EECS Symposium-2022

April 8-9, 2022
Indian Institute of Science,
Bengaluru

Book of Abstracts

This was written on April 8-9, 2022
Indian Institute of Science, Bengaluru .

Preface

The EECS Research Students Symposium - 2022 is the thirteenth in the series of annual research students symposia initiated in 2010. The symposium is organised 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. *Robert Bosch Centre for Cyber-Physical Systems (RBCCPS)*

For the EECS 2022 symposium, a team of six faculty members coordinated by Rahul Saladi (CSA) and consisting of Chirag Jain (CDS), Prathosh A. P. (ECE), Vishnu Mahadeva Iyer (EE), Arup Polley (ESE), and Pushpak Jagtap (RBCCPS), ably assisted by an energetic team of student and staff volunteers, has put in a spectacular effort to organise the event. The primary purpose of this event is to showcase the work of senior research students who are on the threshold of wrapping up their work. These students will present their work as a part of 11 research cluster sessions: Artificial Intelligence and Machine Learning (2 sessions); Brain, Computation and Data Sciences; Cyber-Physical Systems; Microelectronics; Networking and IoT; Power; Security; 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 very lucky 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 – Tanveer F. Syeda-Mahmood (IBM Fellow and Chief Scientist, IBM Almaden Research Center); Krishnaswamy, T. (Director of Engineering at Qualcomm); and K. Ananth Krishnan (Executive Vice President and CTO, TCS). 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 Konduri Aditya [CDS]; Gugan Thoppe [CSA]; Utsav Banerjee [ESE]; and Punit Rathore [RBCCPS].

The organising 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 that 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), TCS Research (Platinum), OPPO (Platinum), Google (Gold), and the Cisco-IISc Centre for Networked Intelligence (Silver)*** *for their generous sponsorship for this event (as on 04 April 2022). Their support is very much appreciated.*

On the last two occasions, the symposia were held online due to COVID-19 constraints. This year's

symposium is in-person. While we are eager to get back on the track to normalcy, 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

Arup Polley	ESE	aruppolley@iisc.ac.in	Book of abstracts, Travel Arrangements, Cluster- SPCOM, Microelectronics
Chirag Jain	CDS	chirag@iisc.ac.in	Publicity, Faculty Talks, Cluster- Visual Analytics, Brain Computation and Data Sciences
Prathosh A P	ECE	prathosh@iisc.ac.in	Food and Snacks Arrangement, Rooms Arrangement, Cluster- AI/ML
Pushpak Jagtap	RBCCPS	pushpak@iisc.ac.in	Cluster- Cyber-Physical Systems
Rahul Saladi	CSA	saladi@iisc.ac.in	Overall Co-ordinator, Plenary Talks, Cluster- Theoretical Computer Science, Security, Networking and IoT
Vishnu Mahadeva Iyer	EE	vishnumi@iisc.ac.in	Food and Snacks Arrangement, Rooms Arrangement, Cluster- Power

1.2 Student Organisers

Abhigyan Dutta	EE	abhigyand@iisc.ac.in	Cluster- AI/ML
Akash Rodhiya	CDS	akashrodhiya@iisc.ac.in	Book of Abstracts, Cluster- AI/ML, Security, Brain Computation and Data Sciences
Anup Kumar	DESE	anupkumar@iisc.ac.in	Cluster- Theoretical Computer Science
Atasi Panda	CSA	atasipanda@iisc.ac.in	Cluster- AI/ML, Security, Brain Computation and Data Sciences
Debangshu Banerjee	ECE	bdebangshu@iisc.ac.in	Cluster- AI/ML
Dharani Moka	EE	dharanimoka@iisc.ac.in	Book of Abstracts, Cluster- AI/ML, Power
Ganesh Kumar Shaw	DESE	ganeshshaw@iisc.ac.in	Plenary Talks (Satish Dhawan Auditorium)
Janaky Murthy	ECE	janakymurthy@iisc.ac.in	Checking condition of projectors
Krishna Chaythanya KV	ECE	krishnackv@iisc.ac.in	Plenary Talks (Satish Dhawan Auditorium), TCS Research Cafe
Lokesh Bansal	RBCCPS	lokeshbansal@iisc.ac.in	Cluster- SPCOM, Visual Analytics, Microelectronics
Manan Tayal	RBCCPS	manantayal@iisc.ac.in	Website, Cluster- AI/ML, Security, Brain Computation and Data Sciences
Koteswar Doddi	ESE	kotesward@iisc.ac.in	Plenary Talks (Satish Dhawan Auditorium)
Rishikesh Gajjala	CSA	rishikeshg@iisc.ac.in	Website, Cluster- SPCOM, Visual Analytics, Microelectronics
Sameer Khadatkar	CDS	sameerraju@iisc.ac.in	Book of Abstracts, T-shirt, Cluster- Cyber-Physical Systems, Networking and IoT
Sankalp Nakhate	ESE	sankalpn@iisc.ac.in	Cluster- Cyber-Physical Systems, Networking and IoT
Saurabh Mahalpure	ESE	saurabhsm@iisc.ac.in	Cluster- Theoretical Computer Science
Shreeparna Dey	CDS	shreeparnad@iisc.ac.in	Poster, Cluster- SPCOM, Visual Analytics, Microelectronics
Utkarsh Joshi	CSA	utkarshjoshi@iisc.ac.in	Goodies, Cluster- AI/ML, Power
Venky Kudaravalli	EE	venkyk@iisc.ac.in	Flyers and Stand banners
Vishal Kushwaha	RBCCPS	vishalk@iisc.ac.in	Plenary Talks (Satish Dhawan Auditorium)
Vishwabandhu Uttam	EE	vishwabandhu@iisc.ac.in	Book of Abstracts, Sponsor's Co-ordinator

1.3 Staff Organisers

Aravind S	CSA	aravindsr@iisc.ac.in	Accommodation and Travel arrangement for Guests
Lavanya A B	RBCCPS	lavanyaa@iisc.ac.in	Staff volunteer support
Rahul Ade	CDS	rahulade786@gmail.com	Arrangement for Refreshments and Management
Srinivasamurthy R	ECE	rsrini@iisc.ac.in	Accommodation, Refreshments, Transport, Department Administrative Assistance
Vaibhav Shinde	DESE	vaibhavsh@iisc.ac.in	Arrangement for Refreshments and Management

1.4 Program at a Glance

EECS, IISc RESEARCH STUDENTS SYMPOSIUM - 2022
AT A GLANCE

Day 1: April 8th (Friday)

Session 1: Plenary talks 09:30-13:00					Lunch Break 13:00-14:30	Session 2: Research cluster talks 14:30-17:30	High Tea Break 17:30-18:00	Session 3: Faculty Talks 18:00-19:30
09:30-10:20 Krishnaswamy T.	Coffee Break	10:50-11:40 Tanveer F. Syeda -Mahmood	Coffee Break	12:10-13:00 Ananth K. Krishnan		Session 2A: Cluster Session Signal Processing and Communication Session 2B: Cluster Session Artificial Intelligence / Machine Learning TCS Research Cafe 15:45 onwards		Konduri Aditya (CDS Gugan Thoppe (CSA) Utsav Banerjee (ESE) Punit Rathore (RBCCPS)

Day 2: April 9th (Saturday)

Session 4: Research cluster talks 10:00-13:00	Lunch Break 13:00-14:30	Session 5: Research cluster talks 14:30-17:00
Session 4A: Cluster Session Theoretical Computer Science		Session 5A: Cluster Session Brain Computation and Data Sciences
Session 4B: Cluster Session Cyber-Physical Systems		Session 5B: Cluster Session Microelectronics
Session 4C: Cluster Session Security		Session 5C: Cluster Session Power
Session 4D: Cluster Session Artificial Intelligence / Machine Learning		Session 5D: Cluster Session Networking and IoT
Session 4E: Cluster Session Visual Analytics		

2. Day 1: 8^{th} April 2022(Friday)

2.1 Inauguration

Speaker: Prof. Rajesh Sundaresan, ECE, IISc

2.2 Session 1 | Plenary Talks

Chair: K V S Hari, Arup Polley, Rajesh Sundaresan
Student Organizer: Krishna, Koteswar, Ganesh, Vishal
Faculty Organizer: Rahul Saladi, CSA
Location: Satish Dhawan Auditorium

2.2.1 Transceiver Design for Cellular: Challenges and Directions

Speaker: Krishnaswamy T, Director, Engineering at Qualcomm

Abstract The talk will cover on the key design challenges facing Transceiver design for Cellular Standards (2G-5G NR). Starting with a short recap of the Cellular Spectrum and Standards and the unique design challenges it imposes on the Transceiver. Finally we delve into some key blocks and problem statements that the audience can mull over for future research.

Bio
Passed out of IIT KGP in 2003 with a President's Silver Medal. Worked with Texas Instruments from 2003-14. While at TI worked on transceivers in sub-micron CMOS processes for GPS, BT and WLAN and on fast switching Fractional-N RF PLL's for PMR Systems . Led the development of a 30dBm Integrated WiFi PA on 45nm CMOS while at TI. From 2014' to present day working at Qualcomm on designing

Multi-Mode, Multi-Band Transceivers primarily for Celullar Standards (2G-5G) as well as IoT radios. Research Interests include digitally assisted RF chains and fast settling low spurious emission RF PLL's. Presently leading a team of 35 RFIC design engineers working on Cellular/IoT radios and discrete RFIC to achieve sub-1dB Noise Figure for Sub-6GHz Cellular bands. Holds 19 patents and 3 IEEE publications (2 at ISSCC and 1 ISCAS).

2.2.2 Coffee break

2.2.3 Medical Sieve Grand Challenge : A Turing Test for Chest Radiology AI

Speaker: Tanveer Syeda-Mahmood, IBM Fellow, IBM Almaden Research Center

Abstract

Chest radiographs are the most common imaging exams in hospitals and clinics, comprising 60% of x-rays in the US. They are also one of the hardest to interpret due to their low resolution in reflecting 2D projections of 3D volumes, and cognitive biases leading to interpretation errors. AI assistance with automated preliminary reads can expedite clinical workflows, reduce bias and increase diagnostic throughput of radiologists. Following the success of Watson Jeopardy, the Medical Sieve Team at IBM Research took on the grand challenge of passing the Turing test in chest radiology by producing an automated preliminary read report using AI to interpret chest Xray imaging in a manner that is virtually indistinguishable from those of radiology residents. In this talk, I will describe the large multi-disciplinary grand challenge data science effort that led to this achievement after overcoming many scientific, technological, and medical knowledge challenges and requiring extensive evaluations through multi-institutional data clinical studies.

Bio

Dr. Tanveer Syeda-Mahmood is an IBM Fellow and was the Chief Scientist/overall lead for the Medical Sieve Radiology Grand Challenge project in IBM Research. As the global research leader in imaging, she conducts research in biomedical imaging, computer vision, pattern recognition and machine learning. Her group's research has successfully turned into first commercial AI products from Watson Health Imaging.

Dr. Tanveer Syeda-Mahmood graduated with a Ph.D from the MIT Artificial Intelligence Lab in 1993. Prior to coming to IBM, Dr. Syeda-Mahmood led the image indexing program at Xerox Research and was one of the early originators of the field of content-based image and video retrieval. Over the past 30 years, her research interests have been in a variety of areas relating to artificial intelligence ranging from computer vision, image and video databases, to recent applications in medical image analysis, healthcare informatics and clinical decision support. She has over 250 refereed publications and nearly 140 filed patents. Dr. Syeda-Mahmood has chaired/is chairing many conferences including CVPR 2008, ISBI2022 (Program Chair), and HISB2011, MICCAI 2023 (General Chair). Dr. Syeda-Mahmood is a Fellow of IEEE and a Fellow of AIMBE. She is the recipient of key innovation awards in IBM including Master Inventor, Best of IBM Award 2015, 2016 and several outstanding innovation awards. In 2016, she received the highest technical honor at IBM and was awarded the

title of IBM Fellow.

2.2.4 Coffee break

2.2.5 Science & Technology for Today & Tomorrow

Speaker: Ananth Krishnan, CTO, Tata Consultancy Services

Abstract Ananth directs research and innovation for the organization. He will discuss science and technology for today tomorrow, supplementing his views with a few live examples. He will also share opportunities for students and researchers and how one can be prepared in an ever-evolving landscape.

Bio Ananth directs Research and Innovation in TCS, India's largest IT Company. Under his leadership, TCS has created a significant portfolio of patents, papers and IP. Ananth has served on several Governing Councils of Academia, Industry Advisory boards, and Government committees. He has been a regular invitee to the Board of TCS since 1999.
He was elected a Fellow of INAE in 2013. He was named a Distinguished Alumnus of IIT Delhi in 2009. He has been listed in Computerworld's Premier 100 IT Leaders (2007), and in Infoworld's Top 25 CTOs (2007). Ananth is an M. Tech. in Computer Science and an M. Sc in Physics from the Indian Institute of Technology, Delhi.

2.2.6 Lunch Break

Location: Main Guest House

2.2.7 TCS Research Cafe

Location: ECE 1.05 (3:45 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 3:45 pm onwards. Interested students can make themselves available at this time.

2.3 Session 2 | Research Cluster Talks

Location: ECE Building

2.3.1 Cluster: Signal Processing and Communication

Cluster Coordinator: Sundeep Prabhakar Chepuri, ECE
Student Organizer: Shreeparna, Lokesh, Rishikesh
Faculty Organizer: Arup Polley, ESE
Location: ECE MP-20

Cluster Overview

Time	Event	Speaker	Affiliation
14:30 - 15:00pm	Keynote 1	A Anil Kumar	TCS research
15:00 - 15:20pm	Student Presentations	Chirag Ramesh	RBCCPS, IISc
15:20 - 15:40pm		Siddhant Rahul Doshi	ECE,IISc
15:40 - 16:10pm	Keynote 2	Kaushic Kalyanaraman	Shell plc
16:10 - 16:40pm	Keynote 3	Ganesan Thiagaraja	MMRFIC
16:40 - 17:00pm	Student Presentation	Samaresh Bera	ECE, IISc
17:00 - 17:20pm		Saurav Roy	ECE, IISc
17:20 - 17:40pm		Aritra Roy	ECE, IISc

Keynote 1: Gesture and air-writing recognition with high resolution SONAR.

Speaker: A Anil Kumar, TCS Research
https://www.linkedin.com/in/a-anil-kumar-69b4a597/

Abstract
Human computer interaction based on gestures forms an important and popular approach among the various other modalities. While camera-based gesture recognition is widely used, privacy restrictions and other limitations such as dependence on lighting prohibit its usage in several applications. Lately, the SONAR-based approach is gaining a lot of attention as microphones and speakers are ubiquitous. In this talk, we will describe our recent works on gesture and air writing recognition based on SONAR. Further, our economical spiked neural network-based classifier implementation shall also be briefly provided.

