feed that selects products just for you, decoding your current search intent even if you put it across ambiguously or showing product recommendations until you convert. On the supply side, AI helps radically simplify the product listing process. All that a seller needs is to capture a photo from their phone camera and AI does the rest - be it extracting product attributes, pricing, or managing budgets on Ads to ensure robust growth. Finally, on order fulfillment, machine learning helps our delivery partners resolve locations from addresses and also catch fraudulent orders to minimize overheads.

Bio

Debdoot Mukherjee is Chief Data Scientist at Meesho, where he leads the AI team that enables every pillar of the e-commerce marketplace to be smarter and more efficient. Additionally, he also leads Meesho's engineering organization focused on shopping experience and user growth. Debdoot has over 15 years of experience in building innovative AI products in social, mobile and e-commerce domains. Prior to Meesho, Debdoot was VP Head of AI at ShareChat Moj, where he led teams in the areas of recommender systems, multimodal learning and camera tech. Before that, he set up the AI team at Hike Messenger that developed novel methods for conversation modeling in Indic languages, massive scale social graph mining etc. Previously, he led ML efforts at Myntra for applications such as personalized search, product discovery, marketing and merchandising intelligence. Debdoot started his career in the domains of enterprise search and information extraction at IBM Research. Debdoot is a gold medallist from IIT Delhi from where he graduated with a Master's degree in Computer Science Engineering.

Student Presentation 3: Multi-modal Query-guided object localization in natural images

Aditay Tripathi

Department of Computational and Data Science,
Indian Institute of Science

Abstract

Multi-modal query-guided object localization involves localizing object instances in an image based on a query of a different modality, such as a sketch of an object or a scene graph. Sketch-guided object localization involves generating region proposals and evaluating them to determine the final localization. Traditional object detection methods, such as FasterRCNN, use a Region Proposal Network (RPN) to generate a set of region proposals. However, the vanilla RPN often fails to produce region proposals that are relevant to the sketch query, particularly for objects that are not well-represented in the dataset, occluded, or not seen during training. To address this problem, we first proposed a novel query-guided region proposal network (RPN) that uses semantic attention weights to generate region proposals relevant to the query sketch and scores them to localize the corresponding object instances in the image. However, the proposed query-guided RPN only performs spatial alignment between the image and sketch features. As a result, we have also developed query-guided vision transformers that can also learn semantic and feature alignment between the query sketch and target image. This improvement has led to significantly better sketch-guided localization performance, with our proposed model achieving a mean average precision (mAP) that is 10% higher than baselines in the closed-set setting and an AP@50 that is 12% better in the open-set setting. Additionally, I have also studied the problem of scene graph localization in natural images. Given a scene graph query containing multiple nodes with varying numbers of edges, we aim to localize all the object instances in the images corresponding to the nodes in the query, satisfying the corresponding relations. To achieve that, we first created a visio-lingual graph with the region proposal and query objects as nodes, and the set of semantic and spatial relations between them correspond to the edges in the visio-lingual graph. We then proposed a novel visio-lingual message-passing network to learn the structured representations for the region proposals and the query nodes. The region proposals are then scored with the query nodes to generate the localization. The proposed method achieves state-of-the-art results on various publicly available datasets.

Student Presentation 4: Cost-Sensitive Self-Training for Optimizing Non-Decomposable Metrics

Harsh Rangwani

Department of Computational and Data Science,
Indian Institute of Science

Abstract

Self-training-based semi-supervised learning algorithms have enabled the learning of highly accurate deep neural networks using only a fraction of labelled data. However, the majority of work on self-training has focused on the objective of improving accuracy whereas practical machine learning systems can have complex goals (e.g. maximizing the minimum of recall across classes, etc.) that are non-decomposable in nature. In this work, we introduce the Cost-Sensitive Self-Training (CSST)

framework, which generalizes the self-training-based methods for optimizing non-decomposable metrics. We prove that our framework can better optimize the desired non-decomposable metric utilizing unlabeled data under similar data distribution assumptions made for the analysis of self-training. Using the proposed CSST framework, we obtain practical self-training methods (for both vision and NLP tasks) for optimizing different non-decomposable metrics using deep neural networks. Our results demonstrate that CSST achieves an improvement over the state-of-the-art in the majority of the cases across datasets and objectives. More details on the work are present in the paper: https://openreview.net/pdf?id=bGo0A4bJBc

Student Presentation 5: Attribute Editing by StyleGAN Latent Space Exploration

Rishubh Parihar

Department of Computational and Data Science,
Indian Institute of Science

Abstract
Unconstrained Image generation with high realism is now possible using recent Generative Adversarial Networks (GANs). However, it is quite challenging to generate images with a given set of attributes. Recent methods use style-based GAN models to perform image editing by leveraging the semantic hierarchy present in the layers of the generator. We present Few-shot Latent-based Attribute Manipulation and Editing (FLAME), a simple yet effective framework to perform highly controlled image editing by latent space manipulation. Specifically, we estimate linear directions in the latent space (of a pre-trained StyleGAN) that controls semantic attributes in the generated image. In contrast to previous methods that either rely on large-scale attribute labeled datasets or attribute classifiers, FLAME uses minimal supervision of a few curated image pairs to estimate disentangled edit directions. FLAME can perform both individual and sequential edits with high precision on a diverse set of images while preserving identity. Further, we propose a novel task of Attribute Style Manipulation to generate diverse styles for attributes such as eyeglass and hair. We first encode a set of synthetic images of the same identity but having different attribute styles in the latent space to estimate an attribute style manifold. Sampling a new latent from this manifold will result in a new attribute style in the generated image. We propose a novel sampling method to sample latent from the manifold, enabling us to generate a diverse set of attribute styles beyond the styles present in the training set. FLAME can generate diverse attribute styles in a disentangled manner. We illustrate the superior performance of FLAME against previous image editing methods by extensive qualitative and quantitative comparisons. FLAME generalizes well on out-of-distribution images from the art domain as well as on other datasets such as cars and churches.

3.1.11 Lunch Break

Location: Main Guest House

3.1.12 Session 4A: Brain, Computational and Data Sciences

Session Chair: Ashwini Dani, Deepak Khatri
Cluster Coordinator: Prasanta Kumar Ghosh
Student Organizer: Aniket, Naman
Faculty Organizer: Utsav Banerjee
Location: ECE Golden Jubilee Hall

Cluster Overview

Time	Event	Speaker	Affiliation
02:30 – 03:00 PM	Invited Talk 1	Upinder S. Bhalla	NCBS, TIFR, Bangalore
03:00 – 03:20 PM	Invited Talk 2	Deepak Khatri	Upside Down Labs, Bangalore
03:20 – 03:50 PM	Invited Talk 3	Thomas Gregor Issac	CBR, IISc Bangalore
03:50 – 04:02 PM	Student Presentations	Shubham Goswami	ECE, IISc
04:02 – 04:14 PM		Ghanshyam Chandra	CDS, IISc
04:14 – 04:26 PM		P. Naveen	CDS, IISc
04:26 – 04:38 PM		Raji Susan Mathew	CDS, IISc
04:38 – 04:50 PM		Pradeep Kumar G	EE, IISc
04:50 – 05:02 PM		Arjun B S	ESE, IISc
05:02 – 05:14 PM		Ganesan Thiagaraja	CDS, IISc
05:14 – 05:26 PM		Shankhadeep Mukherjee	CeNSE, IISc
05:26 – 05:38 PM		Sreekanth Maddaka	CeNSE, IISc

Invited Talk 1: Hardware, software and wetware: How is the brain so computationally efficient?

Speaker: Upinder S. Bhalla, NCBS, TIFR, Bangalore
Personal Webpage

Abstract

Even in the age of GPUs that run at GHz, the brain still stands out as small, fast, and efficient. To first order, a single neuron (brain cell) can be simulated by a rather substantial neural network model, or by a large system of partial differential equations. What computations can the real neuron do with these complex dynamics? I'll discuss two examples, one like the prediction of where a cricket ball will fly, and the other related to the what was that? moment when we hear a repeated sound amidst background noise. One of the uniquely powerful capabilities of neurons is their ability to extract salient signals from complex patterns in space and time, against a background of uncorrelated neural activity. The trajectory prediction problem can be framed as sequential pattern recognition. I'll discuss how sequential pattern recognition is implemented in neurons, and how this operation is equivalent to the functioning of a convolutional neural network. I'll then take on the what was that? problem of recognizing unique repeated inputs. I'll discuss some preliminary data which suggests that excitatory- inhibitory (EI) balance is asymmetric with respect to sequences of patterns. This means that certain spatiotemporal input sequences can 'escape' EI balance and cause the neuron to become more active. Overall, both these computations, take advantage of the intricate biophysics

and biochemistry of the neuron to perform real-time pattern recognition with extraordinary energy efficiency.te imaging biomarkers for studying various CNS disorders.

Bio

How does the brain work? I came to this question in a roundabout way, first through an interest in physics at IIT Kanpur and Cambridge. There I realized that biology was full of amazing mechanisms, and the brain especially so. I did my PhD at Caltech, in what was then a new area of computational neuroscience. Throughout my career I have used computers both as a tool and a metaphor to understand the brain. I have been at NCBS-TIFR in Bangalore since 1996, and here I have studied how animals recognize and find odours, and how memories are formed and stored. I have been deeply involved in efforts to develop open simulation tools and neuronal data, and to promote sharing. I continue to work on the chemical signaling networks in the brain, which underlie everything from memories and computation, to growth, disease, and aging.