Bio
A. Anil Kumar received his Ph.D. degree in electrical and electronic engineering from Nanyang Technological University, Singapore in 2011. Presently, he is a Senior Scientist with TCS Research & Innovation, Bangalore, India; Prior to TCS, he was with Accord software and systems Pvt. Ltd, Bangalore, India during 2002 - 2005, Panasonic Singapore laboratories pvt. Ltd, Singapore during 2010 - 2011 and with Temasek

LaboratoriesNanyang Technological University, Singapore during 2011 - 2015.

His research interests lie in the broad areas of signal processing, communications and machine learning.

Student Presentation 1: Random Access Schemes for Massive Machine-Type Communications

Chirag Ramesh and Chandra R. Murthy

Department of Robert Bosch Centre for Cyber-Physical Systems,
Indian Institute of Science

Abstract

Massive machine-type communications (mMTC) is a 5G and beyond application expected to serve millions of internet-of-things devices within a small region. These devices transmit short packets and are sporadically active. We need to use grant-free random access (RA) protocols to serve such devices. In this work, we look at the coded slotted aloha (CSA) family of RA protocols in which users transmit several encoded replicas of their packets across different resource elements in a frame. We first leverage sparse signal recovery techniques to propose a user activity detection (UAD) algorithm to detect the subset of active users in a frame in CSA. We then perform data decoding and analyse the impact of UAD errors, i.e., false alarms and missed detections, on the performance of the system. This analysis accounts for practical non-idealities such as UAD errors, channel estimation errors, and pilot contamination. Finally, we provide several insights into the performance of RA for mMTC: Which UAD error is more harmful? What limits the performance of the system? How do we overcome these limits?

Student Presentation 2: Graph Neural Networks with Parallel Neighborhood Aggregations

Siddhant Rahul Doshi

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Graph neural networks (GNNs) have become very popular for processing and analyzing graph-structured data in the last few years. GNN architectures learn low-dimensional graph-level or node-level embeddings useful for several downstream machine learning tasks by using message passing as their basic building block that aggregates information from neighborhoods. Existing GNN architectures can be categorized based on how they perform this aggregation task: 1) GNNs that learn the node embeddings by iteratively combining information from its neighborhood by cascading several GNN blocks. We refer to such GNN architectures with sequential aggregation as SA-GNNs and 2) GNN architectures that precompute the node features from different neighborhood depths using a bank of neighborhood aggregation graph operators simultaneously. We refer to such GNN architectures with parallel aggregation as PA-GNNs. Due to the precomputations, PA-GNNs have a natural advantage of reduced training and inference time.

We provide theoretical conditions under which a generic PA-GNN model is provably as powerful as the popular Weisfeiler-Lehman (WL) graph isomorphism test in discriminating non-isomorphic

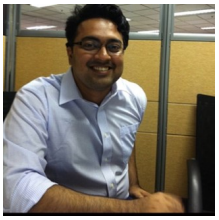
graphs. Although PA-GNNs do not have an apparent relationship with the WL test, we show that the graph embeddings obtained from these two methods are injectively related. We then propose a specialized PA-GNN model, which obeys the developed conditions. We demonstrate via numerical experiments on several graph classification benchmark datasets that the developed model achieves state-of-the-art performance on many diverse real-world datasets while maintaining the discriminative power of the WL test and the computational advantage of preprocessing graphs before the training process.

Keynote 2: AI for sustainability

Speaker: Kaushic Kalyanaraman, Shell plc
https://www.linkedin.com/in/kaushic-k-44677a1/

Abstract

Energy transition in one of the most complex endeavours to be undertaken by humankind. In a span of few decades we have to completely rewire our current industrial system and dramatically alter societal behaviour to achieve COP21 targets. At Shell R&D we are currently working on several ideas in Nature based solutions, Renewable energy and Energy economics in order to advance our abilities in understanding sustainability and developing innovative solutions to accelerate energy transition at a Macro and Microscale. In this talk, Ill briefly highlight some of our research in Sustainability involving Graph ML, Physics informed neural networks and Representational Learning.



Bio

Kaushic Kalyanaraman has over 15 years of experience in Energy industry in domains spanning from LNG, Upstream to Renewable energy in Engineering, Commercial and Technology Development. He currently leads Shell's Machine Learning R&D team with a focus on advancing PiNN, Multimodal ML and Graph ML.

Keynote 3: An Introduction to Reflecting Intelligent Surfaces for 5G and Beyond

Speaker: Ganesan Thiagarajan, MMRFIC Technology Pvt. Ltd
https://www.linkedin.com/in/tganesan/

Abstract

The milli-meter wave carriers used in 5G are typically used as direct line of sight (LOS) medium due to the high pathloss at those frequencies. This also reduces the richness in their corresponding multi- path channels. This not only restricts the availability of high data rate to users who are not in LOS path, but also reduces the effectiveness of spatial multiplexing. However, if the multi-paths in the propagation channel between the gNB and UE can be controlled to have higher processing gain (such as passive focusing gain) or create richness in the multi-path, additional performance gains can be obtained. This talk gives an intuitive understanding on RIS and some of the challenges in implementing them in a heterogenous network with regular gNBs and controllable reflecting surfaces such as RIS.

Bio

Dr. Ganesan Thiagarajan is currently CTO of MMRFIC Technology Pvt. Ltd, Bangalore. With more than 25 years of experience in telecom/semiconductor devices industry, he had delivered multiple products in WLAN, cellular infrastructure and mm-wave Radar systems. He assumed various roles at Motorola, Texas Instruments and Arraycomm Inc., including system architect, Algorithm lead and RD lead. He was elected to Senior Member of Technical Staff (SMTS) during his tenure at Texas Instruments in 2015 — less than 5% of the technical population gets this award. He holds 21 granted patents in USPTO and published several IEEE journal and conference papers.

His research interests are mm-wave communication systems, Joint Radar Communication, Machine learning for signal processing and quantum error correction codes. He is a senior member of IEEE and chair for IEEE ComSoc Bangalore chapter.

Student Presentation 3: End-to-End Network Slicing in 5G Networks with Controlled Slice Redistributions

Samaresh Bera and Neelesh B. Mehta

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Network slicing creates multiple logical networks and enables 5G to meet the diverse performance requirements of emerging services and applications. We model the RAN, edge, and core networks and study end-to-end network slicing in 5G. We consider the problem of admitting new slice requests as a constrained optimization problem that seeks to maximize the total reward to the network operator while considering the impact of slice redistributions in the network. We propose a multi-phase polynomial-time, greedy approach to solve this NP-hard problem. It employs two comprehensive weighted cost functions for request selection and resource allocation that take into account the slice-specific requirements and multi-dimensional resources at the RAN, edge, and core networks. We use a Bayesian optimization technique to automatically tune the cost functions as a function of the network topology, networking resources, resource arrival rate, and slice-specific requirements. Our extensive numerical results show that the proposed approach achieves a total reward that is competitive with the optimal solution and is higher than the benchmark schemes at realistic higher request arrival rates, while requiring fewer slice redistributions.

Student Presentation 4: Communication Using Media-Based Modulation in a Scatter-rich Environment

Saurav Roy

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Media-Based Modulation(MBM) embeds the information in the variation of the propagation medium or channel and hence the RF carrier is modulated after it leaves the transmitter antenna, by incorporating RF mirrors close to the transmitter antenna. In a rich scattering environment, any minute variation of the medium brings about multiple random reflections and in effect each transmitted symbol leads to mutually independent channel utilization. This channel variation leads to different amplitude and phase of the received signals for different transmitted symbols. Number of switching states or Mirror Activation Patterns(MAP) of RF mirrors decides the number of transmitted symbols vis-à-vis the alphabet size. So,the alphabet comprises of the complex channel fading coefficients as symbols, which are obtained at the receiver-side through pilot transmissions. MBM has several advantages over traditional modulation schemes in terms of spectral efficiency, multiplexing gain, energy harvesting, security etc. Here We look at the various aspects of MBM from the communication system design perspective.

Student Presentation 5: Metasurfaces for Microwave Applications

Aritra Roy

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

A Metasurface facilitates exciting surface properties by engineering geometric profiles and find several applications in microwaves and optics. Its surface impedance can be controlled to tailor the amplitude and phase of the impinging waves. Often in a periodic structure, its operation depends on the periodicity and resonant characteristics of the underlying unit cell geometry. These surfaces are used as a microwave reflector, absorber, or phase shifter and are employed in antennas to miniaturize the geometry, reconfigure its radiation properties, or generate multiple main lobes.

In the first part of this work a digitally reconfigurable metasurface is designed, where the transmission through the unit cell is switched ON or OFF, thereby modifying the overall radiation pattern of an antenna placed behind this planar array. The metasurface is designed with a unit cell consisting of a meandered line and a PIN diode. Our experimental studies illustrated for the first time that the presence of scatterers enhances the performance of media based modulation (MBM) using this scheme, and is expected to provide impetus to build practical communication systems using this approach.

In the second part of this work, a wideband metasurface consisting of multiple metallic patches with surface mounted lumped resistors to absorb the EM waves over 1-6 GHz is designed. This metasurface is used with a compact spiral antenna to improve its low-frequency responses . A conventional spiral antenna is a wideband circularly polarized bidirectional radiator used for wideband communication, radar jamming and electronic warfare. When placed inside a compact metallic cavity to mount it on a ship or aircraft, its low-frequency radiation performances are affected. It has been shown that the use of metasurface improves the antenna responses thereby making it suitable for use over a frequency band of 1-18 GHz. Numerical optimization is carried out to design the metasurface geometry as well as to optimize the spiral antenna performance. A prototype antenna with the metasurface is fabricated and characterized inside an anechoic chamber to validate its performance.

2.3.2 Cluster: Artificial Intelligence & Machine Learning

Cluster Coordinator: Chiranjib Bhattacharyya, CSA and Aditya Gopalan, ECE
Student Organizer: Atasi Panda, Manan Tayal, Akash, Abhigyan, Debangshu
Faculty Organizer: Prathosh AP, ECE
Location: ECE Golden Jubilee Hall

Cluster Overview

Time	Event	Speaker	Affiliation
14:30pm-15:15pm	Invited Talk 1	Dr. Mayur Datar	VP, Flipkart
15:15pm-15:45pm	Invited Talk 2	Ms. Anna Roy	Niti Aayog
15:45pm-16:15pm	Invited Talk 3	Prof. Parag Singla	CSE, IIT Delhi
16:15pm-16:45pm	Invited Talk 4	Rishabh Mehrotra	Director of Machine Learning, ShareChat
16:45pm-17:15pm	Invited Talk 5	Prof. Ganesh Ramakrishnan	CSE, IIT Bombay

Keynote 1: Onboarding the next 500 million Indians: Applied innovation in conversational AI

Speaker: Mayur Datar, Chief Data Scientist at Flipkart
https://www.linkedin.com/in/mayur-datar-b0a65018/

Abstract

E-commerce is seeing rapid growth in India. Most of the new users who are coming onboard are non-English speaking users who may have little to no experience with consumer internet. For these users, it is a daunting task to discover the right products that they are looking for, get answers to any questions they may have about the products and complete the purchase online. To add to these challenges, they lack trust in the platform. In this talk we will talk about several applications of NLP and conversational AI that have been employed to overcome these challenges and assist the users in their buying and post purchase journey.

Bio

Mayur Datar works as a Chief Data Scientist with Flipkart in Bengaluru. He leads a large team of data scientists and together they are working on building the most advanced e-commerce landscape in India. Prior to joining Flipkart, Mayur worked for Google as a Research Scientist for over 12 years. He and his teams were credited with working on projects which had a big impact on Google's bottom-line. Mayur has a doctorate in computer science from Stanford university and obtained his Bachelor of Technology from IIT Bombay. He has several publications which have been presented in renowned computer science conferences. He is known in the industry for his technical leadership, pragmatic result oriented machine learning. His research interests include data-mining, algorithms, databases and computer science

theory.

Keynote 2: Experimenting with new age instructions of policy

Speaker: Anna Roy, Indian Economic Services
https://www.indiascienceandtechnology.gov.in/listingpage/anna-roy

Abstract
Ms Roy will highlight the new initiatives in governance in context of constitution of NITI Aayog that replaced the erstwhile Planning Commission. She will speak about functioning of NITI Aayog and how it strives to provide a vision for the growth story for the country. She will explain the collaborative approach being followed and demonstrate some best practices with focus on emerging. Technology. In her talk she will highlight the initiatives taken by NITI Aayog in space of emerging technology like the AI, Blockchain, etc. showcasing efforts that led to streamlining the efforts towards promoting development and adoption of these technologies, improving governance and setting a road-map.

Bio
Ms. Anna Roy is a 1992-batch officer of the Indian Economic Service. She has received her education from Shri Ram College of Commerce, Delhi University, and Delhi School of Economics. She was a lecturer at Delhi University and worked at TERI before joining the IES. In the government she has worked in the Ministry of Finance, Ministry of Civil Aviation, and NITI Aayog. At NITI Aayog she heads the vertical dealing with data management and frontier technologies. In this role, she has led teams, which have brought out major reports like the National Strategy on Artificial Intelligence, Blockchain- the India Strategy, Approach Paper on AIRAWAT, Responsible AI-Principles Enforcement Mechanism, the Data Empowerment Protection Architecture (DEPA) etc.. Ms. Roy also heads the Women Entrepreneurship Platform, a NITI flagship that works towards developing the entrepreneurial ecosystem for women

Keynote 3: Exploiting Structure in the Target (Output) Space for Improved Reasoning and Explainability in Neural Models

Speaker: Prof. Parag Singla, Associate Professor, Department of Computer Science and Engineering, IIT Delhi.
https://www.cse.iitd.ac.in/ parags/

Abstract
Last decade has seen phenomenal growth in application of neural models to a variety of problems, including those in Computer Vision, NLP and Speech, among other domains. One of the recent research directions has been around the problem of incorporating symbolic reasoning in neural networks, to enable them to do more effective reasoning as well as help them be explainable/interpretable. In this talk, we will present two different problems (and corresponding solutions) in this regard which exploit problem structure in the target space. The first one deals with solution multiplicity

in Structured CSPs - we present 1oML, which defines the novel problem of finding one of many solutions for problems expressed as Structured CSPs, such as solving a partially filled Sudoku board. Our solution approach is based on a novel RL formulation, which allows us to choose the right 'y' (target) for a given 'x' (input) while learning the model. Second, we present the problem of explainability in Common-sense Question Answering (CQA). We propose a new dataset (called ECQA), which expresses explanations as a set of positive (negative) properties of the (in)correct answers. We present a neural property ranker/selection module for property retrieval, as well as a GPT-2 based architecture for property generation, given the question and (in)correct answer choice. We conclude with broader research frontiers in the space of neuro-symbolic reasoning.

Bio

Parag Singla is an Associate Professor in the Department of CSE @ IIT Delhi. He received his Bachelors from IIT Bombay, and Masters and PhD from University of Washington, Seattle. He spent a little more than a year as a postdoc at University of Texas at Austin, before starting as a faculty member at IIT Delhi in the end of 2011. His research expertise includes Statistical Relational Learning, Machine Learning, and Artificial Intelligence. His recent focus has been in the area of neuro-symbolic reasoning, which aims to combine the power of symbolic reasoning with neural models. He has authored more than 40 papers in top-tier machine learning conferences and journals, including NeurIPS, AAAI, IJCAI, UAI, ACL, NAACL, CVPR, ICAPS and WWW. He has been a recipient of Visvesvaraya young faculty fellowship from Govt. of India (2016- 2021), and has a best paper award to his name.

Keynote 4: Algorithmic Balancing of Consumer Creator Goals in Multi-stakeholder Recommendations

Speaker: Rishabh Mehrotra, Staff Research Scientist Research Lead at Spotify in London
http://rishabhmehrotra.com/

Abstract

Recommender systems shape the bulk of consumption on digital platforms, and are increasingly expected to not only support consumer needs but also benefit content creators and suppliers by helping them get exposed to consumers and grow their audience. Indeed, most modern digital platforms are multi-stakeholder platforms (e.g. AirBnb: guests and hosts, Youtube: consumers and producers, Uber: riders and drivers, Amazon: buyers and sellers), and rely on recommender systems to strive for a healthy balance between user, creators and platform objectives to ensure long-term health and sustainability of the platform. In this talk, we discuss a few recent advancements in multi-objective modeling spanning fuzzy aggregations, set transformers and reinforcement learning. While the main focus is on multi-objective balancing, the talk also touches upon related problems of trade-off handling, and user/content/creator understanding to support multi-stakeholder platform ecosystems. The talk ends by discussing learnings from the development and deployment of balancing approaches across 400+ million users on large scale recommendation platforms.

Bio

Rishabh Mehrotra currently works as a Director of Machine Learning at ShareChat based in London. His current research focuses on machine learning for marketplaces, multi-objective modeling of recommenders and creator ecosystem. Prior to ShareChat, he was an Area Tech Lead and Staff Scientist/Engineer at Spotify where he led multiple ML projects from basic research to production across 400+ million users. Rishabh has a PhD in Machine Learning from UCL, and 50+ research papers and patents. Some of his recent work has been published at conferences including KDD, WWW, SIGIR, RecSys and WSDM. He has co-taught a number of tutorials and summer school courses on the topics of learning from user interactions, marketplaces, and personalization.

Keynote 5: Data Efficient Machine Learning: Algorithms and Toolkits

Speaker: Ganesh Ramakrishnan, Institute Chair Professor, Department of Computer Science and Engineering, IIT Bombay
https://www.cse.iitb.ac.in/ ganesh/

Abstract

State of the art AI and Deep Learning are very data hungry. This comes at significant cost including larger resource costs (multiple expensive GPUs and cloud costs), training times (often times multiple days), and human labeling costs and time. In this talk we present our an overview of our research efforts toward Data Efficient maChIne LEarning (DECILE) and our associated open source platform (http://www.decile.org) in which we attempt to address the following questions. Can we train state of the art deep models with only a sample (say 5 to 10) of massive datasets, while having negligible impact in accuracy? Can we do this while reducing training time/cost by an order of magnitude, and/or significantly reducing the amount of labeled data required? In this talk, we will cover the following different components of DECILE while also outlining our research along those threads, viz., a) SUBMODLIB, b) CORDS, c) TRUST, d) DISTIL and e) SPEAR. Below, we introduce each component briefly. a) SUBMODLIB (https://github.com/decile-team/submodlib) is a library for submodular optimization. This library implements a number of submodular optimization algorithms and functions (including the submodular mutual information and conditional gain functions) in C++ with Python wrappers. It finds its application in summarization, data subset selection, hyper parameter tuning etc. b) CORDS (https://github.com/decile-team/cords) is a library for COResets and Data Subset selection for compute-efficient training of deep models. We will also briefly present our algorithmic innovations along this thread. c) TRUST (https://github.com/decile-team) is a library for targeted subset selection toward personalization and model remediation that includes several information theoretic measures on sets that have innovated. d) DISTIL (https://github.com/decile-team) is a library for Deep dIverSified inTeractIve Learning toolkit for deep models, that provisions for factoring in the effect of data augmentation on active learning.e) SPEAR (https://github.com/decile-team/spear) is a library for Semi-suPervisEd dAta pRogramming. SPEAR also includes innovative models that we have built for selecting (under some budget constraint) the unlabeled subset to be labeled, that best complements a given set of rules meant for labeling data (referred to as data programming). We

will also briefly introduce the different state-of-the-art algorithms implemented, especially those innovated by us.

Bio

Ganesh Ramakrishnan (https://www.cse.iitb.ac.in/ ganesh/) is currently serving as an Institute Chair Professor at the Department of Computer Science and Engineering, IIT Bombay. His areas of research include human assisted AI/ML, AI/ML in resource constrained environments, learning with symbolic encoding of domain knowledge in ML and NLP, etc. More recently, he has been focusing his energy on organizing relevant machine learning modules for resource constrained environments into https://decile.org/. In the past, he has demonstrated the impact of such data efficient machine learning in applications such as Video Analytics (https://www.cse.iitb.ac.in/ vidsurv) and OCR (https://www.cse.iitb.ac.in/ ocr) and is seeking to make similar impacts in creating a machine translation eco-system (https://www.udaanproject.org/) and in multi-modal analytics (https://www.cse.iitb.ac.in/ malta/). In the past, he has received awards such as IBM Faculty Award, and awards from Qualcomm, Microsoft as well as IIT Bombay Impactful Research Award and most recently the Dr P.K. Patwardhan Award for technology Development. He also held the J.R. Isaac Chair at IIT Bombay. Ganesh is very passionate about boosting the AI research eco-system for India and toward that, the research by him and his students as well as collaborators has resulted in startups that he has either jointly founded, has transferred technology to, or is mentoring. Ganesh is also currently serving as the Professor-in-charge of the Koita Centre for Digital Health at IIT Bombay (https://www.kcdh.iitb.ac.in/).

2.3.3 High Tea Break

2.4 Session 3 | Faculty Talks

Chair: Vikram Srinivasan, Arun Chandrasekhar
Student Organizer: Atasi Panda, Manan Tayal, Akash
Faculty Organizer: Chirag Jain
Location: ECE Golden Jubilee Hall

Cluster Overview

Event	Speaker	Affiliation
Faculty Talk 1	Konduri Aditya	CDS, IISc
Faculty Talk 2	Gugan Thoppe	CSA, IISc
Faculty Talk 3	Utsav Banerjee	ESE, IISc
Faculty Talk 4	Punit Rathore	RBCCPS, IISc

2.4.1 An Overview of Asynchronous Computing Method for Scalable PDE Solvers

Speaker: Konduri Aditya (CDS)

Abstract

Numerical simulations of physical phenomena and engineering systems, governed by non-linear partial differential equations, demand massive computations with extreme levels of parallelism. Current state-of-the-art simulations are routinely performed on hundreds of thousands of processing elements (PEs). At an extreme scale, it is observed that data movement and its synchronization pose a bottleneck in the scalability of solvers. Recently, an asynchronous computing method that relaxes communication synchronization at a mathematical level has shown significant promise in improving the scalability of PDE solvers. In this method, communication synchronization between PEs due to halo exchanges is relaxed, and computations proceed regardless of communication status. It was shown that numerical accuracy of standard schemes like the finite-differences, implemented with relaxed communication synchronization, is significantly affected. Subsequently, new asynchronytolerant schemes were developed to compute accurate solutions and show good scalability. In this talk, an overview of the status of the asynchronous computing method for PDE solvers and its applicability towards exascale simulations will be presented. The relaxation of data synchronization at a mathematical level can further leverage asynchronous parallel communication and runtime models. The coupling of asynchrony-tolerant schemes with such models will be discussed.

Bio

Konduri Aditya is as an Assistant Professor in the Department of Computational and Data Sciences, Indian Institute of Science, Bengaluru, India. Prior to this, He was a Postdoctoral Researcher at the Combustion Research Facility, Sandia National Laboratories, Livermore, CA, United States. Aditya obtained his doctoral degree in Aerospace Engineering from Texas AM University, College Station.

His current research includes large scale simulations of turbulent combustion relevant to gas turbine and scramjet engines, design of machine learning methods for anomalous/extreme event detection in scientific phenomena, and development of scalable asynchronous numerical methods and simulation algorithms for solving partial differential equations on massively parallel computing systems..

2.4.2 Improving Sample Efficiency in Evolutionary RL using Off-policy Ranking

Speaker: Gugan Thoppe (CSA)

Abstract

Evolution Strategy (ES) is a powerful technique for optimization based on the idea of natural evolution. In each of its iterations, a key step entails ranking candidate solutions based on some fitness score. When used in Reinforcement Learning (RL), this ranking step requires evaluating multiple policies. This is presently done via on-policy approaches, leading to increased environmental interactions. To improve sample efficiency, we propose a novel off-policy alternative for ranking. We demonstrate our idea in the context of a state-of-the-art ES method called the Augmented Random

Search (ARS). Simulations in MuJoCo tasks show that, compared to the original ARS, our off-policy variant has similar running times for reaching reward thresholds but needs only around 70% as much data. It also outperforms the recent Trust Region ES. We believe our ideas should be extendable to other ES methods as well.
This is joint work with my Ph.D. student Eshwar and Shishir Kolathaya.

Bio
Gugan Thoppe is an Asst. Professor at the Dept. of Computer Science and Automation, Indian Institute of Science (IISc). Before joining IISc, he was a postdoc for four years: the first two at Technion, Israel, and the next two at Duke University, USA. He has done his PhD and MS with Prof. Vivek Borkar at TIFR Mumbai, India. His PhD work won the TAA-Sasken best thesis award for 2017. He is also a two-time recipient of the IBM PhD fellowship award (2013–14 and 2014-15). His research interests include stochastic approximation and random topology and their applications to reinforcement learning and data analysis.

2.4.3 Efficient Circuits and Systems for Cryptography and Hardware Security

Speaker: Utsav Banerjee, ESE

Abstract
Hardware security has emerged as a growing concern with the advent of the Internet of Things (IoT) which consists of large networks of wireless-connected embedded devices. Although the growth of IoT has enabled novel applications, they have also become attractive targets for cyber attackers. Securing these resource-constrained embedded systems involves circuits, algorithms and architectures with low computation and storage overheads as well as countermeasures against physical attacks. One such approach is the design of efficient cryptographic hardware accelerators for IoT applications. This talk will provide an overview of design considerations and custom hardware architectures for modern public key cryptography based on lattices and elliptic curves. ASIC implementation results will be presented, along with examples of software-hardware co-design, system-level integration and demonstration of end-to-end protocols such as transport layer security. This talk will summarize key results and emerging directions of research in the implementation aspects of cryptography and hardware security.

Bio
Utsav Banerjee received the B.Tech. degree in electronics and electrical communication engineering from the Indian Institute of Technology (IIT) Kharagpur in 2013, and the M.S. and Ph.D. degrees in electrical engineering and computer science from the Massachusetts Institute of Technology (MIT) in 2017 and 2021 respectively. From 2013 to 2015, he was with the low-power system-on-chip design team at Qualcomm, where he was involved in the design and verification of power

management architectures for mobile chipsets. Since October 2021, he has been with the Indian Institute of Science (IISc) Bangalore, where he is currently an Assistant Professor in the Department of Electronic Systems Engineering. His research interests include cryptography, hardware security, digital circuits and embedded systems. He was a recipient of the President of India Gold Medal from IIT Kharagpur in 2013, the Irwin and Joan Jacobs Presidential Fellowship from MIT in 2015, and the Qualcomm Innovation Fellowship in 2016.

2.4.4 Cluster Structure Assessment and Change Detection in Streaming Data

Speaker: Punit Rathore, RBCCPS

Abstract

Everyday, an abundant amount of data is generated from various sources such as Internet of Things (IoT) networks, smartphones, and social network activities. Making sense of such an unprecedented amount of data is essential for many businesses, services and almost every smart city domain such as healthcare, transportation, environment, and energy sectors. The data generated from these domains are mostly unlabeled, anomalous, and streaming, which makes their interpretation challenging to create useful knowledge. Cluster analysis is a useful unsupervised approach to discover the underlying groups and useful patterns in the data. One important problem in cluster analysis is the cluster tendency assessment which asks the question whether data have clusters? If yes, how many? In this talk, Dr. Punit Rathore will present his novel cluster assessment algorithm for time-efficient tracking of cluster structures and change detection in data streams.

Bio

Dr. Punit Rathore is currently an Assistant Professor at Indian Institute of Science, Bangalore in Robert Bosch Centre for Cyberphysical Systems, jointly with Centre for infrastructure, Sustainable Transportation, and Urban Planning. Before joining IISc, Dr. Rathore worked as a Postdoctoral Fellow in Senseable City Lab at Massachusetts Institute of Technology (MIT), Cambridge, USA and in Grab-NUS AI Lab at National University of Singapore. Dr Rathore completed his Ph.D. from the Department of Electrical and Electronics Engineering, University of Melbourne, Australia in Jan-2019. Prior to PhD, Dr. Punit worked as a Researcher in Automation Division at Tata Steel Limited, Jamshedpur, where he developed several real-time systems based on machine learning and machine vision for manufacturing industries. His research work has been internationally recognized with multiple best-paper awards at world-recognized IEEE conferences and best thesis prizes by IEEE System, Man, and Cybernetics Society (SMC) and Melbourne School of Engineering, the University of Melbourne. His current research interests are in unsupervised learning, streaming data analytics, explainable ML, and data-driven techniques for IoT, transportation and autonomous systems.

END OF DAY 1

3. Day 2: 9th April 2022(Saturday)

3.1 Session 4 | Research Cluster Talks

Location: ECE Building

3.1.1 Cluster: Theoretical Computer Science

Cluster Coordinator: Sathish Govindarajan (CSA)
Student Organizer: Saurabh, Rishikesh
Faculty Organizer: Rahul Saladi, CSA
Location: ECE 1.07

Cluster Overview

Cluster Overview			
Time	Event	Speaker	Affiliation
10:00pm-10:20pm	Student Presentations	Nikhil Gupta	CSA,IISc
10:25pm-10:45pm		Raji R. Pillai	CSA,IISc
10:50pm-11:10pm		Aditya Subramanian	CSA,IISc
11:15pm-11:35pm		Aditya Lonkar	CSA,IISc
11:45pm-12:05pm		Utkarsh Joshi	CSA,IISc
12:10pm-12:30pm		Ramakrishnan K	CSA,IISc
12:35pm-12:55pm		K. V. N. Sreenivas	CSA,IISc

Student Presentation 1: Equivalence Test for Read-Once Arithmetic Formulas

Nikhil Gupta

Department of Computer Science and Automation,

Indian Institute of Science

Abstract

A read-once arithmetic formula (ROF) $\mathtt{C}$ over a field $\mathbb{F}$ is a tree, where a leaf node is labelled by either a distinct variable or a constant from $\mathbb{F}$ and a non-leaf node is labelled by either + or $\times$. Every node of $\mathtt{C}$ computes a polynomial naturally - a leaf node computes its label and a + node (or a $\times$ node) computes the sum (respectively, the product) of the polynomials computed by its children. The *equivalence testing* problem for ROFs is as follows: given black-box access to a polynomial $f \in \mathbb{F}[x_1,\ldots,x_n]$ of degree at most n, decide if there exists an ROF $\mathtt{C}$, an invertible matrix $A \in \mathbb{F}^{n\times n}$ and a vector $\mathbf{b} \in \mathbb{F}^n$, such that $f = \mathtt{C}(\mathtt{A}\mathbf{x}+\mathbf{b})$, where $\mathbf{x} = (x_1x_2\cdots x_n)^T$. Further, if the answer is yes then output an ROF $\mathtt{C}$, an invertible matrix A and a vector $\mathbf{b}$, such that $f = \mathtt{C}(\mathtt{A}\mathbf{x}+\mathbf{b})$. In this work, we give a randomized polynomial-time algorithm (with oracle access to the *quadratic form equivalence test* over $\mathbb{F}$) for the equivalence testing problem for ROFs.