Invited Talk 2: Building next generation HCI and BCI with open-source technologies

Speaker: Deepak Khatri, Upside Down Labs, Bangalore
Personal Webpage

Abstract

The spectacular development of BCI HCI technology over the last few decades is the work of several scientists who have helped to build the tools and methods for brain signal acquisition and processing. Their efforts pushed the whole domain to a level where interfacing your brain with a number-crunching bit manipulator is not science fiction now. Our aim of fully understanding the whole brain is a very ambitious goal and it will take several million brain hours to accomplish. If the number of hours is in millions we need to think if are going to get this done as a team of hundreds putting a million hours to solve this a couple of years down the line or if we want some hundred of us working for their lifetime. If you are sane and choose the former we need the students today to think about taking neuroscience as a career and it's our responsibility to provide them with the machines and tools as affordable as possible so that they grow up and build the next generation HCI and BCI disguised as a consumer electronics product. Open science is the right path forward and coupled with OpenSource neural interface equipment can make our dream a reality. We at Upside Down Labs are doing just that. We are the first company in India to design, manufacture, and introduce open-source DIY neuroscience kits for students, researchers, and companies. Our hardware has reached 35+ countries bringing us closer to our aim to impact all young minds in a way that they all can contribute and be a part of this neuro-revolution.

Bio

Deepak Khatri is the Founder of Upside Down labs. He is a Bio-technologist with a passion for Electronics and Computer Science who started Upside Down Labs in 2018 with an aim to make neuroscience affordable and accessible to all. He loves working on technologies that connect the biological world to the digital world.

Invited Talk 3: Longitudinal Studies at Centre for Brain Research (CBR) for Study of the Aging Brains

Speaker: Thomas Gregor Issac, CBR, IISc
Personal Webpage

Abstract

This talk attempts to address the need for such studies, the short- and long-term impact of these studies on the elderly health and how these studies fill up the lacunae of mitigating an unavoidable dementia pandemic in another 2 decades and impresses upon the importance of such studies in bridging the Science-society gap. This could pave the way for improving public awareness and research acumen along with developing translatable, culturally adaptable interventions, socially inclusive policies and 'add life' to the years by improving the quality of life of the Indian elderly population.

Bio

Prof. Thomas Gregor Issac is an Associate Professor at Centre for Brain Research (CBR), IISc. Dr. Issac's expertise is in Neurocognitive disorders, Vascular Cognitive impairment, clinical phenomenology in dentia, neurointerventions, and social policy aspects. He has completed his Ph.D in clinical Neurosciences, MD and Diplomate of National Board in Psychiatry and his DM degree in Geriatric Psychiatry from the National Institute of Mental Health and Neurosciences (NIMHANS). He is the PI and co-PI of TLSA and SANSCOG studies respectively.

Student Presentation 1: Low-storage explicit Runge-Kutta schemes for scalable asynchrony tolerant schemes based PDE solvers

Shubham Goswami

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

The scalability of flow solvers on massively parallel supercomputers can be significantly improved using asynchrony-tolerant (AT) finite difference schemes, which relax communication and data

synchronization requirements at a mathematical level. These schemes are combined with high-order time integration methods like Adams-Bashforth or Runge-Kutta (RK) schemes to provide high-order accurate solutions for time-dependent PDEs. Although low-storage explicit RK (LSERK) schemes require less memory than standard schemes and are widely used in flow solvers, they still require communication and synchronization at every time step and stage to achieve high accuracy. This work presents a novel approach that couples AT and LSERK schemes to solve time-dependent PDEs while reducing communication overhead. The accuracy of this approach is validated using simple 1D model equations. To demonstrate its scalability, massively parallel 3D simulations of decaying Burgers' turbulence were performed. The proposed approach achieves speed-ups up to 6x at extreme scales ($27,000$ cores) compared to a baseline synchronous algorithm, addressing the communication bottleneck issue and showing great promise as we move towards exascale.

Student Presentation 2: Sequence to graph alignment using gap-sensitive co-linear chaining

Ghanshyam Chandra

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract
Co-linear chaining is a widely used technique in sequence alignment tools that follow seed-filter-extend methodology. It is a mathematically rigorous approach to combine short exact matches. For colinear chaining between two sequences, efficient subquadratic-time chaining algorithms are well-known for linear, concave and convex gap cost functions [Eppstein et al. JACM'92]. However, developing extensions of chaining algorithms for directed acyclic graphs (DAGs) has been challenging. Recently, a new sparse dynamic programming framework was introduced that exploits small path cover of pangenome reference DAGs, and enables efficient chaining [Makinen et al. TALG'19, RECOMB'18]. However, the underlying problem formulation did not consider gap cost which makes chaining less effective in practice. To address this, we develop novel problem formulations and optimal chaining algorithms that support a variety of gap cost functions. We demonstrate empirically the ability of our provably-good chaining implementation to align long reads more precisely in comparison to existing aligners. For mapping simulated long reads from human genome to a pangenome DAG of 95 human haplotypes, we achieve 98.7
Keywords : Functional connectivity, phase synchronization, electroencephalogram (EEG), breathing, breath-hold.

Student Presentation 3: TTC-QSM : Model Based Test Time Correction for Improved Quantitative

P. Naveen

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract
Quantitative susceptibility mapping (QSM) is an advanced magnetic resonance (MR) imaging technique for quantifying the magnetic tissue susceptibility of the brain. Deep learning methods have shown promising results in deconvolving the susceptibility distribution from the measured local field obtained from the MR phase. Although the existing deep learning based QSM methods

can yield high-quality reconstructions, they are highly biased toward the training data distribution and need more generalizability. This work aims to introduce a model based test time correction approach to improve the deep learning based QSM reconstruction and reduce the inherent bias towards the training data distribution without adapting the model weights. In the proposed method, the susceptibility map prediction obtained from the deep learning model has been refined iteratively to ensure consistency with the measured local field, imposing model based data consistency. The performance of the proposed approach was also evaluated using the susceptibility map predictions obtained from state-of-the-art deep learning based QSM reconstruction approaches such as QSMnet, learned proximal convolutional neural network (LPCNN), and fidelity-imposed network edit (FINE). The proposed method yielded improved and consistent performance across different methods in all test cases. The proposed approach was also effective on MR volumes obtained under different acquisition settings.

Student Presentation 4: Model-Resolution based Deconvolution for Improved Quantitative Susceptibility Mapping

Raji Susan Mathew

Department of Computational and Data Sciences,,
Indian Institute of Science

Abstract

Quantitative susceptibility mapping (QSM) utilizes the relationship between the measured local field and the unknown susceptibility map to perform dipole deconvolution. The aim of this work is to introduce and systematically evaluate the model-resolution based deconvolution for improved estimation of the susceptibility map obtained using the thresholded k-space division (TKD). A two-step approach has been proposed wherein the first step involves the TKD susceptibility map computation and the second step involves the correction of this susceptibility map using the model-resolution matrix. The TKD estimated susceptibility map can be expressed as the weighted average of the true susceptibility map where the weights are determined by the rows of the model-resolution matrix, and hence a deconvolution of the TKD susceptibility map using the model-resolution matrix yields a better approximation to the true susceptibility map. The proposed approach was compared with L2 regularization, TKD, re-scaled TKD in superfast dipole inversion, and modulated closed-form method. It was observed that the proposed approach showed a substantial reduction in the streaking artifacts across 92 test volumes considered in this study. The proposed approach also showed better error reduction, edge preservation, and contrast-to-noise ratio compared to other approaches. The proposed model-resolution based deconvolution compensates for the truncation of zero coefficients in the dipole kernel at the magic angle and hence provides a closer approximation to the true susceptibility map compared to other direct methods.

Student Presentation 5: Changes in higher-order interaction measures synergy and redundancy during non-ordinary states of consciousness

Pradeep Kumar G

Department of Electrical Engineering,
Indian Institute of Science, Bangalore

Abstract

Higher-order interdependencies in the electroencephalogram (EEG) data reflect the changes in functional interactions between different brain regions for information processing. These interactions are required for specific cognitive functions during different non-ordinary states of consciousness (NSCs). These functional interdependencies may be decomposed into synergistic information which can be only decoded by using the information from all the sources considered and redundant information which is the common information provided by all the sources. We used synergy and redundancy measures derived from information about organizational structure (O-information) to investigate higher-order interactions and their statistical interdependencies during the NSCs. We analysed resting EEG data from 22 long-term meditators, 9 volunteers undergoing hypnosis and 23 practitioners of self-induced cognitive trance (SICT). During meditation, synergy increased in delta band except in left-fronto-temporal, right frontal regions, in theta band globally and redundancy decreased globally in delta, posterior region in theta and frontal, central, posterior regions in beta2 bands. During hypnosis, synergy decreased except in the left-frontal, right-frontal, left parietal and right parietal regions in the delta band. The decrease was also observed in the right-frontal and left parietal regions in beta2 bands. Redundancy during hypnosis did not change. During SICT, synergy decreased in the left-frontal and posterior regions in the delta band. Redundancy during SICT showed non-significant decrease in frontal, posterior regions in delta, theta, alpha and beta1 bands. The redundancy values were always higher than synergy values in all the bands across all the datasets. There exist common and distinct patterns across different NSCs. These findings reveal the feasibility of using higher-order interaction measures as biomarkers to study different conscious states.

Student Presentation 6: Towards an Indigenous Smart Intraoperative Probe for Brain Tumour Delineation

Arjun B S

Department of Electronic System Engineering,
Indian Institute of Science

Abstract:

Tumours affecting the brain are known to have a high incidence, mortality, and morbidity. Identifying tumour margins during surgical resection strongly influences the effectiveness of chemotherapy and radiation. Hence, various intra-operative techniques are used for brain tumour delineation during surgery as pre-operative imaging tools are rendered ineffective due to the plasticity of the brain and the phenomenon of brain shift. Therefore, developing an intraoperative tool is required to augment brain tumour treatment by achieving gross total resection through accurate tumour margin assessment. In this regard, a multimodal probe is being developed to explore the changes in electromechanical

properties of tissues due to tumours as a modality to delineate tumours from normal. Towards this goal, microelectromechanical systems (MEMS)-based electrical and mechanical were fabricated indigenously. The talk presents the experimental work that describes the integration of the fabricated electrical and mechanical sensors into a portable system for tissue ex vivo characterization that provides insights into the tissue properties that can potentially be used for tumour delineation. The study showed that electrical impedance spectroscopy could delineate between tumour and normal tissues. On the other hand, the mechanical characterization showed a clear difference between different grades of tumours and between different normal regions. The talk also describes the ongoing work developing the hardware and software for a novel electrical impedance tomography approach for brain tumour imaging and the steerable multimodal robotic intraoperative probe that has been envisaged. Once developed, the multimodal intraoperative probe will be the first of its kind and possibly overcome the current limitations in brain tumour treatment by delineating the tumour in a robust, reliable, and cost-effective way. The probe will potentially improve treatment procedures, paving the way for advancement towards a new class of brain tumour surgical technologies.