At the heart of this algorithm lies a detailed analysis of the *essential variables* of the Hessian determinant of an ROF. This analysis becomes technically challenging due to the arbitrary structure of the underlying tree of an ROF. We overcome this challenge and use the knowledge of the essential variables to design an efficient randomized equivalence test for ROFs.
This is a joint work with Chandan Saha and Bhargav Thankey.

Student Presentation 2: Algorithmic Problems on Vertex Deletion and Graph Coloring

Raji R. Pillai and Sunil Chandran L

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

Vertex deletion problems form a core topic in algorithmic graph theory with many applications. Typically, the objective of a vertex deletion problem is to delete the minimum number of vertices so that the remaining graph satisfies some property. Many classic optimization problems like MAXIMUM CLIQUE, MAXIMUM INDEPENDENT SET, VERTEX COVER are examples of vertex deletion problems. We study popular vertex deletion problems called CLUSTER VERTEX DELETION and its generalisation s-CLUB CLUSTER VERTEX DELETION, both being important in the context of graph-based data clustering. A *cluster* is often viewed as a dense subgraph (often a *clique*) and *partitioning* a graph into such clusters is one of the main objectives of *graph-based data clustering*. However, to account for the errors introduced during the construction of the network, the clusters of certain networks may be retrieved by making a small number of modifications such as deleting some vertices.

Given a graph G, the objective of CLUSTER VERTEX DELETION (CVD) is to delete a minimum number of vertices so that the remaining graph is a set of disjoint cliques. We focus on polynomial-time solvability of CVD on special classes of graphs. Chordal graphs (graphs with no induced cycle of length greater than 3) are well studied class of graphs having many applications in algorithmic graph theory. Though polynomial-time algorithms for certain sub classes of chordal graphs such as interval graphs, block graphs and split graphs are known, the computational complexity of CVD on chordal graphs remains unknown. We study CVD on *well-partitioned chordal graphs*, another sub class of chordal graphs that generalizes split graphs, which is introduced as a

tool for narrowing down complexity gaps for problems that are hard on chordal graphs, and easy on split graphs.

In many applications the equivalence of cluster and clique is too restrictive. For example, in protein networks where proteins are the vertices and the edges indicate the interaction between the proteins, a more appropriate notion of clusters may have a diameter of more than 1. Therefore researchers have defined the notion of *s-clubs*. An s-club is a graph with *diameter* at most s. The objective of s-CLUB CLUSTER VERTEX DELETION (s-CVD) is to delete the minimum number of vertices from the input graph so that all connected components of the resultant graph is an s-club. We propose a polynomial-time algorithm for (s-CVD) on *trapezoid* graphs, a class of intersection graphs. To the best of our knowledge, our result provides the first polynomial-time algorithm for CLUSTER VERTEX DELETION on trapezoid graphs. We also provide a faster algorithm for s-CVD on *interval graphs*. For each $s \geq 1$, we give an $O(n(n+m))$-time algorithm for s-CVD on interval graphs with n vertices and m edges. We also prove some hardness results for s-CVD on planar bipartite graphs, split graphs and well-partitioned chordal graphs for each $s \geq 2$.

Graph coloring has diverse applications and is still a prominent research area to tackle many practical problems by simulating them as coloring the vertices or edges of a graph subject to some constraints. Efficient and scalable implementation of parallel algorithms on multiprocessor architectures with multiple memory banks require simultaneous access to the data items. Such "conflict-free" access to parallel memory systems and other applied problems motivate the study of *rainbow coloring* of a graph, in which there is a fixed template $\mathscr{T}$ (or a family of templates), and one seeks to color the vertices of an input graph G with as few colors as possible, so that each copy of $\mathscr{T}$ in G is rainbow colored, i.e., has no two vertices the same color. We call such coloring a *template-driven rainbow coloring* and study the rainbow coloring of proper interval graphs (as hosts) for cycle templates.

Student Presentation 3: A PTAS for the Horizontal Rectangle Stabbing Problem

Arindam Khan, Aditya Subramanian and Andreas Wiese

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

We study rectangle stabbing problems in which we are given n axis-aligned rectangles in the plane that we want to *stab*, i.e., we want to select line segments such that for each given rectangle there is a line segment that intersects two opposite edges of it. In the *horizontal rectangle stabbing problem* (STABBING), the goal is to find a set of horizontal line segments of minimum total length such that all rectangles are stabbed. In *general rectangle stabbing problem*, also known as *horizontal-vertical stabbing problem* (HV-STABBING), the goal is to find a set of rectilinear (i.e., either vertical or horizontal) line segments of minimum total length such that all rectangles are stabbed. Both variants are NP-hard. Chan, van Dijk, Fleszar, Spoerhase, and Wolff initiated the study of these problems by providing constant approximation algorithms. Recently, Eisenbrand, Gallato, Svensson, and Venzin have presented a QPTAS and a polynomial-time 8-approximation algorithm for STABBING but it was open whether the problem admits a PTAS.

In this work, we obtain a PTAS for STABBING, settling this question. For HV-STABBING, we obtain a $(2+\varepsilon)$-approximation. We also obtain PTASes for special cases of HV-STABBING: (i) when all rectangles are squares, (ii) when each rectangle's width is at most its height, and (iii) when all rectangles are δ-large, i.e., have at least one edge whose length is at least δ, while all edge lengths are at most 1. Our result also implies improved approximations for other problems such as *generalized minimum Manhattan network*.

Student Presentation 4: Tight Approximation Algorithms for Two-dimensional Guillotine Strip Packing

Aditya Lonkar

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

In the STRIP PACKING problem (SP), we are given a vertical half-strip $[0,W]\times[0,\infty)$ and a set of n axis-aligned rectangles of width at most W. The goal is to find a non-overlapping packing of all rectangles into the strip such that the height of the packing is minimized. A well-studied and frequently used practical constraint is to allow only those packings that are guillotine separable, i.e., every rectangle in the packing can be obtained by recursively applying a sequence of edge-to-edge axis-parallel cuts (guillotine cuts) that do not intersect any item of the solution. In this paper, we study approximation algorithms for the GUILLOTINE STRIP PACKING problem (GSP), i.e., the STRIP PACKING problem where we require additionally that the packing needs to be guillotine separable. This problem generalizes the classical BIN PACKING problem and also makespan minimization on identical machines, and thus it is already strongly NP-hard. Moreover, due to a reduction from the PARTITION problem, it is NP-hard to obtain a polynomial-time $(3/2-\varepsilon)$-approximation algorithm for GSP for any $\varepsilon>0$ (exactly as STRIP PACKING). We provide a matching polynomial time $(3/2+\varepsilon)$-approximation algorithm for GSP. Furthermore, we present a pseudo-polynomial time $(1+\varepsilon)$-approximation algorithm for GSP. This is surprising as it is NP-hard to obtain a $(5/4-\varepsilon)$-approximation algorithm for (general) STRIP PACKING in pseudo-polynomial time. Thus, our results essentially settle the approximability of GSP for both the polynomial and the pseudo-polynomial settings.

Student Presentation 5: Fast Algorithms for Max Cut on Geometric Intersection Graphs

Utkarsh Joshi

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

Fast Algorithms for Max Cut on Geometric Intersection Graphs In the max cut problem, given a graph, the goal is to partition the vertex set into two disjoint sets such that the number of edges having their endpoints in different sets is maximized. Max cut is an NP-hard problem. The seminal work by Goemans and Williamson gave an approximation algorithm for the max cut problem having an approximation ratio of 0.878.

In this work, we design fast algorithms for max cut on geometric intersection graphs. In a geometric intersection graph, given a collection of n geometric objects as the input, each object corresponds to a vertex and there is an edge between two vertices if and only if the corresponding objects intersect. Since we are dealing with the geometric intersection graphs, which have more structure than general graphs, the following questions are of interest: Are there special cases of geometric intersection graphs for which max cut can be solved exactly in polynomial time? It can be shown that the random cut gives a 0.5 approximation for the max cut. Is it possible to design linear or near-linear time algorithms (in terms of n) and beat the 0.5 approximation barrier? The edge-set of the graph is not explicitly given as input; therefore, designing linear time algorithms is of interest. Can an approximation factor better than 0.878 be obtained for the geometric intersection graphs?

An exact and fast algorithm for laminar geometric intersection graphs. Our algorithm uses a greedy strategy. A fast algorithm is obtained by combining the properties of laminar objects with range searching data structures. An O(n log n) time algorithm with an approximation factor of 2/3 for unit interval intersection graphs. We decompose the unit intervals into several cliques, and based on the number of edges between "adjacent" cliques, we choose an appropriate partitioning strategy. An O(n log n) time algorithm with an approximation factor of 7/13 for unit square intersection graphs. We use the "largest clique" in the graph to beat the 0.5 approximation barrier.

Student Presentation 6: On Slowly-varying Non-stationary Bandits

Ramakrishnan Krishnamurthy, Aditya Gopalan

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

We consider minimisation of dynamic regret in non-stationary bandits with a slowly varying property. Namely, we assume that arms' rewards are stochastic and independent over time, but that the absolute difference between the expected rewards of any arm at any two consecutive time-steps is at most a drift limit $\delta > 0$. For this setting that has not received enough attention in the past, we give a new algorithm which extends naturally the well-known Successive Elimination algorithm to the non-stationary bandit setting. We establish the first instance-dependent regret upper bound for slowly varying non-stationary bandits. The analysis in turn relies on a novel characterization of the instance as a *detectable gap* profile that depends on the expected arm reward differences. We also provide the first minimax regret lower bound for this problem, enabling us to show that our algorithm is essentially minimax optimal. Also, this lower bound we obtain matches that of the more general total variation-budgeted bandits problem, establishing that the seemingly easier former problem is at least as hard as the more general latter problem in the minimax sense. We complement our theoretical results with experimental illustrations.

Student Presentation 7: Near-optimal Algorithm for Stochastic Online Bin Packing

K. V. N. Sreenivas

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

We study the online bin packing problem under the i.i.d. model. In the bin packing problem, we are given n items with sizes in $(0,1]$ and the goal is to pack them into the minimum number of unit-sized bins. In the i.i.d. model, the item sizes are sampled independently and identically from a distribution in $(0,1]$. Both the distribution and the total number of items are unknown. The items arrive one by one and their sizes are revealed upon their arrival and they must be packed immediately and irrevocably in bins of size 1. We provide a simple meta-algorithm that takes an offline α-asymptotic approximation algorithm and provides a polynomial-time $(\alpha+\varepsilon)$-competitive algorithm for online bin packing under the i.i.d. model, where $\varepsilon > 0$ is a small constant. Using the AFPTAS for offline bin packing, we thus provide a linear time $(1+\varepsilon)$-competitive algorithm for online bin packing under the i.i.d. model, thus settling the problem.

3.1.2 Cluster: Cyber-Physical Systems

Cluster Coordinator: Vaibhav Katewa, RBCCPS
Student Organizer: Sameer, Sankalp
Faculty Organizer: Pushpak Jagtap, RBCCPS
Location: ECE MP-30

Cluster Overview

Cluster Overview			
Time	Event	Speaker	Affiliation
10:00am-10:45am	Invited Talk 1	Ashish Joglekar	ARTPARK, IISc
10:45am-11:05am	Student Presentations	Rohit Chowdhury	CDS, IISc
11:10am-11:30am		Pankaj Mishra	RBCCPS,IISc
11:30am-11:45am		Break	-
11:45am-12:05pm		Srikrishna Acharya	RBCCPS,IISc
12:05pm-12:25pm		Himanshu Sharma	RBCCPS,IISc
12:25pm-12:45pm		Vishal Kushwaha	RBCCPS,IISc

Invited Talk 1: Demo of Sensor Data Acquisition and Visualization using Open Source Tools

Speaker: Ashish Joglekar, Senior Member of Technical Staff (Electronics HW design), ARTPARK, IISc.

Abstract In this session, I want to talk about some of the open source tools that I use on a regular basis.
These tools have helped me deploy an end to end IIoT solution quickly and I hope these tools will help you too.
You may have already used some of these tools.
Note: I will be using a temperature controller node for this demonstration.

We will use the following tools:

** GNU Plot: Graphing utility
** TK UI: A library of basic elements for building a graphical user interfaces.

** Netcat: A computer networking utility for reading from and writing to network connections using TCP or UDP
** Mosquitto MQTT Broker and Clients: MQ(Message Queue) Telemetry Transport
** Node Red: A flow-based development tool for visual programming
** Influx DB: A time series database (TSDB)
** Grafana: Analytics and monitoring solution for every databas

Bio

I am currently working as a Senior Member of Technical Staff (Electronics HW design) at the AI and Robotics Technology Park at IISc. I am also a visiting faculty at RBCCPS, IISc.
From 2015-2020 I was at the Robert Bosch Center for Cyber Physical Systems as a Member of Tech. Staff. (HW design)
I completed my PhD from Department of Electronic Systems Engineering IISc in the area of EMI/EMC in power converters. I worked on active EMI filters for mitigation of EMI in power converters as part of my PhD work.
I have worked on projects like Neonatal Baby monitoring device, Low cost Phasor Measurement Unit for Smart Grids, Solar PV Fault monitoring device, VLC capable LED street lights, Data driven digital twin for energy optimization of industrial assembly lines, Tele-autonomous vehicles, autonomous charging port for drones, custom FOC motor drivers etc. Many of these have resulted in patents and publications.
I am currently working on developing a joint actuator for a compliant robotic arm.
My research interests include Sensors and actuators, Analog front end design, Power Electronics, Motors and motor drivers, EMI/EMC, PCB design, Embedded control, data acquisition systems and overall systems integration and design.