Student Presentation 7: Tau-cell-based Analog Silicon Retina with Spatio-Temporal Filtering and Contrast Gain Control

Prince Philip

Department of Electronic System Engineering,
Indian Institute of Science

Abstract:
Developing precise artificial retinas is crucial because they hold the potential to restore vision, improve visual prosthetics, advance research, and enhance computer vision systems. Emulating the luminance and contrast adaption features of the retina is essential to improve visual perception and efficiency to provide an environment realistic representation to the user. In this study, we introduce an artificial retina model that leverages its potent adaptation to luminance and contrast to enhance vision sensing and information processing. The model has the ability to achieve the realization of both tonic and phasic cells in the simplest manner. Furthermore, It is possible to reconfigure the implementation of the proposed analog silicon retina, which is inspired by biology and features a center-surround receptive field. Our results demonstrate that the retinal computing modules achieve comparable performance to software retinal implementations, and a pixel is fabricated in a 180nm CMOS process.

Student Presentation 8: Synthesizing optimal visual stimuli with deep generative networks

Shankhadeep Mukherjee

Centre for Neuroscience,
Indian Institute of Science

Abstract
The brain's visual system comprises a hierarchy of regions that encode progressively more complex visual features. For example, neurons in lower areas, like the primary visual cortex (V1), respond best to oriented bars, whereas neurons in higher areas, like the fusiform face area (FFA), respond best to face-like stimuli. The precise feature sensitivity of these brain areas has been meticulously

worked out through decades of research by showing 100s or 1000s of exemplars of various classes of stimuli to fixating animals (or humans) while recording activity from these brain areas. Nonetheless, given constraints on experimental time, the repertoire of visual categories that have been explored is limited. Here, we seek to synthesize "super-stimuli" – images with features that activate specific areas of visual cortex much more strongly than conventional categories of images. Yet, the enormous number of potential feature combinations to be explored renders this task challenging. To address this challenge, we extend a previous framework (Xdream - Xiao, 2020) that employs a deep generative network (BigGanDeep - Brock, 2019) in conjunction with a heuristic optimization approach (genetic algorithm). We build a robust CNN-based encoder for human functional MRI (fMRI) brain responses based on recent work (Beliy, 2019) and incorporate the encoder in a closed-loop optimization framework. Our approach generates meaningfully novel "super-stimuli" both for brain regions individually, as well as chimeric "super-stimuli" that are jointly optimal for multiple brain regions (e.g., V1+FFA). In ongoing work, we seek to validate the images generated by this approach by directly measuring human visual cortex responses to these images "live", inside the fMRI scanner.

Student Presentation 9: Persistent photoconductivity-based optoelectronic synaptic transistors for neuromorphic computing

Sreekanth Maddaka

Centre for Nano Science and Engineering,
Indian Institute of Science

Abstract

With the emergence of artificial intelligence, big data, internet of things, advanced communication technology, etc., the processing of ever-growing data is difficult with von-Neumann based conventional computers due to their high-power consumption and low processing speed. In a great quest for highly energy-efficient and high-speed computational devices, inspired by extremely energy efficient and parallel-processing abilities of brain, neuromorphic or brain-inspired computing is being explored widely across the globe. In this computing, various synaptic functions of a brain such as short-term plasticity, long-term plasticity, paired pulse depression, spike-time dependent plasticity, short-term depression, long-term depression, etc. are emulated using various artificial synaptic devices like electronic, photonic, optoelectronic, spintronic devices, etc. In present talk, I would be discussing about persistent photoconductivity (PPC), PPC induced emulation of various synaptic functions using phototransistors and the related work underway in our group will be covered.

3.1.13 Session 4B: Microelectronics, RF, and Photonics

Session Chair: Shivaleelaesamudra Sharanappa
Cluster Coordinator:Srinivas Talabattula, Arup Polley
Student Organizer: Yashash, Krishna
Faculty Organizer: Debdeep Sarkar
Location: ECE MP-20

Cluster Overview

Time	Event	Speaker	Affiliation
02:30 – 03:00 PM	ARTPARK Talk	Syed Adil Hassan	Head of the Startup at ARTPARK Accelerator Program
03:00 – 03:30 PM	Invited Talk 1	Rajappa Papannareddy	Founding CEO of PR Lightcom
03:30 – 03:50 PM	Invited Talk 2	V. Mahadevan	PESIT, Ex-ISRO
03:50 – 04:05 PM	Student Presentations	Jogesh Chandra Dash	ECE,IISc
04:05 – 04:20 PM		Pushkar Dasika	ECE,IISc
04:20 – 04:35 PM		Lal Krishna	ECE,IISc
04:35 – 04:50 PM		Asish Prosad	ECE,IISc
04:50 – 05:05 PM		Sathisha R N	ECE,IISc
05:05 – 05:20 PM		Pratik Kumar	ESE,IISc
05:20 – 05:35 PM		Pradeep Kumar Gautam	ESE,IISc

ARTPARK Talk :Startup @ ARTPARK: Translate Laboratory Ideas into Impactful Products

Speaker: Syed Adil Hassan, Head of the Startup at ARTPARK Accelerator Program
Personal Webpage

Abstract

What it takes to start your deep-tech entrepreneurship journey. Startup@ARTPARK Program is a platform for aspiring entrepreneurs who aim to solve significant challenges faced in the developing world through technology. The program fosters the translation of ideas into a business through opportunities for collaboration and learning; and an industry-led mentorship program. So let's connect, build and create your venture with the Startup@ARTPARK program.

Bio

Adil Hassan is the Head of the Startup@ARTPARK Accelerator Program and the head of Marketing Communications at ARTPARK (AI Robotics Technology Park). Crafting and growing tech brands is his forte! At ARTPARK, he is helping to shape ideas into products in AI and Robotics landscape. Before this, Adil worked at Google India, Intel Technology Wizcraft pvt ltd. Additionally, he has associated with companies like Volvo, Nike, Fujitsu, Dell, and others.

He has 12+ years of exposure to the startup ecosystem, Marketing and brand management.

Invited Talk 1 : Design Tools for OFC Systems and Network Planning

Speaker: Rajappa Papannareddy, Founding CEO of PR Lightcom
Personal Webpage

Abstract
During the last few decades, optical fiber technologies have evolved from a few Mb/sto100 Gb/s data links networks. The design tools have played an important role towards the design and development of OFC systems and networks. First, this talk presents an overview of OFC systems and networks and then discusses the newly developed design tools: OFC-Systems Soft WDM-NetSoft for systems engineering and network planning. Additionally, the performances of these design tools are reviewed with examples.

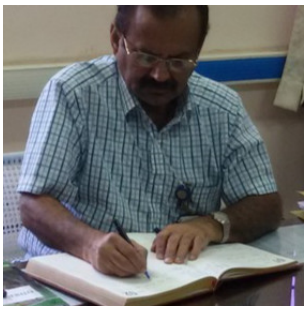
Bio
Rajappa Papannareddy received his Ph.D. Degree in electrical engineering from Southern Methodist University in1987, MSEE from the University of Maryland in 1983, and B.E (Electronics) from Bangalore University in 1975.He has published several journal andpresented many papersat several IEEE ASEE conferences during his tenure at Purdue UniversityNorth Central, U.S.A. In addition, he has published two textbooks in the area of optical fiber communicationsystems. He is now a retired Professor of Electrical Engineering ofPurdue University.His past work experience includes a Senior Engineer position at ISRO Satellite Centre in Bangalore, Staff Engineer at ARRISin U.S.A.and a Principal Engineer at CIENA in U.S.A.Currently, he offers optical network training courses to the academia and industry.

Invited Talk 2 : Satellite Communication and Antenna

Speaker: V. Mahadevan, PESIT, Ex-ISRO
Personal Webpage

Abstract
Satellite communication is one of the major mode of communication as it has access to even the remote locations, otherwise very difficult to reach by normal terrestrial methods. The talk outlines a brief about the various satellite systems followed by detailed description of communication systems along with the Antenna System. The systems onboard the spacecraft needs a very special design as it has to withstand the severe conditions of temperature and pressure of the outerspace, the severe vibration and shock during launch, and adhere to various other constraints like size, weight, configuration etc. posed by the spacecraft apart from its flawless performance throughout the mission life of about 10-15 years. The various blocks involved in communication are briefly touched upon along with the link. The mainframe communication system is the Tracking Telemetry and Command and based on the mission a High Data rate Transmission system or communication transponders are used and all systems need to operate at specific frequency bands allotted for the purpose by the international body. The Antenna pattern required for various services vary from Omni-directional

to Sharp Beam and again to some sort of shaped or contoured beam. Typical examples of various antenna systems along with insight into its design, qualification and application are included to get an idea about the tasks involved. A few antenna hardware developed for spacecraft as well as ground tracking are included to show the complexities involved which includes the Deep Space Network Antenna.



Bio

. V. Mahadevan obtained his B.Tech (Hons) in Electronics Communication from IIT Kharagpur and M.E. in Communication Engineering from IISc Bangalore. He joined ISRO Satellite Centre in the Communication Systems Group and contributed in the design and development of Antenna Passive Systems flown in many spacecrafts. One of the major contribution is in the development of Active Phased Array Antennas which was successfully flown and is being adopted for many future spacecrafts. He was appointed as Associated Project Director for CATF (Compact Antenna Test Facility) and the same was established in ISRO Bangalore in a record time. He held a number of posts in various satellite projects and finally appointed to the post of Group Director, Communication Systems Group, ISRO Satellite Centre, Bangalore. He retired on superannuation in April 2010 and served for about a decade as Professor in the Dept. of Electronics and Communications/ Telecommunication at PES University, Bangalore. He is a Senior Member of IEEE, Life Member ASI (Astronautical Society of India), Life Fellow Member IETE, Distinguished Member ATMS(Antenna Test and Measurement Society) and has published a number of papers in international and national journals.