Student Presentation 1: Optimal Path Planning of Autonomous Marine Vehicles in Stochastic Dynamic Ocean Flows using a GPU-Accelerated Algorithm

Rohit Chowdhury

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

Autonomous marine vehicles play an essential role in many ocean science and engineering applications. Planning time and energy optimal paths for these vehicles to navigate in stochastic dynamic ocean environments is essential to reduce operational costs. In some missions, they must also harvest solar, wind, or wave energy (modeled as a stochastic scalar field) and move in optimal paths that minimize net energy consumption. Markov Decision Processes (MDPs) provide a natural framework for sequential decision making for robotic agents in such environments. However, building a realistic model and solving the modeledMDP becomes computationally expensive in large-scale real-time applications, warranting the need of parallel algorithms and efficient implementation. In the present work, we introduce an efficient end-to-end GPU-accelerated algorithm that (i) builds the MDP

model (computing transition probabilities and expected one-step rewards); and (ii) solves the MDP to compute an optimal policy. We develop methodical and algorithmic solutions to overcome the limited global memory of GPUs by (i) using a dynamic reduced-order representation of the ocean flows, (ii) leveraging the sparse nature of the state transition probability matrix, (iii) introducing a neighbouring sub-grid concept and (iv) proving that it is sufficient to use only the stochastic scalar field's mean to compute the expected one-step rewards for missions involving energy harvesting from the environment; thereby saving memory and reducing the computational effort. We demonstrate the algorithm on a simulated stochastic dynamic environment and highlight that it builds the MDP model and computes the optimal policy 600-1000x faster than conventional CPU implementations, making it suitable for real-time use. We also demonstrate applications of our planner for multi-objective optimization problems, where trade-offs between multiple conflicting objectives are achieved (such as minimizing expected mission time, energy consumption, and environmental energy harvesting).

Student Presentation 2: Control of nonlinear systems with state constraints

Pankaj Mishra

Robert Bosch Center for Cyber Physical Systems,
Indian Institute of Science

Abstract
Designing control for practical systems invites complications in the form of constraints. These constraints could appear in different forms, such as performance, saturation, physical stoppages, and safety specifications. The presentation will include the importance of considering constraints in controller design, various approaches to dealing with state-constrained nonlinear systems, and a brief discussion on the use of design tools such as Backstepping and Barrier Lyapunov Function for the design of controllers for state-constrained systems in an adaptive framework.

Student Presentation 3: CORNET: A Co-Simulation Middleware for Robot Networks

Srikrishna Acharya and Bharadwaj Amrutur

Department of Robert Bosch Centre for Cyber-Physical Systems,
Indian Institute of Science

Abstract
We present a networked co-simulation framework for multi-robot systems applications. This is necessary to co-design the multi-robots' autonomy logic and the communication protocols. The proposed framework extends existing tools to simulate the robot's autonomy and network-related aspects. We have used Gazebo with ROS/ROS2 to develop the autonomy logic for robots and mininet-WiFi as the network simulator to capture the cyber-physical systems properties of the multi-robot system. This framework addresses the need to seamlessly integrate the two simulation environments by synchronizing mobility and time, allowing for easy migration of the algorithms to real platforms.

Student Presentation 4: Vision-based Tele-Operation for Robot Arm Manipulation

Himanshu Sharma and Bharadwaj Amrutur

Department of Robert Bosch Centre for Cyber-Physical Systems,
Indian Institute of Science

Abstract
It's worth the time to acknowledge just how amazingly well we can perform tasks with our hands. Starting from picking up a coin to button up our shirts. All these tasks for robots are still very forefront of robotics research & require significant interactions between vision, perception, planning & control. Becoming an expert in all of them is quite a challenge. Here comes the Tele-operation which offers the robots reasoning skills, intuition and creativity for performing these tasks in unstructured environments and unfamiliar objects. Herein, we present a low cost vision based Tele-operation of KUKA IIWA industrial robot Arm, where we would be imitating in real-time the natural motion of human operator seen from a depth camera on his side from the view of the activities of the robot from the cameras on robot-side on a screen. This tele-operated semi-autonomous control has potential applications in unstructured dynamic environments where the presence of human is not desirable for e.g. handling nuclear waste, deep under water to space explorations.

Student Presentation 5: Evaluating the Benefits of Collaboration between Rideshare and Transit Service Providers

Vishal Kushwaha

Robert Bosch Centre for 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 proposed a tri-level game theory and discrete choice theory-based model to determine optimal travel prices for such travel mode. The model was applied on a travel corridor of a major city in India which shows increased profits and market shares, and decreased travel times for RSPs and bus agency. The benefits for travelers were also observed.

3.1.3 Cluster: Security

Cluster Coordinator: Arpita Patra (CSA) and Chaya Ganesh (CSA)
Student Organizer: Atasi Panda, Manan Tayal, Akash
Faculty Organizer: Rahul Saladi, CSA
Location: ECE Golden Jubilee Hall

Time	Event	Speaker	Affiliation
10:00 - 10:40am	Invited Talk 1	Akshayaram Srinivasan	Reader, TIFR
10:45 - 11:25am	Invited Talk 2	Sikhar Patranabis	IBM Research, India
11:30 - 11:37am	Student Presentations	Nikhil Agarwal	CSA, IISc
11:37 - 11:44am		Varsha Bhat	CSA, IISc
11:44 - 11:51pm		Varkey M John	ECE, IISc
11:51 - 11:58am		Nishat Koti	CSA, IISc
11:58 - 12:05am		Praneeth Kumar V.	ECE, IISc
12:05 - 13:00pm	Keynote	Ittai Abraham	VMware Research

Cluster Overview

Invited Talk 1: Round-Optimal Black-Box Protocol Compilers.

Speaker: Akshayaram Srinivasan, Reader, TIFR

Abstract Secure Multiparty Computation (MPC) is a foundational cryptographic primitive with numerous applications. There are two popular adversarial models that have been considered in the literature for analyzing the security of MPC protocols. The first is called semi-honest security and this protects only against a weaker form of adversary where the corrupted parties are forced to follow the protocol. The more stronger malicious adversarial model allows the corrupted parties to deviate arbitrarily from the protocol specification. Typically, semi-honest protocols are easy to construct and analyze whereas constructing malicious protocols involve sophisticated tools and techniques. Our focus is on constructing compilers that upgrade the security of protocols from semi-honest to malicious with little overhead.

The prior general purpose compilers for upgrading security either make non-black-box use of the underlying cryptographic primitives and thereby, incur a huge computational blow-up or the black-box versions have a large overhead in the round complexity. In this talk, I will describe a round-preserving black-box compiler for upgrading the security of round-optimal semi-honest protocols. The compiler can be instantiated either in the random oracle model or in the 1-out-of-2 OT correlations model. As a result of this compiler, we get the first constructions of two-round malicious-secure OT, two-round NISC protocol, round-optimal 2PC and MPC that make black-box use of a two-round semi-honest OT in the random oracle model.

Bio

Akshayaram Srinivasan is a Reader in the School of Technology and Computer Science at Tata Institute of Fundamental Research, Mumbai. His research interests are broadly in the area of Cryptography, with a focus on its theoretical foundations. Before joining TIFR, he obtained his Ph.D. in Computer Science from University of California, Berkeley and his B.Tech in Computer Science and Engineering from Indian Institute of Technology, Madras. His research has been recognized with a best paper award at Eurocrypt 2018 and with an invitation to the Journal of Cryptology for a paper in Crypto 2019.

Invited Talk 2: Rethinking Searchable Encryption

Speaker: Sikhar Patranabis, IBM Research India (IBM IRL)

Abstract Database encryption is a key enabler for secure storage-as-a-service, wherein clients can securely outsource the storage and processing of large databases to (potentially untrusted) third party cloud servers. Over the past 20 years, searchable symmetric encryption (SSE) has emerged as an attractive and highly practical subclass of database encryption that allows directly querying encrypted databases, without actually decrypting the data. A crucial aspect of designing any SSE scheme is to minimize leakage, i.e., the information learnt by the untrusted server about the client's data and queries. In this talk, I will introduce a new and practically motivated system-wide viewpoint of analyzing the leakage of SSE schemes. This naturally leads to the question: do existing SSE schemes in the literature actually protect the security of data and queries when analyzed from such a system-wide viewpoint? The answer turns out to be no – we develop a new inference attack that exploits system-wide leakage to achieve practically efficient, highly scalable, and accurate query reconstruction against a vast majority of existing SSE schemes. I will then briefly discuss the possibility of applying existing leakage-suppression techniques such as volume-hiding encrypted multi-maps to protect SSE schemes against attacks exploiting system-wide leakage. The answer here also turns out to be negative. We validate this via experiments showing that such leakage protected implementations of SSE are practically inefficient and do not realistically scale to large databases. In totality, I hope to convey through this talk the need to thoroughly re-evaluate how to build SSE schemes (and more generally database encryption schemes) that offer both security and efficiency in practice. Based on a joint work with Zichen Gui and Kenny Paterson. No prior background on cryptography will be required.

Bio

Sikhar Patranabis is a research scientist at IBM Research India (IBM IRL), where he is a member of the blockchain and supply chain department. His research focuses on theoretical and applied aspects of cryptography and hardware security. He was previously a staff research scientist at Visa Research USA, a postdoctoral researcher at ETH Zurich, Switzerland, and a research associate at IISc Bangalore. He received his PhD and B.Tech in Computer Science and Engineering from IIT Kharagpur. He is the recipient of an IBM PhD fellowship, a Qualcomm Innovation Fellowship, and the President of India gold medal from IIT Kharagpur.

Student Presentation 1: An Evaluation of Basic Protection Mechanisms in Financial Apps on Mobile Devices

Nikhil Agrawal, Kanchi Gopinath and Vinod Ganapathy

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

This work concerns the robustness of security checks in financial mobile applications. The best practices recommended by the Open Web Application Security Project (OWASP) for developing such apps, demand that developers include several checks in these apps, such as detection of running on a rooted device, certificate checks, and so on. Ideally, these checks must be introduced in a sophisticated way and must not be locatable through trivial static analysis, so that attackers cannot bypass them trivially. In this work, we conduct a large-scale study focused on financial apps on the Android platform and determine the robustness of these checks.

Our study shows that a significant fraction of the financial apps does not have the various self-defense checks recommended by the OWASP. Then we showed that among the apps with at least one security check, > 50% of such apps at least one check could be trivially bypassed. Some of such financial apps have installation counts exceeding 100 million from Google Play. This entire process of detecting the self-defense check and bypassing it is automated. We believe that the results of our study can guide developers of these financial apps in inserting security checks in a more robust fashion.

Student Presentation 2: You Share Because We Care: Fully Secure Allegation Escrow System

Nishat Koti*, Varsha Bhat Kukkala†, Arpita Patra‡

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

The rising issues of harassment, exploitation, corruption and other forms of abuse have led victims to seek comfort by acting in unison against common perpetrators. This is corroborated by the widespread #MeToo movement, which was explicitly against sexual harassment. One way to curb these issues is to install allegation escrow systems that allow victims to report such incidents. The escrows are responsible for identifying victims of a common perpetrator and taking the necessary action to bring justice to them. However, users hesitate to participate in these systems due to the fear of such sensitive reports being leaked to perpetrators, who may further misuse them. Thus, to increase trust in the system, cryptographic solutions are being designed. Several such web-based platforms have been proposed to realize secure allegation escrow (SAE) systems, each improving over its predecessors.

In the work of Arun et al. (NDSS'20), which presents the state-of-the-art solution, we identify attacks that can leak sensitive information and compromise victim privacy. We also report issues present in prior works that were left unidentified. To arrest all these breaches, we put forth an SAE system that prevents the identified attacks and retains the salient features from all prior works. The cryptographic technique of secure multi-party computation (MPC) serves as the primary underlying tool in designing our system. At the heart of our system lies a new duplicity check protocol and an improved matching protocol. We also provide additional features such as allegation modification and deletion, which were absent in the state of the art. To demonstrate feasibility, we benchmark the proposed system with state-of-the-art MPC protocols and report the cost of processing an allegation. Different settings that affect system performance are analyzed, and the reported values showcase the practicality of our solution.

Student Presentation 3: Fundamental Connections between Opacity and Attack Detection in Linear Systems

Varkey M. John, Vaibhav Katewa

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
Opacity and attack detectability are important properties for any system as they allow the states to remain private and malicious attacks to be detected, respectively. In this paper, we show that a fundamental trade-off exists between these properties for a linear dynamical system, in the sense that if an opaque system is subjected to attacks, all attacks cannot be detected. We first characterize the opacity conditions for the system in terms of its weakly unobservable subspace (WUS) and show that the number of opaque states is proportional to the size of the WUS. Further, we establish conditions under which increasing the opaque sets also increases the set of undetectable attacks. This highlights a fundamental trade-off between security and privacy. We demonstrate application of our results on a real-world system model.

Student Presentation 4: PentaGOD: Stepping beyond traditional GOD with five parties

Nishat Koti

Department of Computer Science and Automation,
Indian Institute of Science

Abstract
Secure multiparty computation (MPC) is increasingly being used to address privacy issues in various applications. The recent work of Alon et.al. (CRYPTO'20) identified the shortcomings of traditional MPC and defined a Friends-and-Foes (FaF) security notion to address the same. We showcase the need for FaF security in real-world applications such as dark pools. This subsequently necessitates designing concretely efficient FaF-secure protocols. Towards this, keeping efficiency at the center stage, we design ring-based FaF-secure MPC protocols in the small-party honest-majority setting. Specifically, we provide (1,1)-FaF secure 5 party computation protocols (5PC) that consider one malicious and one semi-honest corruption and constitutes the optimal setting for attaining honest-majority. At the heart of it lies the multiplication protocol that requires a single round of communication with 8 ring elements (amortized). To facilitate having FaF-secure variants for several applications, we design a variety of building blocks optimized for our FaF setting. The practicality of the designed (1,1)-FaF secure 5PC framework is showcased by benchmarking dark pools. In the process, we also improve the efficiency and security of the dark pool protocols over the existing traditionally secure ones. This improvement is witnessed as a gain of up to $62\times$ in throughput compared to the existing ones. Finally, to demonstrate the versatility of our framework, we also benchmark popular deep neural networks.

Student Presentation 5: Secret Key Agreement and Secure Omniscience of Tree-PIN Source with Linear Wiretapper

Praneeth Kumar V.

Department of Electrical Communication Engineering
,Indian Institute of Science

Abstract
In the setting of the multiterminal source model for secure computation, users who privately observe correlated random variables from a source try to compute functions of these private observations through interactive public discussion. The goal of the users is to keep these computed functions secure from a wiretapper who has some side information (a random variable possibly correlated with the source) and has noiseless access to the public discussion. In this work, we focus on a pairwise independent network (PIN) source model defined on a tree with a linear wiretapper that can observe arbitrary linear combinations of the source. For this model, we explore the connection between secret key agreement and secure omniscience. While the secret key agreement problem on this model considers the generation of a maximum-rate secret key through public discussion, the secure omniscience problem is concerned with communication protocols for omniscience that minimize the rate of information leakage to the wiretapper. Our main result is that a maximum-rate secret key can be generated through an omniscience scheme that minimizes the information leakage rate. Moreover, we obtain single-letter characterizations of the wiretap secret key capacity and the minimum leakage rate for omniscience.

Invited talk 3: Blockchains, Consensus and Mechanisms for Trusted Coordination

Speaker: Ittai Abraham, VMware Research

Abstract
Consensus is a fundamental problem in Computer Science that captures the essence of our ability to create trust and cooperate despite adverse conditions. This talk provides a brief overview of two amazing stories. The first is how such a simple problem, defined over 40 years ago, is still an active area of study and of innovation, both in theoretical research and in more applied system research. The second is how results in Computer Science that seemed completely impractical just 10 or 20 years ago are now at the forefront of the Blockchain and Cryptocurrency revolution and are redefining how large-scale cooperation and governance can emerge.