Student Presentation 1: Full-Duplex Antenna Design for V2X-ITS Application: An Approach Towards Future 6G Communication

Jogesh Chandra Dash

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Full-Duplex (FD) transmission, is an envisioned technology for the future 6G services, uses simultaneous transmission and reception (STAR) of signal with the same frequency and time slot thereby catering to ultra-reliable low latency communication (URLLC) with high spectral efficiency. However, the self-interference (SI) in the FD system due to its STAR feature creates a communication barrier. There are various active (analog/digital domain) and passive (antenna domain) SI cancellation techniques reported in the literature to compensate SI in the FD system, where the active cancellation technique needs additional chancellor circuits and signal processing block which increases system complexity, power consumption, and cost. Therefore, high antenna domain isolation is desirable as the first line of defence in the communication chain to reduce the burden on the active SI cancellation system.

In this work, we discuss three different Full-Duplex (FD) antenna designs with three unique techniques of antenna domain self-interference-cancellation (SIC) between Tx and Rx ports. First, we propose a two-element FD antenna design with a stacked configuration with SI-cancellation

using antenna design asymmetry, defected ground structure, and near-field decoupling structure (NFDS) simultaneously, achieving 90 dB isolation at 5.85 GHz operating frequency. Secondly, we propose a two-element planar FD antenna design with SI-cancellation using metallic via loaded field confinement and DGS simultaneously, thereby achieving 90 dB isolation at 5.9 GHz operating frequency. Finally, we proposed a shared-radiator-based planar FD antenna design with SI-cancellation using via and stub-resonator loading thereby achieving 60 dB isolation between Tx and Rx at 5.9 GHz operating frequency. The proposed designs are suitable for future 6G applications such as V2X-ITS (Intelligent Transportation Systems) at the sub-6 GHz (IEEE 802.11p) Band and scalable to other frequencies.

Student Presentation 2: Low dimensional field-effect-transistors

Dasika Pushkar

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

The solid-state transistor has been one of the most influential inventions of the 20th century. Transistor is the fundamental building block of all modern computing devices. Silicon has been the preferred material to make transistors to date. The ease of fabrication of silicon-transistor-based integrated circuits and rapid downscaling of the transistor has helped to kick-start the information revolution worldwide. However, the rapid downscaling of the transistor has proven to be increasingly challenging due to increasing short-channel effects. This has led to a new search for materials that meet the ever-increasing computing requirements.

Van der Waal's materials have been considered a promising alternative for silicon in next-generation computation systems. Van der Waal's materials help in reducing the dimension of the typical 3D transistor to 2D or even 1D without sacrificing surface stability. In the present talk, we present our work on low-dimensional transistors – both one-dimensional and two-dimensional material-based transistors showing promising results. We present many exciting properties of Tellurium nanowire-based transistors. In addition to the regular field-effect-transistor structure, we present a 2D material tunnelling-based field-effect-transistor. We would also discuss the 2D material-based multi-bridge architecture, which would help reduce the device footprint so that more devices can be accommodated in a given area.

Student Presentation 3: Resonant metasurfaces for photonic applications in the mid-infrared wavelength

Lal Krishna A.S.

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Resonant metasurfaces are artificially engineered devices for achieving exceptional spectral properties as well as multi-fold enhancement of electromagnetic field at nanoscale. We explore the possibility of resonant metasurfaces in realizing nanoscale devices in the mid-infrared wavelength region, to aid applications including spectroscopy (molecular fingerprints), defence, remote sensing, free space

communication etc. In the first part of the work, we designed and experimentally demonstrated a novel quasi bound state in continuum (BIC) resonance with the resonant electric field confined as a slot-mode (>30% mode field confinement, Q factor 400) within a low refractive index medium sandwiched between high-index layers at 3.41 m wavelength. Such devices find applications in resonantly enhanced sensing and active photonic devices. In the next part of the work, off-axis excited guided-mode resonance (GMR) hybridization in one-dimensional (1D) grating structures operating in the 3 m wavelength range is experimentally demonstrated. We could demonstrate, band-flip between GMR and Friedrich-Wintgen type bound-states in-the-continuum (FW-BICs) accompanied by a band closure and subsequent electromagnetically induced transparency (EIT) like resonance feature with duty cycle engineering. These devices can resonantly enhance (more than two orders of magnitude) weak absorption signatures from analytes as demonstrated in the work using polymethyl methacrylate (PMMA) as an example.

Student Presentation 4: Single and Two-photon Absorption Induced all-Optical Control of Gallium Selenide Integrated Silicon Nitride Photonic Devices

Asish Prosad

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

In this work, we report single- and two-photon absorption-based transmission and resonance modulation in multilayer Gallium Selenide (GaSe) integrated silicon nitride (Si3N4) waveguides and ring resonators operating in the 700-800 nm wavelength range. Intensity dependent saturable absorption at lower optical powers followed by two-photon absorption (TPA) at higher power levels in GaSe integrated Si3N4 waveguides is observed for 785 nm pulsed laser excitation. TPA coefficient of 0.112 cm/GW for the GaSe-Si3N4 composite waveguide and three-photon absorption coefficient of 1.246x106 cm3/GW2 for the bare Si3N4 waveguides are extracted from the intensity dependent transmission measurement. Single-photon absorption process induced by a blue laser incident on the multilayer GaSe on top of the Si3N4 ring resonator is used for all-optical resonance tuning through free-carrier refraction effect. Strong blue shift of 12.3 pm/mW in the resonance combined with resonance broadening are used to extract free carrier induced refractive index and absorption changes. TPA in GaSe integrated Si3N4 ring resonator is also shown to result in a blue shift of the resonances excited using 785 nm pulsed laser excitation. This work demonstrates all-optical control of the optical properties of 2D material integrated Si3N4 guided-wave structures operating in the shorter near infrared wavelength range with potential applications as active optical functionalities in integrated quantum photonics, miniaturized sensing devices, and biomedical imaging.

Student Presentation 5: Data rate enhancement schemes and hybrid networks-Experimental works on Optical wireless communication

SATHISHA R N

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

The goal of the research work is to explore the communication performance of Visible light communication (VLC)/Optical wireless communication (OWC) in the indoor applications. With the use of Hermitian symmetry operation to make the time domain waveforms real-valued and non-negative, modified M-QAM/OFDM formats resulted in significant improvement to the data-rates. Due to the redundant subcarrier mapping in Hermitian symmetry of about 50%, the overall spectral efficiency of transmission is also reduced and hence reduces the achievable data rates. In order to improve on this, Laser based non-Hermitian data transmission scheme is proposed and implemented. This has resulted in significant improvement in data rates. Non orthogonal Multiple Access (NOMA) schemes are being used introduced in the VLC context to solve near-far user problems. NOMA usage in VLC also improves the spectral efficiency and hence allows to support more users. The basic experiments are tried out in laser based transmission for two users using 4-QAM transmission. There is a plan to explore capabilities of NOMA based VLC schemes.

Student Presentation 6: Analog Compute Ecosystem for Machine Learning at the Edge

Pratik Kumar

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

Machine Learning (ML) algorithms are widely used in a variety of applications ranging from self-driving cars to edge applications such as the Internet of Things (IoT). Currently, such algorithms are executed on digital architectures (also called digital accelerators) designed specifically for high-volume calculations offering dramatically larger amounts of data movement per joule. However, such digital accelerators are highly power-hungry and area-inefficient, posing a severe challenge for several design applications. In this regard, analog AI accelerators can offer unmatched power density, performance, and area benefits to their digital counterparts. To date, the power density and performance benefits of analog designs remain unmatched by their digital counterparts. Yet the popularity of analog designs has long been hindered due to the lack of robust modular architectures that can be easily synthesized across process technology nodes and different biasing conditions. The current research has barely scratched the surface of high-performance analog accelerators. The objective of this work is to, (i) create a novel analog computing framework for designing high-performance and energy-efficient analog compute systems for machine learning tasks; (ii) create an end-to-end Analog AI Compute Ecosystem comprising of reconfigurable Analog AI Accelerator processor, a design Compiler to map dataflow graph on the processor and an automated AI Test Framework for chip testing.

Student Presentation 7: Scalable Control Electronics for Quantum Computer

Pradeep Kumar Gautam

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract Quantum processors utilize the properties of quantum parallelism and quantum interference in solving certain computational problems much faster than classical computer. Qubits are the basic building blocks of a quantum processor which require pulses in giga hertz range and latency in nanoseconds for control and readout. The room temperature electronics that support the control and measurement of the qubits pose three main challenges namely scalability, direct microwave synthesis and a unified interface. In this Project, we use the evaluation kit ZCU111 to develop SQ-CARS, a scalable, configurable and phase synchronized system for multi-qubit control and readout with an easy to use Python programming interface. The scalability to a larger number of qubits is realized by synchronizing multiple channels deterministically. All the control and readout features are supported using a python based user interface. This system can synthesize arbitrary vector microwave pulses using the second-Nyquist zone technique for frequencies in the range of 4-9 GHz. It also supports low pass filters of tunable cutoff frequencies and rotation blocks which can be utilized to perform lock-in detection and provide active feedback. We further perform various time-domain measurements to characterize a superconducting transmon qubit and benchmark our results against traditionally used setups.

3.1.14 Session 4C: Power Engineering

Session Chair: Vishnu Mahadeva Iyer, Samir Hazra
Cluster Coordinator: Vishnu Mahadeva Iyer, Samir Hazra
Student Organizer: Sagnik, Abhishek
Faculty Organizer: Kiran Kumari
Location: ECE 1.08

Cluster Overview

Time	Event	Speaker	Affiliation
02:30 – 03:00 PM	Invited Talk 1	Anil Kulkarni	EE, IIT Bombay
03:00 – 03:20 PM	Invited Talk 2	Shashidhar Mathapati	Delta India Electronics, Bengaluru
03:20 – 03:34 PM	Student Presentations	Thirumalasetty Mouli	EE,IISc
03:34 – 03:48 PM		Anupam Verma	EE,IISc
03:48 – 04:02 PM		Sugoto Maulik	EE,IISc
04:02 – 04:16 PM		Himanshu Bhusan Sandhibigraha	EE,IISc
04:16 – 04:30 PM		Vishwabandhu Uttam	EE,IISc
04:30 – 04:44 PM		Manish Mandal	EE,IISc
04:44 – 04:58 PM		Ranashree Ram	ECE,IISc
04:58 – 05:12 PM		Deepak Kaushik	EE,IISc
05:12 – 05:26 PM		Francis C Joseph	EE,IISc

Invited Talk 1: Correlation of Diverse Measurement Records for Disturbance Diagnosis in Power Systems

Speaker: Anil Kulkarni, EE, IIT Bombay
Personal Webpage

Abstract

Disturbances continually occur in a power system but the system is usually able to ride through them by appropriate actions of protective relays in the vicinity of the disturbances. In rare cases, the disturbance spreads and causes widespread outages. In these situations, post-disturbance diagnostics become necessary to identify the problems and take corrective measures. Disturbance measurements come in various forms including relay records, Disturbance Recorders(DRs), pre-disturbance SCADA data, sequence-of-event recorders and Phasor Measurement Units. Harmonizing the data from these different sources having different sampling rates, recording duration and time-stamping accuracy requires pre-processing, followed by application of domain knowledge to diagnose the disturbance accurately. This involves the consideration of both electro-magnetic and electro-mechanical transient signatures present in various records. Through real-life examples this talk brings out how this is done, and discusses the prospects of semi-automating this process.

Bio

A.M. Kulkarni is a Professor in the Electrical Engineering Department, IIT Bombay India. He obtained his BE degree in Electrical Engineering from the University of Roorkee, India in 1992, and his ME and PhD degrees in 1994 and 1998 respectively, from the Indian Institute of Science, Bangalore. His broad areas of interest are in Power System Dynamics, HVDC and FACTS, and Wide Area Measurement Systems (WAMS) applications. He has worked closely with utilities in India on several projects, including the PSS tuning exercise in the Eastern and Western regional grids, and the analysis of blackouts in North India (2012) and Mumbai (2020). Recently he has been working as a part of an IIT Bombay team that is developing analytics for the WAMS implementation in India.

Invited Talk 2: Creativity and Innovation in the context of Engineering

Speaker: Shashidhar Mathapati, Delta India Electronics, Bengaluru
Personal Webpage

Abstract

Creativity and innovation are crucial elements for success in today's fast-paced and ever-changing world. In the context of engineering companies, they are key drivers of growth, competitiveness, and sustainability. Organizations that encourage creativity and innovation are more likely to succeed in the long run. They are better equipped to adapt to changing market conditions, anticipate customer needs, and stay ahead of the competition. Moreover, fostering a culture of creativity and innovation can lead to increased employee engagement, job satisfaction, and retention. Additionally, it is essential to create a culture that values and rewards creativity and innovation, rather than punishing failure.

Bio

Dr. Shashidhar Mathapati is the Chief Technology Officer (CTO) at Delta Electronics India, a position he has held since 2019. He defines and monitors the new company's technology directs, RD strategy, and oversees Delta's design and development. Dr. Mathapati has an extensive professional career with more than 20 years of experience in the world of engineering and technology. He joined Delta in 2011 as an engineering manager focused on high power and high voltage power electronics, particularly for renewables and energy infrastructure segments. As the Chief Technology Officer at Delta, Dr. Mathapati is responsible for creating and heading the company's design and development of power electronics products and solutions across India. He is focused on driving the company's vision of helping the world run better and improving people's lives by building sustainable products.

Dr. Mathapati holds a Bachelor's degree from Gulbarga University (1995-1999), a Master's from IISC (2000-2002), and a PhD from Paderborn University (2005-2010).

Student Presentation 1: PWM-Based Optimal Predictive Direct Torque Control of Switched Reluctance Machine

Thirumalasetty Mouli

Department of Electrical Engineering,
Indian Institute of Science

Abstract
Switched reluctance machine is a promising permanent magnet- less choice for applications like electric vehicles. SRM has a rugged structure with no rotor winding and its simple construction makes this machine easy to manufacture. The inherent pulsating nature of torque and non-unique phase-current-shapes make the torque control of SRM challenging. Several indirect torque control techniques, which involve extensive offline computation of torque-sharing functions and optimal current shapes, have been proposed in the literature to reduce torque ripple and RMS phase currents. Various Finite-Control-Set-based (FCS), model predictive torque controllers are proposed to directly control the torque by applying an optimal switching state. The optimal switching state is evaluated by minimizing the cost function, by considering all possible switching states of the H-bridge converter. However, FCS-based torque controllers operates at variable switching frequencies and the computational complexity of these controllers increases exponentially with an increase in the prediction horizon . To address the issues of FCS-based controller, in this work a fixed-frequency PWM-based predictive torque controller is proposed. The proposed controller analytically computes the optimal duty ratio in run time by minimizing the torque error and RMS phase currents simultaneously. This is achieved through usage of simplified flux-linkage model and static torque look-up table of SRM. The details related to the implementation of the proposed torque controller are discussed. Further, the performance of the proposed controller is compared with an existing FCS-based-direct torque controller through simulations. The performance of the proposed controller at multiple torque levels and speeds are validated both through experiments and simulations on an 8/6 pole, 4kW, 4-phase laboratory prototype SRM.

Student Presentation 2: Modified Single-Pulse-Operated Switched Reluctance Generator: Modeling, Analysis, and Experimental Verification

Anupam Verma

Department of Electrical Engineering,
Indian Institute of Science

Abstract
Modified single-pulse mode is known to reduce the output current ripple of a switched reluctance generator (SRG) compared to single-pulse mode. This paper presents a novel mathematical model of SRG operating under modified single-pulse mode. The model inputs are DC-link voltage, prime-mover speed, low-current inductance profile, and three switching angles of the power converter. The phase current, DC bus current contributed by each phase, and the average output current of an SRG system are expressed as analytical function of model inputs. The model can be utilized for

performance prediction and control of modified single-pulse-operated SRG. The phase current, DC bus contributed by each phase, and the average output current obtained using the proposed model are all validated through simulations and experiments. Further, using the proposed model, the DC-link voltage dynamics of SRG for constant-resistance, constant-current, and constant-power loads are predicted and validated through simulations and experiments on a 4-kW 1500-rpm SRG.

Student Presentation 3: Dual Mode Operation of Grid-Tied Inverters

Sugoto Maulik

Department of Electrical Engineering,
Indian Institute of Science

Abstract

The advent and increased penetration of localized power generation in the form of distributed energy sources have brought significant changes in the behavior of the power distribution network. Effective integration of distributed sources improves the peak demand-handling capability of the network and adds redundancy to the system. However, such systems form unintentional islands in cases of grid outages. Such islands are highly undesirable for the safety and stability of the distribution network. Thus these networks require dedicated islanding detection schemes. This talk proposes a state-feedback-based islanding detection method, which achieves detection within one power cycle of operation while ensuring a zero non-detection zone. Furthermore, a post-island control scheme is proposed to transfer the islanded source from grid-connected to grid-forming control. The islanding detection and subsequent transfer scheme combine to ensure a seamless transfer of control and uninterrupted operation of local loads.

Student Presentation 4: A Multi-port Isolated Active Clamp Boost PFC-Converter-based Charger for Electric Vehicles

HIMANSHU BHUSAN SANDHIBIGRAHA

Department of Electrical Engineering,
Indian Institute of Science

Abstract

With the growing number of electric vehicles (EV), the demand for public charging infrastructure is on the rise. Due to the lack of standardisation of battery voltage and current levels, it is challenging to design and develop off-board chargers in a charging facility that can cater to multiple vehicles from different manufacturers. In this work, a multi-port isolated active clamp boost Power Factor Correction (PFC) topology is proposed as a unified multi-port off-board charger for electric two-wheelers. The unified multi-port charger has three output ports, and thus it is able to charge three vehicles simultaneously. Also, each output port can cater to a wide range of battery voltage and current levels. Experimental results from a 1.2 kW hardware prototype are shown to demonstrate the operation functionality of the unified multi-port charger.

Student Presentation 5: A Unified Modeling Approach for Design and Performance Improvement of Triple Active Bridge Converter

Vishwabandhu Uttam

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Triple Active Bridge (TAB) converter is a multi-port DC-DC converter. This converter is an extension of the popular Dual Active Bridge converter. It features desirable traits of the DAB converter, such as high power density, galvanic isolation, and bi-directional power flow between any of the ports. As in other multi-port converters, redundant power conversion is minimized through component sharing among the ports in a TAB converter. All the switches in a TAB converter can undergo soft-switching over a wide range of operating points, reducing switching losses and the size of auxiliary components. The multiple degrees of freedom in modulating a TAB converter offer several design and operational flexibilities.

However, this converter has yet to come into the limelight despite these advantages. One of the reasons is the lack of a unified analytical framework for the design and operation of this converter. The existing models for the TAB converter are limited in scope and cannot be easily used for the design and operational optimization of the converter. This work focuses on developing simple, unified models for analyzing the TAB converter. Firstly, the popular Fundamental Harmonic Approximated (FHA) large-signal and small-signal models are evaluated to understand their limitations. Improved large-signal and small-signal Generalised Harmonic Models (GHM) are developed by incorporating the impact of higher-order harmonics. While the GHM is shown to be superior for small-signal analysis of the converter and the design of a closed-loop control system, it is not suitable to analyze the soft-switching bounds of the TAB converter. To overcome the limitations of GHM, a Unified Model that incorporates the impact of the magnetising inductance of the three-winding transformer is proposed. The Unified Model can accurately predict the AC port currents at the switching instants and is used to study the soft-switching bounds of the TAB converter. The GHM and Unified Model are validated through extensive switching circuit simulations and experimental results from a 1 kW hardware prototype developed in the laboratory. Further, a new design algorithm for the TAB converter is proposed. The proposed algorithm leverages the FHA model's simplicity and the Unified Model's accuracy. Finally, a new modulation scheme based on Penta Phase Shift with five degrees of freedom is proposed to achieve soft-switching across the operational range of the TAB converter.