Bio
Ittai Abraham is a Senior Researcher at VMware Research. His work spans from the theory of algorithms through the foundations of distributed computing to practical aspects in industrial research, algorithm engineering, distributed systems and blockchain technology.

3.1.4 Cluster: Artificial Intelligence & Machine Learning

Cluster Coordinator: Chiranjib Bhattacharyya (CSA) and Aditya Gopalan (ECE)
Student Organizer: Utkarsh, Dharani, Abhigyan, Debangshu
Faculty Organizer: Prathosh AP, ECE
Location: ECE 1.08

Time	Event	Speaker	Affiliation
10:00 - 10:15am	Student Presentations	Anjali P	CDS ,IISc
10:15 - 10:30am		Abhishek Ramdas Nair	DESE, IISc
10:30 - 10:45am		Radha Agarwal	DESE, IISc
10:45 - 11:00am		Anoop C. S.	EE, IISc
11:00 - 11:15am		Prachi Singh	EE, IISc
11:15 - 11:30am		Shreyas Ramoji	EE,IISc
11:30 - 11:45am		Shivika Narang	CSA,IISc

Cluster Overview

Student Presentation 1: Inter and Intra-Annual Spatio-Temporal Variability of Habitat Suitability for Asian Elephants in India: A Random Forest Model-based Analysis

Anjali P

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

We develop a Random Forest model to estimate the species distribution of Asian elephants in India and study the inter and intra-annual spatiotemporal variability of habitats suitable for them. Climatic, topographic variables and satellite-derived Land Use/Land Cover (LULC), Net Primary Productivity (NPP), Leaf Area Index (LAI), and Normalized Difference Vegetation Index (NDVI) are used as predictors, and the species sighting data of Asian elephants from Global Biodiversity Information Reserve is used to develop the Random Forest model. A careful hyper-parameter tuning and training-validation-testing cycle are completed to identify the significant predictors and develop a final model that gives precision and recall of 0.78 and 0.77. The model is applied to estimate the spatial and temporal variability of suitable habitats. We observe that seasonal reduction in the suitable habitat may explain the migration patterns of Asian elephants and the increasing human-elephant conflict. Further, the total available suitable habitat area is observed to have reduced, which exacerbates the problem. This machine learning model is intended to serve as an input to the Agent-Based Model that we are building as part of our Artificial Intelligence-driven decision support tool to reduce human-wildlife conflict.

Student Presentation 2: Template Vector Machines: A Classification Framework for Energy Efficient Edge Devices

Abhishek Ramdas Nair

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

Energy-efficient devices are essential in edge computing and the tiny Machine Learning (tinyML) paradigm. Edge devices are often constrained by the available computational power and hardware resource. To this end, we present a novel classification framework, Template Vector Machines, for time-series data. Unlike a conventional pattern recognizer, where the feature extraction and

classification are designed independently, this architecture integrates the convolution and nonlinear filtering operations directly into the kernels of a Support Vector Machine (SVM). The result of this integration is a framework system whose memory and computational footprint (training and inference) are light enough to be implemented on a constrained IoT platform like microcontrollers or Field Programmable Gate Array (FPGA)-based systems. Template Vector Machines do not impose restrictions on the kernel to be positive-definite and allow the user to define memory constraints in fixed template vectors. This makes the framework scalable and enables its implementation for low-power, high-density, and memory-constrained embedded applications. We demonstrate the capabilities of this system on microcontrollers using audio data to identify bird species and classify gestures using IMU data.

Student Presentation 3: tinyRadar: mmWave Radar based Human Activity Classification for Edge Computing

Radha Agarwal

Department of Electonic Systems Engineering,
Indian Institute of Science

Abstract

The current state-of-the-art systems for patient monitoring, elderly, and child care are mainly camera-based and often require cloud computing. Camera-based systems pose a privacy risk, and cloud computing can lead to higher latency, data theft, and connectivity issues. To address this, we have developed a novel tinyML-based single-chip radar solution for on-edge sensing and detection of human activity. Edge computing within a small form factor makes it a more portable, fast, and secure solution. On top of that, radar provides an advantage by protecting the privacy and operating in fog, dust, and low light environment. We have used the Texas Instruments IWR6843 millimeter-wave radar board to implement the signal processing chain and classification model. A dataset for four different human activities generalized over six subjects was collected to train the 8-bit quantized Convolutional Neural Network. The real-time inference engine implemented on Cortex-R4F using CMSIS-NN framework has a model size of 1.44KB, gives the classification result after every 120ms, and has an overall subject-independent accuracy of 96.43%.

Student Presentation 4: Suitability of syllable-based modeling units for End-to-End Speech Recognition in Indian Languages

Anoop C S and A G Ramakrishnan

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Most Indian languages are spoken in units of syllables. However, speech recognition systems developed for Indian languages generally use characters or phonemes as modeling units. In this work, we evaluate the performance of syllable-based modeling units in end-to-end speech recognition for several Indian languages. We represent the text in 3 different forms: native script, Sanskrit library phonetics (SLP1) encoding, and syllables, and tokenize them with sub-word units like character, byte-pair encoding (BPE), and unigram language modeling (ULM). We compare the

performance of these tokens in monolingual training and cross-lingual transfer learning. We find that syllable-based BPE/ULM subword units give promising results in the monolingual setup if the dataset is sufficiently diverse to represent the syllable distribution in the language. For Vāksañcayaḥ dataset in Sanskrit, syllable-BPE tokens achieve state-of-the-art results. We also experiment on their capability to complement SLP1-character models through a pretraining - finetuning setup. However, no significant advantages are observed. We find that the SLP1-character units are much better than syllable-based units for cross-lingual transfer learning.

Student Presentation 5: Graph Neural Models for Speaker Diarization

Prachi Singh and Sriram Ganapathy

Department of Electrical Engineering,
Indian Institute of Science

Abstract
Speaker diarization is the task of automatic segmentation of the given audio recording into regions corresponding to different speakers. It is an important step in information extraction from conversational speech. The applications range from rich speech transcription to analysing turn-taking behavior in clinical diagnosis. Graph Neural Networks (GNN) have been widely explored for text classification and image clustering tasks but their use in speech research is nascent. The diarization problem can be formulated as graph clustering in which nodes represent the features vectors obtained after segmenting the audio into short segments and the edges represent the similarities between the nodes. In the talk, I will discuss the GNN applications specific to speech, model architecture, performance gains and advantages over the conventional approach.

Student Presentation 6: On the use of Cross-Attention for Speaker Verification

Shreyas Ramoji and Sriram Ganapathy

Department of Electrical Engineering,
Indian Institute of Science

Abstract
Automatic Speaker verification is the task of determining whether a test segment of speech contains a particular speaker of interest, given an enrollment recording of the speaker. Current approaches to Speaker Verification involve using neural networks such as residual networks (ResNets), time-delay neural networks (TDNNs), and their variants such as the Factorized TDNN and ECAPA-TDNN, to name a few. These models involve extracting embeddings of fixed dimensions from speech segments with variable durations, followed by a backend scoring approach such as cosine scoring or the PLDA to compute a log-likelihood ratio score. A recent innovation in the architecture front for speaker verification involves employing emphasized channel attention, propagation, and aggregation into the popular time-delay neural network architectures (ECAPA-TDNN). In this presentation, I will discuss my ongoing work involving modifications to the ECAPA-TDNN model. Here, we use cross-attention to selectively propagate the relevant channels and temporal frames of a test utterance using attention weights obtained from the enrollment recording. We can interpret these as enrollment-aware representations of the test segments that can potentially favor the task of speaker verification, particularly in challenging conditions such as shorter test duration or noisy test

conditions. While these models are more complex and slower to train than the regular embedding extractors, the time taken to verify a test recording is similar. Hence, research along these lines can potentially give rise to more reliable speaker verification models for real-life applications.

Student Presentation 7: On Achieving Leximin Fairness and Stability in Many-to-One Matchings

Shivika Narang

Department of Computer Science and Automation,
Indian Institute of Science

Abstract

The past few years have seen a surge of work on fairness in allocation problems where items must be fairly divided among agents having individual preferences. In comparison, fairness in settings with preferences on both sides, that is, where agents have to be matched to other agents, has received much less attention. Moreover, two-sided matching literature has largely focused on ordinal preferences. This paper initiates the study of fairness in stable many-to-one matchings under cardinal valuations. We study leximin optimality over stable many-to-one matchings. We first investigate matching problems with *ranked valuations* where all agents on each side have the same preference orders or rankings over the agents on the other side (but not necessarily the same valuations). Here, we provide a complete characterisation of the space of stable matchings. This leads to **FaSt**, a novel and efficient algorithm to compute a leximin optimal stable matching under ranked *isometric* valuations (where, for each pair of agents, the valuation of one agent for the other is the same). Building upon FaSt, we present an efficient algorithm, **FaSt-Gen**, that finds the leximin optimal stable matching for a more general ranked setting. We next establish that, in the absence of rankings and under strict preferences, finding a leximin optimal stable matching is NP-Hard. Further, with weak rankings, the problem is strongly NP-Hard, even under isometric valuations. In fact, when additivity and non-negativity are the only assumptions, we show that, unless P=NP, no efficient polynomial factor approximation is possible.

3.1.5 Cluster: Visual Analytics

Cluster Coordinator: Chandra Sekhar Seelamantula (EE) and Venkatesh Babu (CDS)
Student Organizer: Shreeparna, Lokesh, Anup
Faculty Organizer: Chirag Jain, CDS
Location: ECE MP-20

Cluster Overview

Invited talk 1: Learning to synthesize image and video contents

Speaker: Prof. Ming-Hsuan Yang, professor at UC Merced and a research scientist with Google

Abstract

In this talk, I will first review our recent work on synthesizing image and video contents. The underlying theme is to exploit different priors to synthesize diverse content with robust formulations. I will then present our recent work on image synthesis, video synthesis, and frame interpolation. I

Time	Event	Speaker	Affiliation
10:00 - 10:30am	Invited Talk 1	Ming-Hsuan Yang	UC Merced & Google Research
10:30 - 10:50am	Invited Talk 2	Kuldeep Kulkarni	Adobe Research
10:50 - 11:10am	Invited Talk 3	Nisheeth Lahoti	RephraseAI
11:10 - 11:20am	Student Presentations	Lalit Manam	EE, IISc
11:20 - 11:30am		Ruturaj Gavaskar	EE, IISc
11:30 - 11:40am		Jogendra Nath Kundu	CDS, IISc
11:40 - 11:50am		Manu Ghulyani	EE, IISc
11:50 - 12:00pm		Gaurav Kumar Nayak	CDS, IISc
12:00 - 12:10pm		Aditay Tripathi	CDS, IISc
12:10 - 12:20pm		Siddarth Asokan	RBCCPS/EE, IISc
12:20 - 12:30pm		Lakshmi Annamalai	ESE, IISc
12:30 - 12:36pm		Mani Madhoolika Bulusu	EE, IISc
12:36 - 12:42pm		Tejan Naresh Naik Karmali	EE, IISc
12:42 - 12:48pm		Vikash Kumar	CDS, IISc
12:48 - 12:54pm		Chaitra Sheshgiri Jambigi	CDS, IISc
12:54 - 13:00pm		Vignesh Kannan	CDS, IISc

will also present our recent work on learning to synthesize images with limited training data. When time allows, I will also discuss some recent findings for other vision tasks.

Bio

Ming-Hsuan Yang is a professor at UC Merced and a research scientist with Google. He received Google Faculty Award in 2009 and Faculty Early Career Development (CAREER) award from the National Science Foundation in 2012. Yang received paper awards at UIST 2017, CVPR 2018, and ACCV 2018. He served as a program co-chair for ACCV 2016 and ICCV 2019. Yang is a Fellow of the IEEE and ACM.

Invited Talk 2: Image and Video Editing via Manipulating Intermediate representations
Speaker: Kuldeep Kulkarni, Research Scientist in Adobe Research

Abstract

Manipulation of natural images for tasks like object insertion, out-painting or creating animations is extremely difficult if we operate purely in the pixel domain. The goal of this talk is to drive home the advantages of manipulating visual data by expressing them in intermediate representations and manipulating them instead of the pixels directly. Specifically, I will focus on two recent works with image out-painting and animating still images as target applications. I will first talk about a semantically-aware novel paradigm to perform image extrapolation that enables the addition of new object instances. Expressing the images in semantic label space allows us to complete the existing objects more effectively as well allows us to add completely new objects that otherwise

is very difficult when working in pixel domain. Then I will talk about a method we developed to interactively control the animation of fluid elements that have repeating textures like water, smoke, fire in still images to generate cinemagraphs. To this end, we allow the user to provide any number of arrow directions and their associated speeds along with a mask of the regions the user wants to animate. The user-provided input arrow directions, their corresponding speed values, and the mask are then converted into a dense flow map representing a constant optical flow map. We observe that the constant flow map, obtained using simple exponential operations can closely approximate the plausible motion of elements in the image. We further show that the computed dense optical flow map can be effectively used in conjunction with generative-adversarial network (GAN) to autoregressively generate future frames.

Bio

I am a research scientist in Adobe Research, Bengaluru, India. Before that I did a post-doc stint at Carnegie Mellon University where I worked with Aswin Sankaranarayanan. I received my PhD in Electrical Engineering from Arizona State University under the supervision of Pavan Turaga. Prior to that, I received my undergraduate degree in Electrical Engineering from the National Institute of Technology Karnataka, Surathkal, India in 2009. My current research interests are in the areas of computer vision, specifically image and video synthesis.
My personal website: https://kuldeepkulkarni.github.io/

Invited Talk 3: Research in startups: a case of synthetic media
Speaker: Nisheeth Lahoti, co-founder at Rephrase.ai

Abstract

Using the startup I cofounded as a case study, I'll talk about the experience of doing deep tech research in startups, the challenges that are unique to the context and some of the major differences compared to typical experiences in academia and industry. Also includes a whirlwind tour about the field of synthetic media and some technical problems in it.

Bio Nisheeth is a co-founder at Rephrase.ai and leads deep tech there. Rephrase.ai is a generative AI company that can create realistic voices and videos of people saying any text. Nisheeth graduated from the computer science dept. in IIT Bombay in 2015, worked in Google for a year and then founded two startups, SoundRex and Rephrase. He has amateur interests in mathematics (which he spends most of his spare time on) and physics (was an IPhO silver medalist, still likes to read up)

Student Presentation 1: Advances in Large-Scale 3D Reconstruction

Lalit Manam

Department of Electrical Engineering,
Indian Institute of Science

Abstract
The problem of large-scale 3D reconstruction from images has been of great interest in the computer vision community. In recent years there have been significant advances in

multiple aspects of the reconstruction pipeline. In this talk, I will describe the challenges involved and the two principal approaches of incremental and global 3D reconstruction. I will also briefly analyse the nature of learning based solutions for 3D reconstruction.

Student Presentation 2: Regularization using denoising: Exact and robust signal recovery

Rutuja Gavaskar

Department of Electrical Engineering,
Indian Institute of Science

Abstract
Plug-and-play (PnP) is a relatively recent regularization technique for image reconstruction problems. As opposed to traditional methods that involve choosing a suitable regularizer function, PnP uses a high-quality denoiser such as nonlocal means (NLM) or BM3D within a proximal algorithm (e.g. ISTA or ADMM) to implicitly perform regularization. PnP has become popular in the imaging community; however, its regularization capacity is not fully understood yet. For example, it is not known if PnP can in theory recover a signal from few measurements, as in classical compressed sensing, and if the recovery is robust to noise. In this talk, we explore these questions and present some novel theoretical and experimental results.

Student Presentation 3: Non-Local Latent Relation Distillation for Self-Adaptive 3D Human Pose Estimation

Jogendra Nath Kundu

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract
Available 3D human pose estimation approaches leverage different forms of strong (2D/3D pose) or weak (multi-view or depth) paired supervision. Barring synthetic or in-studio domains, acquiring such supervision for each new target environment is highly inconvenient. To this end, we cast 3D pose learning as a self-supervised adaptation problem that aims to transfer the task knowledge from a labeled source domain to a completely unpaired target. We propose to infer image-to-pose via two explicit mappings viz. image-to-latent and latent-to-pose where the latter is a pre-learned decoder obtained from a prior-enforcing generative adversarial auto-encoder. Next, we introduce relation distillation as a means to align the unpaired cross-modal samples i.e. the unpaired target

videos and unpaired 3D pose sequences. To this end, we propose a new set of non-local relations in order to characterize long-range latent pose interactions unlike general contrastive relations where positive couplings are limited to a local neighborhood structure. Further, we provide an objective way to quantify non-localness in order to select the most effective relation set. We evaluate different self-adaptation settings and demonstrate state-of-the-art 3D human pose estimation performance on standard benchmarks.

Student Presentation 4: Structure preserving regularization for imaging inverse problems

Manu Ghulyani

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Image restoration is an important inverse problem of great research interest. Image restoration is often solved by the regularization approach. The conventional regularization approaches address the ill-posedness of reconstruction from distorted measurements, but the restored images

tend to suffer from loss of details such as blurring of edges.

Some works based on approximation of l0 norm have shown superior performance. These methods have led to significant improvement in reconstruction image quality restoration. These methods also possess theoretically sound guarantees on the reconstructed image based on assumptions on the forward model and noise. In this work, we propose to extend the popular Hessian-Schatten (HS) norm regularization by imposing a non-convex penalty on the singular values of the im-

age Hessian. We demonstrate that the quality of reconstruction increases significantly by applying the proposed non-convex functional.

Student Presentation 5: DAD: Data-free Adversarial Defense at Test Time

Gaurav Kumar Nayak

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

Deep models are highly susceptible to adversarial attacks. Such attacks are carefully crafted imperceptible noises that can fool the network and can cause severe consequences when deployed. To encounter them, the model requires training data for adversarial training or explicit regularization-based techniques. However, privacy has become an important concern, restricting access to only trained models but not the training data (e.g. biometric data). Also, data curation is expensive and companies may have proprietary rights over it. To handle such situations, we propose a completely novel problem of 'test-time adversarial defense in absence of training data and even their statistics'. We solve it in two stages: a) detection and b) correction of adversarial samples. Our adversarial sample detection framework is initially trained on arbitrary data and is subsequently adapted to the unlabelled test data through unsupervised domain adaptation. We further correct the predictions on detected adversarial samples by transforming them in Fourier domain and obtaining their low frequency component at our proposed suitable radius for model prediction. We demonstrate the efficacy of our proposed technique via extensive experiments against several adversarial attacks and

for different model architectures and datasets. For a non-robust Resnet-18 model pre-trained on CIFAR-10, our detection method correctly identifies 91.42% adversaries. Also, we significantly improve the adversarial accuracy from 0% to 37.37% with a minimal drop of 0.02% in clean accuracy on state-of-the-art 'Auto Attack' without having to retrain the model.

Student Presentation 6: Multi-modal query guided object localization in natural images

Aditay Tripathi

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

Localizing objects in a scene has been a long-sought pursuit in computer vision literature. More recent works focus on localizing objects in the image using text and image queries. However, there are many different kinds of unexplored modalities in the literature. In this work, we rigorously study the problem of localizing objects in the image using queries such as sketches, gloss, and scene graphs.

Sketch query: We introduce the novel problem of localizing all the instances of an object (seen or unseen during training) in a natural image via sketch query. The sketch-guided object localization proves to be more challenging when we consider the following: (i) the sketches used as queries are abstract representations with little information on the shape and salient attributes of the object, (ii) the sketches have significant variability as they are hand-drawn by a diverse set of untrained human subjects, and (iii) there exists a domain gap between sketch queries and target natural images as these are sampled from very different data distributions. To address the problem of sketch-guided object localization, we propose a novel cross-modal attention scheme that guides the region proposal network (RPN) to generate object proposals relevant to the sketch query. These object proposals are later scored against the query to obtain final localization. Our method is effective with as little as a single sketch query. Moreover, it also generalizes well to object categories not seen during training (one-shot localization) and is effective in localizing multiple object instances present in the image.

Sketch and gloss queries: Hand-drawn sketches are suitable as a query when neither an image nor the object class is available. However, hand-drawn crude sketches alone might be ambiguous for object localization when used as queries. On the other hand, a linguistic definition of the object category and the sketch query give better visual and semantic cues for object localization. This work presents a multimodal query-guided object localization approach under the challenging open-set setting. In particular, we use queries from two modalities, namely, hand-drawn sketch and description of the object (also known as gloss), to perform object localization. Multimodal query-guided object localization is a challenging task, especially when the large domain gap exists between the queries and the natural images and the challenge in optimally combining the complementary and minimal information present across the queries. To address the aforementioned challenges, we present a novel cross-modal attention scheme that guides the region proposal network to generate object proposals relevant to the input queries and a novel orthogonal projection-based proposal scoring technique that scores each proposal with respect to the queries, thereby yielding the final localization results.

Scene graph query: We present a framework for jointly grounding objects that follow certain semantic relationship constraints given in a scene graph. A typical natural scene contains several objects, often exhibiting visual relationships of varied complexities between them. These inter-object relationships provide strong contextual cues to improve grounding performance compared to a

traditional object query-based localization task. A scene graph is an efficient and structured way to represent all the objects in the image and their semantic relationships. In an attempt to bridge these two modalities representing scenes and utilize contextual information to improve object localization, we rigorously study the problem of grounding scene graphs in natural images. To this end, we propose a graph neural network-based approach which we refer to as Visio-Lingual Message Passing Graph Neural Network (VL-MPAG Net). The model first constructs a directed graph with object proposals as nodes and an edge between a pair of nodes representing a plausible relation between them. Then a three-step inter-graph and intra-graph message passing are performed to learn the context-dependent representation of the proposals and query objects. These object representations are used to score the proposals to generate object localization.

Student Presentation 7: Teaching a GAN What Not to Learn

Siddarth Asokan

Department of Robert Bosch Centre for Cyberphysical Systems/ Electrical Engineering, Indian Institute of Science

Abstract

Generative adversarial networks (GANs) are an unsupervised deep learning framework consisting of two neural networks tasked with modelling the underlying distributions of a target dataset, usually images. The supervised and semi-supervised counterparts learn target classes in the dataset by providing labelled data and using multi-class discriminators. In this presentation, we will explore a novel perspective to the supervised GAN problem, one that is motivated by the philosophy of the famous Persian poet Rumi who said, *"The art of knowing is knowing what to ignore."* In the *RumiGAN framework*, we not only provide the GAN *positive* data that it must learn to model, but also present it with so-called *negative* samples that it must learn to avoid. In this talk, we will explore some of the basic mathematical aspects of formulating various standard GAN frameworks within the *Rumi* approach, and demonstrate applications to data balancing, where RumiGANs can generate realistic samples from a desired positive classes that have as low as 5% representation in the entire dataset.

Student Presentation 8: Event-LSTM: An Unsupervised and Asynchronous Learning-based Representation for Event-based Data

Lakshmi Annamalai

Department of Electronic Systems Engineering, Indian Institute of Science

Abstract

Event-based cameras, also known as silicon retinas, are a novel type of biologically inspired sensors that encode per-pixel scene dynamics asynchronously with microsecond resolution in the form of a stream of events. Key advantages of an event camera are: high temporal resolution, sparse data, high dynamic range, and low power requirements, which makes it a suitable choice for resource-constrained environments. However, one of the most challenging aspects of working with event cameras is the continuous and asynchronous nature of the data. This has prompted a paradigm shift that allows efficient extraction of meaningful information from the space-time event data.

Inspired by the benchmark set by the traditional vision and deep learning approaches, one of the predominant areas of research in event data focuses on aggregating the information conveyed by individual events onto a spatial grid representation. This ensures its compatibility with the tools available from the conventional vision domain. While interest in converting events into spatial representation by hand-crafted data transformations is growing, only very few approaches have looked into the more complex solutions that data-driven deep learning methods can provide. However, not every application has enough volume of labelled data to quench the data-hunger thirst of supervised deep learning algorithms, limiting the design of deep supervised networks to approximate complex functions. Hence, we have formulated the problem at hand as an unsupervised transformation to mitigate the challenges faced by supervised approaches due to limited availability of labelled data in the event domain.

The proposed Event-LSTM is a generic, deep learning-based task-independent architecture for transforming raw events into spatial grid representation. We achieve task independence by operating the popular architecture, LSTM, in an unsupervised setting to learn a mapping from raw events into a task-unaware spatial representation, which we call LSTM Time Surface (LSTM-TS). The Event-LSTM puts forth unsupervised event data representation generation as an alternative to data-hungry supervised learning approaches. It eliminates the need for large quantities of labelled data for each task at hand.

To take advantage of the asynchronous sensing principle of event cameras, Event-LSTM adapts asynchronous sampling of 2D spatial grid. The asynchronous 2D spatial grid sampling approach enables speed invariant feature extraction to cope with intraclass motion variations. It also initiates processing only when a specified number of events is accumulated, resulting in non-redundant energy-efficient feature extraction.

Student Presentation 9: Interpolation of 3D Digital Elevation Models

Mani Madhoolika Bulusu

Department of Electrical Engineering,
Indian Institute of Science

Abstract

A Digital Elevation Model (DEM) is a two-dimensional discrete function that defines the topographic surface of any terrain as a set of values measured or computed at the grid nodes. Applications of DEMs include hydrologic and geologic analyses, hazard monitoring, natural resources exploration, and traditional cartographic applications, such as the production of contour, hill-shaded, slope, and aspect maps. They capture the elevations of the surface at locations specified by (latitude, longitude) at irregularly spaced locations. But for all practical purposes, one needs the DEMs on regular grids. And hence the need to interpolate from the known measurements to estimate the elevations at all the terrain locations.

This talk covers Inverse Distance Weighting (IDW) and polyharmonic splines interpolation in irregularly spaced data interpolation. Deep Learning has proven to work exceptionally well for natural images denoising and inpainting. We present how the problem of DEM interpolation is cast as an inpainting problem and solved using the concepts of cycle consistency and generative adversarial network (GAN). We discuss relevant experiments to demonstrate its effectiveness. We finally discuss the major advantages and the issues one faces with the data-driven approach.

Student Presentation 10: LEAD: Self-Supervised Landmark Estimation by Aligning Distributions of Feature Similarity

Tejan Naresh Naik Karmali

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

In this work, we introduce LEAD, an approach to discover landmarks from an unannotated collection of category-specific images. Existing works in self-supervised landmark detection are based on learning dense (pixel-level) feature representations from an image, which are further used to learn landmarks in a semi-supervised manner. While there have been advances in self-supervised learning of image features for instance-level tasks like classification, these methods do not ensure dense equivariant representations. The property of equivariance is of interest for dense prediction tasks like landmark estimation. In this work, we introduce an approach to enhance the learning of dense equivariant representations in a self-supervised fashion. We follow a two-stage training approach: first, we train a network using the BYOLobjective which operates at an instance level. The correspondences obtained through this network are further used to train a dense and compact representation of the image using a lightweight network. We show that having such a prior in the feature extractor helps in landmark detection, even under drastically limited number of annotations while also improving generalization across scale variations.

Student Presentation 11: Improving Domain Adaptation through Class Aware Frequency Transformation

Vikash Kumar

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

In this work, we explore the usage of the Frequency Transformation for reducing the domain shift between the Source and Target domain (e.g., synthetic image and real image respectively) towards solving the Domain Adaptation task. Most of the Unsupervised Domain Adaptation (UDA) algorithms focus on reducing the global domain shift between labelled Source and unlabelled Target domain by matching the marginal distributions under a small domain gap assumption. UDA performance degrades for the cases where the domain gap between Source and Target distribution is large. In order to bring the Source and the Target domains closer, we propose a traditional image processing technique based novel approach **C**lass **A**ware **F**requency **T**ransformation (**CAFT**) that utilizes pseudo label based class consistent low-frequency swapping for improving the overall performance of the existing UDA algorithms. The proposed approach, when compared with the state-of-the-art deep learning based methods, is computationally more efficient and can easily be plugged into any existing UDA algorithm to improve its performance. Additionally, we introduce a novel approach based on absolute difference of top-2 class prediction probability (ADT2P) for filtering target pseudo labels into clean and noisy sets. Samples with clean pseudo label can be used to improve the performance of unsupervised learning algorithms. We name the overall framework as **CAFT++**.

Student Presentation 12: MMD-ReID: A Simple but Effective Solution for Visible-Thermal Person ReID

Chaitra S. Jambigi

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

Learning modality invariant features is central to the problem of Visible-Thermal cross-modal Person Reidentification (VT-ReID), where query and gallery images come from different modalities. Existing works implicitly align the modalities in pixel and feature spaces by either using adversarial learning or carefully designing feature extraction modules that heavily rely on domain knowledge. We propose a simple but effective framework, MMD-ReID, that reduces the modality gap by an explicit discrepancy reduction constraint. MMD-ReID takes inspiration from Maximum Mean Discrepancy (MMD), a widely used statistical tool for hypothesis testing that determines the distance between two distributions. MMD-ReID uses a novel margin-based formulation to match class-conditional feature distributions of visible and thermal samples to minimize intra-class distances while maintaining feature discriminability. MMD-ReID is a simple framework in terms of architecture and loss formulation. We conduct extensive experiments to demonstrate both qualitatively and quantitatively the effectiveness of MMD-ReID in aligning the marginal and class conditional distributions, thus learning both modality-independent and identity-consistent features. The proposed framework significantly outperforms the state-of-the-art methods on SYSU-MM01 and RegDB datasets.