Student Presentation 6: Investigation and comparison of switching transient modeling of SiC MOSFET in Kelvin-source packages with common-source package

Manish Mandal

Department of Electrical Engineering,
Indian Institute of Science

Abstract

With superior electrical and thermal performance, SiC MOSFETs offer a viable replacement for silicon IGBT in the voltage range of 1200-1700V. Among the commercially available SiC MOSFETs,

Kelvin-source and common-source (through-hole) packages are suitable for high-power designs. Due to a significant reduction in the common-source inductance in the Kelvin-source packaged (TO-247-4) SiC MOSFETs, these devices have faster switching transient and lower switching losses when compared to SiC MOSFETs in common-source packages (TO-247-3). This, however, also has a significant impact on the switching dynamics. In this talk, the investigation of the analytical switching transient modeling of Kelvin-source packaged SiC MOSFETs is presented and compared with the traditional model for SiC MOSFETs in common-source packages. This study considers the non-linear nature of the channel current and functional dependence of device parasitic capacitances on their terminal voltages, along with the effect of external circuit parasitics. The proposed analytical model estimates switching loss, switching times, (di/dt) and (dv/dt). The accuracy of the proposed analytical model is validated through behavioral simulation and/or experiment for a 1.2kV four terminal (To-247-4) device and a Schottky diode pair. This study shows that During the turn-on transition, the drain-source voltage falls significantly during the current-rise period due to a significant difference between the channel and the drain current. This makes the analysis fully coupled compared with common-source packaged SiC MOSFETs. During the turn-off transition, the channel current collapses to zero in the voltage-rise period resulting in significantly lower losses. However, this results in the loss of voltage slew rate control

3.1.15 High Tea break

Student Presentation 7: Developmental Studies on a Multistage Induction Coilgun-Based Electromagnetic Launcher

Ranashree Ram

Department of Electrical Engineering,
Indian Institute of Science

Abstract

The archetypal chemical propellant-based launchers (e.g., guns, missiles, spacecraft launchers, etc.) with their hot trailing plume (hence, known as the “hot-launching system”) has been widely deployed over the decades by various agencies. However, because of certain disadvantages of these systems and the physical limitations associated with their designs, electromagnetic launchers (EMLs) seem to offer an alternative way forward as the next-generation hypervelocity (>3 km/s) launchers. They are being researched in select countries around the globe due to their promising capability to successfully replace the archetypal chemical launchers in hypervelocity launching applications. The multistage induction coilgun is one such futuristic class of EMLs that works on the principle of electromagnetic induction between an array of coils (or drive coils), which are wound on a long insulating barrel of appropriate length, and an electrically conducting projectile (or armature) placed inside the barrel. Previously charged high-voltage capacitor banks are sequentially discharged into the coils through high-voltage solid-state switches leading to the generation and flow of high-magnitude impulse currents through the coils. Time-varying magnetic flux thus produced by the pulsed currents through the coils interact with the projectile inside and induce a resultant current on it. The propulsive electromagnetic force exerted on the projectile is a product of the excitation current through the coil, the induced current on the projectile, and the mutual inductance gradient (i.e., the change in mutual inductance between the coil and the projectile as the projectile travels through the coil). The “turn on” and “turn off” of the coils in the various stages must be precisely and appropriately synchronized

during the multistage operation to achieve a higher projectile velocity – this makes its successful design and operation a challenge. The absence of flame and high-pressure gas makes the induction coilgun a "cold-launching system."

Several applications of the induction coilgun include: Civilian and Atomic Energy Application To produce hypervelocity particles for impact studies. Missile Launching To launch to an altitude where the main rocket motor can be ignited. Thus, the launch pad can stay hidden from the enemies' infrared (IR) sensors due to the absence of initial flame and high-pressure gas during launching. Artillery Guns Heavy class guns, viz., cannon, howitzer, mortar. Naval Guns Low fire risk in the absence of storage requirements of explosive-laden cartridges in the ship. Anti-tank Guns They can penetrate the thick armor due to high velocity. Space Application To place small satellites (a few hundred kilograms or less) into low-earth orbit (LEO: 180-2,000 km from earth's surface).

The USA, USSR, China, and South Korea are a few countries to name, who are working on developing coilgun technology to implement it in their defense and space sectors. Owing to its high confidentiality in defense and space applications, not much can be known from their published works. Until now, India has relied on some foreign countries for defense-related items, which often keeps India under geopolitical pressure. However, no country will share the advanced complex coilgun technology with us due to its high confidentiality. Hence, India must leap into this EML race to be self-reliant in the defense and space sectors and bring the "Make in India" initiative a success. The Pulsed Power Laboratory of IISc Bangalore endeavors to contribute toward this goal. The author's aim to design, fabricate, and operate a four-stage induction coilgun has been achieved successfully. The present research work aims to understand the factors contributing to achieving a higher muzzle velocity for a projectile of a given mass with the coilgun, which can be used for the applications mentioned earlier. The presentation will focus on the author's design and developmental work on a four-stage induction coilgun-based EML at the Pulsed Power Laboratory of the Department of Electrical Engineering at the Indian Institute of Science, Bangalore, India.

The author has designed, developed, and fabricated a laboratory-scale prototype of a four-stage induction coilgun. The computer simulation analysis has been performed using MATLAB and finite element method (FEM)-based Ansys software. The author also presents experimental verification of the simulation results. Solenoid and sleeve-type projectiles of different shapes and dimensions have been fabricated to perform the analysis. A maximum of 40 m/s muzzle velocity with a 40 g projectile has been achieved using the experimental setup of the four-stage induction coilgun.

The author also designed and fabricated a high-speed infrared transmitter-receiver-based sensor (with 25 ns rise and fall time) to quickly sense the moving projectile (or armature) inside the barrel. The triggering instant of the subsequent stage coils of a multistage coilgun critically depends on the projectile's position inside the barrel. The projectile will fail to achieve the highest muzzle velocity if the subsequent stage coils are not optimally triggered in a sequence. The fast-moving projectile through the barrel necessitates the fast sensing of its position inside the barrel.

In addition, the author has also designed, developed, and fabricated a high-speed gate driver circuit with a peak 25 kV DC isolation for the signal circuit from the high voltage power circuit within a compact space of the printed circuit board (PCB) to trigger the high-voltage SCRs used for triggering the pulsed power source of each stage of the coilgun. Solid-state SCRs are necessary for a reliable and spontaneous triggering of the stage coils in a multistage coilgun. The high-speed triggering of the SCRs is simultaneously important with the high-speed sensor development for a successful operation of a multistage coilgun. An appropriate gate current with proper pulse shape and width is crucial for the fast triggering of an SCR. Also, transient overvoltage protection, overcurrent protection, dv/dt protection, di/dt protection, and gate protection of the SCR are essential since

the coilgun operates with a high magnitude impulse current and voltage. The gate driver circuit developed to trigger the SCR considers all these aspects.

The author used optical fiber links in the signal circuit to prevent electromagnetic interference (EMI) in the data transmission due to the large drive coil current. The author could successfully synchronize the stages of the coilgun by preventing the spurious triggering of SCRs using EMI-shielded gate-cathode leads. The large current flowing through each stage coil creates EMI problems in the coilgun. The EMI issues corrupt the sensor data, which prevents successful sensing of the projectile's position. Also, EMI causes the SCRs to trigger the coils spuriously, being indifferent to the projectile's optimal triggering position inside the coil. Synchronizing the triggering of stages by preventing the EMI issues is the most significant challenge and importance in successfully operating a multistage induction coilgun.

A 32-bit ARM core microcontroller board with an 84 MHz clock has been used to fast control the flow sequence of the sensor and gate driver circuits.

Student Presentation 8: Development of Pulsed Power Systems and Tooling Coils for Electromagnetic Manufacturing Applications

Deepak Kaushik

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Introduction: Electromagnetic forming (EMF) is a state-of-the-art and emerging non-conventional manufacturing technology. It is a pulse-forming process where the reshaping of the workpiece takes place extremely fast (within a few μs). A pulsed current is passed through a tooling coil, accelerating the workpiece to a very high velocity of 100-1000 m/s. Thus, high strain rates in the range of 103 to 104 s-1 are applied on the workpiece, which offers several advantages in terms of increased formability, reduced spring-back, etc. The interaction of the induced currents in the workpiece resulting from the passage of pulsed current in the tooling coil generates the necessary force on the workpiece. The tooling coil is the most vital tool in the EM forming assembly. The two approaches to improve the performance of the electromagnetic manufacturing process are: Design and develop high-performance tooling coils to increase the available pressure and improve the design of the pulse power circuit as per the process requirements. Improve the deformation effects in the workpiece by changing the material properties, such as reducing the flow stress by changing the temperature or employing hybrid manufacturing involving a combination of conventional and electromagnetic methods.

Applications of the present research work: Interest in lightweight materials in the automotive and aerospace sectors has driven the research toward electromagnetic forming. It is extensively used to obtain complex shapes, which are very difficult to obtain using traditional manufacturing processes. EM forming processes are used to carry out several manufacturing operations, such as forming, flanging, hemming, shearing, etc., of sheet metals and tubular workpieces. Atomic Energy establishments use electromagnetic manufacturing system for end cap sealing and welding of nuclear fuel rods. It is highly impractical to use conventional methods in such environments. Space research laboratories are also developing an electromagnetic manufacturing system for joining stainless steel to other materials for space applications.

Contributions by the author: Development of a fast and efficient simulation method for simulating

a coupled analysis of the Electromagnetic Manufacturing process: A multi-physics coupled study of transient electromagnetic, thermal, and mechanical fields is imperative to predict the dynamic deformation of the workpiece during the manufacturing process. A fast and efficient method for analyzing a coupled transient electromagnetic and mechanical problem using an analytical model that uses the lumped circuit equivalent of current-carrying filaments to compute the electromagnetic pressure distribution on the workpiece has been developed. We have compared the results obtained from our method with those obtained using FEM techniques and found them to be in good agreement with each other. The computational time elapsed for solving the electromagnetic problem for 500 µs with a step time of 5 µs using a 3D FEM model was 3 h 11 min without considering the velocity effects and 23 h 40 min considering the velocity effects, respectively. The proposed model took 1.90 s and 37.70 s for the former and latter cases, respectively.

Development of a clamp-on type uniform pressure actuator for magnetic pulse forming of tubular structures: The agile manufacturing of the workpieces requires them to be easily removed and replaced from the assembly. However, in most industrial applications, the finished assembly is such that removing the conventional helical actuator is impractical. The salient features of the designed actuator include pressure distribution free from end effects, where the pressure on the workpiece drops to 58% of the peak in the conventional helical actuator. It is also marginally less sensitive to standoff distance. The reduction in the peak is only 13% as compared to the conventional actuator, which shows a drastic drop of 56% as the standoff distance varies from 2 mm to 5 mm. The stress on the conventional helical actuator coil is repulsive. In contrast, the stress on the proposed actuator is compressive and reinforces it against the toroidal former making it comparatively robust to failure. The proposed actuator is openable and can be reused easily for repeated applications.

Development of a dual-channel uniform pressure actuator (UPA) for pulse forming of the sheet metal: The salient features of the designed dual-channel actuator are as follows. The designed tooling coil draws 6.2% more current and applies 24.9% more force than the conventional UPTC for the same pulsed power source parameters. The spatial distribution of the pressure is identical in both the tooling coils, but the magnitude of the pressure in the proposed dual-channel tooling coil is about 23% higher. In addition, the proposed tooling coil also has better capabilities for handling the electromagnetic stress on it during the forming process. The free-forming experiment conducted validates that the proposed dual-channel tooling coil has a significant increase in workpiece deformation. It has increased 25% each for 1 kV and 1.25 kV initial charging voltage of the capacitor bank, 33.3% for 1.5 kV initial charging voltage, and 28.5% for the initial charging voltage of 2 kV, with the other parameters of the pulsed power system being identical.

Development of a single universal uniform pressure actuator for attractive and repulsive forming of sheet metals: Attractive forming of sheet metals is a challenging class of manufacturing techniques, where the inner surfaces of the workpiece are not readily accessible for applications such as electromagnetic dent repairing etc. The pulsed power circuit and the tooling coil designs are very complex to generate an attractive force on the non-ferrous workpiece. The tooling coil and the pulsed power circuit requirement change as per the desired operation to be carried out on the workpiece. We have designed a single universal type uniform pressure tooling coil that can be easily used for both attractive and repulsive forming of sheet metal without changing the topology of the pulse power circuit used. The result has been experimentally validated for both attractive and repulsive modes of operation.

Design of pulse forming systems for electromagnetic manufacturing applications: The work focuses on the specific inverse problem of source design from the output objective temporal force waveform required for final mechanical deformation in the workpiece. The tooling coil

and workpiece system have been analytically modeled. An optimization technique to solve the inverse problem for finding the required control has been devised with an accuracy well within 0.5% for the proposed model target waveform. A pulsed power circuit topology has been proposed to achieve the required control current through the tooling coil. A curve-fitting technique based on unconstrained optimization has been proposed to obtain the parameters of the circuit. The set of optimal parameters for the designed pulsed power circuit, i.e., the system capacitance (C), initial capacitor voltage Vco to control the peak magnitude of the force, and the crowbar path resistance Rd have been calculated with an accuracy well within 8%. The experimentally obtained deformation is 33 mm for the designed pulsed power system with a capacitance of 540 μF, and 23 mm for the designed pulsed power system with a capacitance of 270 μF. The simulated deformations are 35.5 mm, and 25.5 mm, respectively, which validates the design technique.

Influence of preheating of the workpiece on the performance of the pulsed electromagnetic forming process: The temperature of the workpiece affects the electromagnetic and mechanical behavior of the workpiece. Aluminum is one of the workpiece materials used in the pulsed electromagnetic forming process. It is well known that aluminum has better formability at elevated temperatures. Hence high temperature-forming methods have been used extensively to manufacture different components for various industrial applications. However, at elevated temperatures, the resistance of the workpiece increases and thus affects the induced currents in the workpiece. This leads to a change in the temporal profile of the force on the workpiece, and hence the temperature becomes a critical process parameter to be studied. The work explores the effect of temperature on forming behavior of bulging tubular workpieces.

Student Presentation 9: Parareal-in-Time Implementation for Power System Dynamic Simulations

Francis C Joseph

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Power system dynamic simulations are one of the tools to ascertain the grid's stability. These simulations involve the solution of differential-algebraic equations (DAE). The solutions of such DAE are computationally intensive when large grids are to be studied; hence, a parallel solution is essential. The Parareal-in-time algorithm belongs to a class of temporal decomposition methods for the parallel solution of differential equations. This talk considers the Parareal method for dynamic simulation of large power systems with MPI-based parallelization. Conventional parareal performance depends on the choice of time coarsening employed, the quality of initial value generated while coarsening and overall accuracy. Hence much dependence on user experience to choose input parameters. Therefore, a novel semi-analytic adaptive method is formulated to provide dynamic time coarsening while maintaining an acceptable initial value concerning the accuracy required. Thereby, the parareal implementation depends on only one user input: accuracy. Two types of communication schemes, master Worker and distributed, are implemented for parareal to solve the DAEs using a partitioned approach. A space-parallel shared memory-based algorithm is also proposed to reduce the matrix and vector operations time needed for the DAE solution. The proposed methods are tested on large systems using full-order generator models with saturation effects and composite load models.

3.1.16 Session 4D: Computer Systems, Networking and IoT

Session Chair: T V Prabhakar, Sumit Kumar Mandal
Cluster Coordinator: Sathish Vadhiyar, T V Prabhakar
Student Organizer: Sai Teja, Sudarshan
Faculty Organizer: Vaanathi Sundaresan
Location: ECE MP-30

Cluster Overview

Time	Event	Speaker	Affiliation
02:30 – 03:00 PM	Invited Talk 1	Samar Agnihotri	IIT Mandi
03:00 – 03:20 PM	Invited Talk 2	Praveen Jayachandran	IBM India
03:20 – 03:34 PM	Student Presentations	Shrutkirthi S. Godkhindi	ESE, IISc
03:35 – 03:48 PM		Krishna Chaitanya	ECE, IISc
03:48 – 04:02 PM		Anu Krishna V	ESE, IISc
04:02 – 04:16 PM		Ashwin Prasad	CSA, IISc
04:16 – 04:30 PM		Archita Ghosh	CDS, IISc
04:30 – 04:44 PM		Shweta Pandey	CSA, IISc
04:44 – 04:58 PM		Alvin George	CSA, IISc
04:58 – 05:12 PM		Ajay Kumar Sandula	CPS, IISc
05:12 – 05:26 PM		Mukund Mitra,	CPS, IISc

Invited Talk 1: Capacity characterization of wireless relay networks

Speaker: Samar Agnihotri, IIT Mandi
Personal Webpage

Abstract

The information-theoretic capacity of general relay networks has been an open problem for more than the last fifty years. Numerous achievability schemes have been proposed. However, none of these schemes consistently provides tight characterization of the capacity or outperforms all other schemes in all scenarios. Further, the computational complexity of most of such schemes render their end-to-end performance characterization intractable. Toward our pursuit of constructing low-complexity schemes to tightly characterize the capacity of general relay networks, we analyze the performance of one of the simplest relaying schemes: amplify-and-forward in Gaussian relay networks. In this talk, we discuss some of the major results and insights that we obtained from this work and which we hope to be useful for addressing the general problem.

Bio

Samar Agnihotri is a faculty member in the School of Computing and Electrical Engineering at IIT Mandi. He holds M.Sc (Engg.) and Ph.D. degrees in Electrical Sciences from IISc. His research interests are in the areas of information theory and communications.

Invited Talk 2: The Journey to Multi-cloud Networking

Speaker: Praveen Jayachandran
Personal Webpage

Abstract

Multi-cloud Networking is crucial for modern enterprises in today's hyper-connected era where applications, data, and devices are globally distributed among multiple cloud providers, private data centers, mobile locations, and edge environments.

Decades ago, Internet Protocol allowed world-wide connectivity and completely changed the world. In the past fifteen years a wide set of private networking technologies have emerged including public cloud SDNs for VPC services, SDN overlays for data centers, and SD-WANs for interconnecting remote locations. These technologies were created to provide the required modern networking capabilities while overcoming the shortcomings of the original Internet protocol design. As a result, the current networking world is a collection of different non-compatible and non-interoperable public and private networking technologies.

This situation creates a big obstacle for developing a scalable and secure networking solution for evolving multi-cloud enterprise application deployment. Kubernetes and application-centric networking technologies that emerged in the cloud era, have only added more complexity and challenges. This talk will present a vision for multi-cloud networking, covering its requirements, presenting current networking solutions, their gaps and challenges.

Bio

Praveen Jayachandran is a senior technical staff member and senior manager of the Hybrid Cloud operations department at IBM Research, India. His work spans network management, observability, and managing systems and data at scale, specifically for multi-cloud, 5G and Edge environments. He is an IBM Master Inventor, a member of the IBM Academy of Technology, and a senior member of IEEE. He holds a PhD from the University of Illinois at Urbana-Champaign, USA.

Student Presentation 1: UUTS: Towards a unified reliable IoT Network

Shrutkirthi S. Godkhindi

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

Core idea is to enable UUTS (Underwater-Underground-Terrestrial-Satellite) communication technologies to provide a seamless support to applications that might require realtime performance. The first step in this direction is to explore the performance of RF underwater. We selected LoRa as a candidate due to

its strength in Chirp Spread Spectrum CSS modulation scheme and conduct extensive measurements to characterize the link. Our measurement results in an open well show that reflections from the wall provide approximately 8dBm improvement in the received signal strength and consequently, the communication range is extended by 0.5mts. Furthermore, we explored the possibility to receive LoRa satellite signal by placing a receiver underwater in a plastic tank. We report an SNR of -18dB approximately. Our other measurements address the impact of water quality on received signal strength. For instance, when water salinity was increased from 135ppm to 7600ppm the signal strength decreased by approximately 10dBm. Our underground to terrestrial link exhibited a received signal strength of approximately -92dBm when the receiver was placed 3m below the ground surface.

Student Presentation 2: Sequential Detection Techniques for Early Detection of Rolling Element Bearing Faults

Krishna Chaythanya KV

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Condition monitoring of industrial machinery is an important application domain for cyber physical systems (CPS), and the early detection of rolling-element bearing faults is an essential part of such a CPS. Existing techniques for the detection of defects in bearings typically utilize only a fixed window of samples, which does not make effective use of accumulated evidence over time, and hence, such techniques have a long detection delay for a given false alarm rate. We study sequential algorithms, which can provide low detection delay for the same false alarm rate. Typical defects in a rolling-element bearing induce a cyclostationary vibration signal, and hence, there are correlations in the frequency domain. This property yields a statistic with a parametric distribution, which can be used to pose a non-Bayesian parametric quickest change detection problem, from a known pre-change distribution to an unknown post-change distribution whose parameters belong to a known set. We then utilize a computationally efficient generalized CUSUM algorithm, derived from the Generalized Likelihood Ratio principle, and provide analytical bounds on the probability of false alarm and the expected detection delay for a general class of probability distributions.

We evaluate the performance of the generalized CUSUM algorithm, first using a synthetic dataset and then using a publicly available bearing vibration dataset. We then compare the performance of our proposed algorithm with the performance of algorithms commonly proposed and studied in the literature, on these two datasets. We find that our sequential algorithm, based on spectral correlations induced by post-defect cyclostationarity, can detect small changes, with SNR as low as -30dB, with a reasonable delay to detection, while ensuring a low false alarm rate, and being computationally simple to implement.

Student Presentation 3: Caching Dynamic Contents via Mortal Restless Bandits.

Anu Krishna V.

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract
We study content caching in a network consisting of a server and a base station with a finite capacity cache. Contents are dynamic. They stochastically arrive in the system, stay for random times, and their popularities also randomly vary while they are alive. Fetching contents from the server and storing them in the base station cache incurs a cost. But not having the requested contents at the base station also incurs a cost that reflects QoS deficiency. We study optimal proactive caching aiming at minimizing the time-average content miss and caching costs. We formulate this problem as an average cost Markov decision problem that is a restless multi-armed bandit problem. We argue that the problem is indexable and explicitly derive the Whittle indices. Finally, we demonstrate the efficacy of the Whittle index policy via numerical evaluation

Student Presentation 4: TREEBEARD: An Optimizing Compiler for Decision Tree Based ML Inference

Ashwin Prasad

Department of Computer Science and Automation,
Indian Institute of Science

Abstract
Decision tree ensembles are among the most commonly used machine learning models. These models are used in a wide range of applications and are deployed at scale. Decision tree ensemble inference is usually performed with libraries such as XGBoost, LightGBM, and Sklearn. These libraries incorporate a fixed set of optimizations for the hardware targets they support. However, maintaining these optimizations is prohibitively expensive with the evolution of hardware. Further, they do not specialize the inference code to the model being used, leaving significant performance on the table. This talk will describe TREEBEARD, an optimizing compiler that progressively lowers the inference computation to optimized CPU code through multiple intermediate abstractions. By applying model-specific optimizations at the higher levels, tree walk optimizations at the middle level, and machine-specific optimizations lower down, TREEBEARD can specialize inference code for each model on each supported CPU target. TREEBEARD combines several novel optimizations at various abstraction levels to mitigate architectural bottlenecks and enable SIMD vectorization of tree walks. We implemented TREEBEARD using the MLIR compiler infrastructure and evaluated it on a diverse set of benchmarks. TREEBEARD is significantly faster than state-of-the-art systems, XGBoost, Treelite and Hummingbird, by 2.6x, 4.7x and 5.4x respectively in a single-core execution setting, and by 2.3x, 2.7x and 14x respectively in multi-core settings.

Student Presentation 5: Understanding Resiliency of Cloud Storage Services

Archita Ghosh

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

A cloud storage system requires multiple functional and management layers to render a global-scale storage solution. Providing a reliable service through this complex architecture becomes a challenging task. Moreover, the mere complexity of the system makes it difficult to identify the critical components for maintaining a reliable service. While data redundancy has been the predominant factor in improving reliability, it is crucial to understand if that is sufficient for the reliability of a cloud storage service. This work proposes a resiliency evaluation method that identifies the components necessary for storage service rendition and the ability of the system to absorb the effect of their failures. Using this method, the resiliency of two distinct cloud storage services, OpenStack Swift and CephFS, are evaluated. The evaluation has revealed that data access requests may get delayed (up to 8x of mean response time) and even fail due to the lack of resiliency for access path components, even when there is enough user data redundancy. The lack of effort is evident while maintaining the consistency of critical internal data components resulting in reduced reliability. Even for stored data, some common failures result in loss of recoverability. The work then identifies the actions a system can take to make the service resilient. These techniques are incorporated into the system model to show how they can improve the storage system's resiliency.

3.1.17 High Tea break

Student Presentation 6: GPM: Leveraging Persistent Memory from a GPU

Shweta Pandey

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

The GPU is a key computing platform for many application domains. While the new non-volatile memory technology has brought the promise of byte-addressable persistence (a.k.a., persistent memory, or PM) to CPU applications, the same, unfortunately, is beyond the reach of GPU programs. We take three key steps toward enabling GPU programs to access PM directly. First, enable direct access to PM from within a GPU kernel without modifying the hardware. Next, we demonstrate three classes of GPU-accelerated applications that benefit from the PM. In the process, we create a workload suite with nine such applications. We then create a GPU library, written in CUDA, to support logging, checkpointing, and primitives for native persistence for programmers to leverage PM easily. This work was published in ASPLOS'22.

Student Presentation 7: Verifying Temporal Properties of Control Systems using Abstraction Refinement

Alvin A George

Department of Cyber Physical Systems,
Indian Institute of Science

Abstract

A Control System with a PID controller is an infinite state system. Given a temporal specification, our goal is to check whether the system satisfies the property. At a high level, our approach to solving the verification problem starts by constructing a finite state abstraction using predicate abstraction technique and then using the counter-example guided abstraction refinement (CEGAR) technique to verify the abstract system against the LTL property. Checking the feasibility of the counter-examples returned is a key step in this procedure. Current methods are either incomplete (Recurrent point method), or imprecise (Post image method) in checking feasibility. We propose a new algorithm to check this.

Student Presentation 8: A multi-armed bandit approach for demand aware multi-robot task scheduling

Ajay Kumar Sandula

Department of Cyber Physical Systems,
Indian Institute of Science

Abstract

This talk address the problem of multi-robot task scheduling by estimating the demand for the tasks. When multiple robots work together to complete a task, scheduling becomes more complicated, especially when resources are limited. Real-world tasks are generated based on demand, and it's important to prioritize tasks based on estimated demand. We propose a stochastic multi-agent multi-armed bandit based task scheduler which prioritizes the tasks based on the estimated demand for the tasks. The tasks are prioritized based on the priority order received from the multi-armed bandit solvers. We used the thompson sampling bandit algorithm with a combination of -greedy approach to solve the multi-agent multi-armed bandit problem, where agents collaborate among themselves to estimate the demand from the environment. Compared to other approaches such as FCFS(first-come-first- serve), rate monotonic scheduling, and heuristic-based Min- interference approaches, our proposed approach performed better in terms of the "demand aware performance index.

Student Presentation 9: Investigating Sampling-based Inverse Reinforcement Learning for Robot Navigation and 3D Target Prediction in Extended Reality

Mukund Mitra

Department of Cyber Physical Systems,
Indian Institute of Science

Abstract
To increase the performance of HRI/HCI systems, it is important to make the system learn from human demonstrations. Inverse reinforcement learning learns reward function from demonstrations which can be generalised to an unseen environment. In IRL algorithms, it is challenging to calculate the intractable partition function. In this work we present a sampling-based maximum entropy inverse reinforcement algorithm (SMEIRL) to efficiently estimate the partition function. We implemented and analysed the performance of the proposed algorithm for 2D mobile robot navigation and 3D target prediction in Virtual and Mixed Reality.

3.1.18 Best Presentation Award Ceremony

Location: ECE Lunch Hut

4. List of Session Speakers

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14th EECS Research Students Symposium 2023

We are excited to inform you about the 14th EECS Research Students Symposium, Indian Institute of Science (IISc), Bengaluru, to be held on the 3rd and 4th of April, 2023. The EECS division focuses on Electrical, Electronics, and Computer Sciences research. It will include participation from the departments of Electrical Communication Engineering (ECE), Electrical Engineering (EE), Electronic Systems Engineering (DESE), Computer Science and Automation (CSA), Computational and Data Sciences (CDS), and the Robert Bosch Centre for Cyber-Physical Systems (RBCCPS). This annual event has served as an excellent forum for interaction among IISc's graduate students and leaders from industry and academia.

An in-person event!

Event programme

- **Plenary talks by eminent industry leaders in topical areas**
- **Faculty talks**
- **Research talks by senior graduate students**

Research clusters

- **Artificial Intelligence and Machine Learning**
- **Brain, Computation, and Data Sciences**
- **Computer Systems**
- **Cyber Physical Systems**
- **Microelectronics, RF, and Photonics**
- **Networking and IoT**
- **Power Engineering**
- **Security and Privacy**
- **Signal Processing and Communications**
- **Theoretical Computer Science**
- **Visual Analytics**

We invite you to attend the event