Student Presentation 13: Quality Assessment of Low-light Restored Images: A Subjective Study and an Unsupervised Model

Vignesh Kannan and Rajiv Soundararajan

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

The quality assessment (QA) of restored low-light images is an important tool for benchmarking and improving low-light restoration (LLR) algorithms. While several LLR algorithms exist, the subjective perception of the restored images has been much less studied. Challenges in capturing aligned low-light and well-lit image pairs and collecting a large number of human opinion scores of quality for training, warrant the design of unsupervised (or opinion unaware) no-reference (NR) QA methods. This work studies the subjective perception of low-light restored images and their unsupervised NR QA. Our contributions are two-fold. We first create a dataset of restored low-light images using various LLR methods, conduct a subjective QA study, and benchmark the performance of existing QA methods. We then present a self-supervised contrastive learning technique to extract distortion-aware features from the restored low-light images. We show that these features can be effectively used to build an opinion unaware image quality analyzer. Detailed experiments reveal that our unsupervised NR QA model achieves state-of-the-art performance among all such quality measures for low-light restored images.

3.1.6 Lunch Break

Location: Main Guest House

3.1.7 Cluster: Brain, Computation, And Data Sciences

Cluster Coordinator: Prasanta Ghosh (EE) and Sridharan Devarajan (CNS)
Student Organizer: Atasi Panda, Manan Tayal, Akash
Faculty Organizer: Chirag Jain (CDS)
Location: ECE Golden Jubilee Hall

Time	Event	Speaker	Affiliation
14:30 - 15:00pm	Invited Talk	Manoj Kumar	DNIR, NIMHANS,
15:00 - 15:15pm	Student Presentations	Manasi Tiwari	CDS, IISc
15:15 - 15:30pm		Anusha A. S.	EE, IISc
15:30 - 15:45pm		Anirudh Jonnalagadda	CDS, IISc
15:45 - 16:00pm		Akshara Soman	EE, IISc
16:00 - 16:15pm		Suman Chatterjee	ESE, IISc
16:15 - 16:30pm		Sangeeta Yadav	CDS, IISc
16:30 - 16:45pm		Bharat Ricchariya	CSA, IISc
16:45 - 17:00pm		Abhishek Ajayakuma	CDS, IISc
17:00 - 17:15pm		Arnab Kabiraj	ESE, IISc
17:15 - 17:30pm		Shubham Goswami	CDS, IISc
18:00 - 18:30pm	Faculty Talk	SP Arun	CNS/ECE, IISc
18:30 - 19:00pm	Open Discussion	Sridharan Devarajan	

Invited Talk 1: Emerging Translational Neuroimaging Approaches to study Neuroscience: Mice to Men.

Speaker: Dr. Manoj Kumar, Assistant Professor & Ramalingaswami Fellow, DNIR, NIMHANS

Abstract
Translational neuroimaging methods has empowered Neuroscience with a tool to investigate the inner structure and workings of the CNS. Translational MRI research provides an opportunity for developing non-invasive advanced neuroimaging methods for early and accurate detection and characterization of various neurological disorders in humans and animal models. These translational neuroimaging methods hold promise as non-invasive, quantitative parameters to assess the structural and functional brain connectivity and probe metabolic alternations and may be used as surrogate imaging biomarkers for studying various CNS disorders.

Bio
Dr. Manoj Kumar is currently working as an Assistant Professor in the Department of Neuroimaging and Interventional Radiology, National Institute of Mental Health and Neurosciences (NIMHANS), Bangalore, since 2019. Dr. Manoj has completed his post-doctoral research training at

the Laboratory of Molecular imaging, Perlman school of medicine, University of Pennsylvania, Philadelphia, USA. He has a keen interest in magnetic resonance imaging (MRI) and Spectroscopy (MRS) techniques to understand the pathophysiological basis of pediatrician brain diseases and neurodevelopmental disorders. His area of research is to develop non-invasive advanced MR imaging methods for early and accurate diagnosis and characterization of neurodevelopmental abnormalities in human and animal models of various pathological conditions.

Student Presentation 1: Pipelined Preconditioned s-step Conjugate Gradient Methods for Distributed Memory Systems

Manasi Tiwari

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

Preconditioned Conjugate Gradient (PCG) method is a widely used iterative method for solving large linear systems of equations. Pipelined variants of PCG present independent computations in the PCG method and overlap these computations with non-blocking allreduces. We have developed a novel pipelined PCG algorithm called PIPE-sCG (Pipelined s-step Conjugate Gradient) that provides a large overlap of global communication and computations at higher number of cores in distributed memory CPU systems. Our method achieves this overlap by introducing new recurrence computations. We have also developed a preconditioned version of PIPE-sCG. The advantages of our methods are that they do not introduce any extra preconditioner or sparse matrix vector product kernels in order to provide the overlap and can work with preconditioned, unpreconditioned and natural norms of the residual, as opposed to the state-of-the-art methods. We compare our method with other pipelined CG methods for Poisson problems and demonstrate that our method gives the least runtimes. Our method gives up to 2.9x speedup over PCG method, 2.15x speedup over PIPECG method and 1.2x speedup over PIPECG-OATI method at large number of cores.

Student Presentation 2: The functional connectivity landscape of the human brain associated with breathing and breath-hold

Anusha A. S.

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Breathing is one of the most basic functions of the human body and is central to life. It allows the body to obtain the energy it needs to sustain itself and its activities. Breathing happens naturally at rest and involves automatic but active inspiration and passive expiration. Each breath is known to follow a rhythm, that is instigated and synchronized by coupled oscillators periodically driving the respiratory cycle, most prominently the pre-Bötzinger complex located in the medulla. This brainstem neural microcircuit typically controls respiration autonomously, making the act of breathing seem effortless and continuous even during sleep or when a person is unconscious. However, it is also possible

for humans to voluntarily control their breathing, e.g., during speech, singing, crying, or during voluntary breath-holding. Even though this adaptive characteristic of respiration can be an indication of the top-down architecture of the functional neuroanatomy of voluntary respiratory control, the mechanisms underlying breath control, and the extent to which rhythmic brain activity is modulated by the rhythmic act of breathing is not fully understood at the moment. Our research focusses on investigating the differences in the electroencephalogram (EEG) based functional connectivity (FC) of the human brain during normal breathing, and voluntary breath-hold, to locate the cortical regions where the modulations are localized, and to distinguish the effects during different phases of the respiratory cycle.

Keywords : Functional connectivity, phase synchronization, electroencephalogram (EEG), breathing, breath-hold.

Student Presentation 3: A study of the fourth order joint statistical moment for dimensionality reduction of combustion datasets

Anirudh Jonnalagadda*, Shubham P. Kulkarni*, Akash Rodhiya*, Hemanth Kolla[a], Konduri Aditya*

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[a] *Sandia National Laboratories, Livermore, California, USA*

Abstract

Principal Component Analysis (PCA) is a popular dimensionality reduction technique widely used to reduce the computational cost associated with numerical simulations of combustion phenomena. However, PCA, which transforms the thermo-chemical state space based on eigenvectors of co-variance of the data, could fail to capture information regarding important localized chemical dynamics, such as the formation of ignition kernels, appearing as outlier samples in a dataset. In this paper, we propose an alternate dimensionality reduction procedure, wherein the required principal vectors are computed from a high-order joint statistical moment, namely the co-kurtosis tensor, which may better identify directions in the state space that represent stiff dynamics. We first demonstrate the potential of the proposed method using a synthetically generated dataset that is representative of typical combustion simulations. Thereafter, we characterize and contrast against PCA, the performance of the proposed method for datasets representing spontaneous ignition of premixed ethylene in a simple homogeneous reactor and ethanol-fueled homogeneous charged compression ignition (HCCI) engine. Specifically, we compare the low-dimensional manifolds in terms of reconstruction errors of the original thermo-chemical state, species production rates, and heat release rate to assess the suitability of the proposed co-kurtosis based dimensionality reduction technique. We find that the co-kurtosis based reduced manifold represents the stiff chemical dynamics, as captured by the species production rates and heat release, in the reacting zones of the system much better than PCA.

Student Presentation 4: ERP Evidences of Rapid Semantic Learning in Foreign Language Word Comprehension

Akshara Soman and Sriram Ganapathy

Department of Electrical Engineering,
Indian Institute of Science

Abstract

The event-related potential (ERP) of electroencephalography (EEG) signals has been well studied in the case of native language speech comprehension using semantically matched and mis-matched end-words. The presence of semantic incongruity in the audio stimulus elicits a N400 component in the ERP waveform. However, it is unclear whether the semantic dissimilarity effects in ERP also appear for foreign language words that were learned in a rapid language learning task. In this study, we introduced the semantics of Japanese words to subjects who had no prior exposure to Japanese language. Following this language learning task, we performed ERP analysis using English sentences of semantically matched and mis-matched nature where the end-words were replaced with their Japanese counterparts. The ERP analysis revealed that, even with a short learning cycle, the semantically matched and mis-matched end-words elicited different EEG patterns (similar to the native language case). However, the patterns seen for the newly learnt word stimuli showed the presence of P600 component (delayed and opposite in polarity to those seen in the known language). A topographical analysis revealed that P600 responses were pre-dominantly observed in the parietal region and in the left hemisphere. The absence of N400 component in this rapid learning task can be considered as evidence for its association with long-term memory processing. Further, the ERP waveform for the Japanese end-words, prior to semantic learning, showed a P3a component owing to the subject's reaction to a novel stimulus. These differences were more pronounced in the centro-parietal scalp electrodes.

Student Presentation 5: Design and Development of Implantable Electrode Arrays for Recording Signals from Rat's Brain

Suman Chatterjee[a], Vikas V[b] and Hardik J. Pandya[a,*]

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[b]*Department of Neurosurgery, National Institute of Mental Health and Neurosciences, Bangalore*
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Abstract

Electroencephalography (EEG) is a widely utilized electrophysiological monitoring technique to record the electrical activities of the brain for both research and clinical applications. Recently, the popularity of electrocorticography (ECoG), compared to EEG, has increased due to relatively higher spatial resolution and improved signal-to-noise ratio (SNR). ECoG signals, the intracranial recording of electrical signatures of the brain, are recorded by minimally invasive planar electrode arrays placed on the cortical surface. Flexible arrays minimize the tissue damage and induce minimal inflammation upon implantation. However, the commercially available implantable electrode arrays offer a poor spatial resolution. Therefore, there is a need for an electrode array with a higher density of electrodes to provide better spatial resolution for mapping brain surfaces. We have developed a biocompatible, flexible, and high-density micro-electrode array (MEA) for a simultaneous 32-channel recording of ECoG signals. Two OpenBCI Cyton Daisy Biosensing Boards were used for signal acquisition. In acute experiments, we have demonstrated that the fabricated MEA can record the baseline ECoG signals, the induced epileptic activities, and the recovered baseline activities after administering antiepileptic drug from the cortical surface of an anesthetized rat. We observed a significant increment in amplitude (approximately ten times than baseline) of the brain signals as the epilepsy was induced after topical application of a convulsant. After intraperitoneal application of an antiepileptic drug, we observed recovered baseline signals with a lower amplitude than the normal baseline signals. Though the ECoG signals can achieve better spatial resolution than EEG, it offers a limited understanding of

the activities at a brain depth where the signal originates. Recently, the implanted depth electrodes have been used for acquiring signals (Local field potentials, LFPs) from deeper regions of the brain to study the cortex, hippocampus, thalamus, and other deep brain structures. Our other work reports the design and fabrication of a silicon-based 13-channel single-shank microneedle electrode array to acquire and understand LFPs from a rat's brain. In acute in vivo experiments, LFPs from the somatosensory cortex of anesthetized rats were recorded and were acquired using OpenBCI Cyton Daisy Biosensing Board at normal, epileptic (chemically induced), and recovered (after application of antiepileptic drug) conditions. The recorded signals help us understand the response of the different layers of cortical columns after applying a convulsant and an antiepileptic drug.

Student Presentation 6: SPDE-NetII: Optimal stabilization parameter prediction with neural networks

Sangeeta Yadav, Prof. Sashikumaar Ganesan

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract:
A one-fit-all numerical solution strategy for the Singularly Perturbed Partial Differential Equations (SPPDEs) does not exist and has been an open challenge in computational sciences. A number of stabilization techniques have been proposed over the years in order to obtain a stable solution for such problems, which is also free of spurious oscillations. However, most of the stabilization techniques rely on an optimal value of the stabilization parameter, which unfortunately remains difficult to evaluate. Although an analytical formula for the optimal value of the stabilization parameter exists for a select few scenarios, such an expression for a general case does not exist. In this work, we propose a deep neural network based approach for approximating the stabilization parameter for an accurate and stable solution of the 2-dimensional convection dominated convection-diffusion equation. In this technique, the stabilization parameter is approximated by a neural network by minimizing the residual along with the crosswind term. We show that this approach outperforms state-of-the-art PINN and VarNet neural network based PDE solvers.

Student Presentation 7: Structural connectivity based markers for brain-aging and cognitive decline

Bharat Richhariya[1,2], Varsha Sreenivasan[1], Devarajan Sridharan[1,2,3], and the TLSA team[3]

[1]*Centre for Neuroscience,*
[2]*Computer Science and Automation,*
[3]*Centre for Brain Research, Indian Institute of Science, Bangalore, India*

Abstract:
Cognitive decline is common in the aging population. However, chronological age may not necessarily be an accurate marker of brain health. Recently, several studies have employed neuroimaging based techniques to accurately determine brain health, also known as "brain age". Brain Age Gap Estimation (BrainAGE) seeks to accurately estimate the difference between chronological age and brain age, with the aim of establishing trajectories of healthy aging. Accurate estimation of the brain-age gap can aid in timely identification of markers of brain-related disorders. Here,

using structural (T1-weighted) magnetic resonance imaging (sMRI) and diffusion MRI (dMRI), we seek to identify anatomical and connectivity-based markers of brain age, in a large cohort of healthy participants from the TATA Longitudinal Study of Ageing (TLSA). We analyzed 23 standardized cognitive test scores using factor analysis and observed that the variation across all scores could be explained by two latent factors alone. Next, we used the T1-weighted images of each participant to extract structural features using a pre-trained simple fully convolutional neural network (SFCN). We then used these features to predict the brain age for each participant using a leave-k-participant-out approach. Predicted brain age correlated significantly with chronological age ($r = 0.76$, $p < 0.001$) with a mean absolute error (MAE) of 3.98 years. In parallel, we asked if anatomical connectivity could also predict brain age. For this, we estimated the structural brain connectome for each participant, and quantified brain-wide anatomical connectivity. We then used these connectivity features in a multiple linear regression model with recursive feature elimination. Our regression model robustly predicted brain age ($r = 0.64$, $p < 0.001$; MAE=5.00 years). We further pruned the structural connectomes using state-of-the-art pruning algorithms, ReAl-LiFE and SIFT2, to obtain more robust connectivity estimates. Here again, we observed similar results (ReAl-LiFE: $r = 0.5$, $p < 0.001$, MAE=5.6 years; SIFT2: $r = 0.57$, $p < 0.001$, MAE=5.26 years). After pruning, the brain regions critical for these age predictions involved the frontal cortex (posterior cingulate gyrus) and the occipital cortex (lingual gyrus). We then combined the structural and the connectivity features to predict age. Predicted brain age strongly correlated with chronological age ($r = 0.76$, $p < 0.001$; MAE=3.94 years), perhaps largely driven by the structural features themselves. Finally, we asked if the brain-age gap (δ) was indicative of participants' cognitive performance. Indeed, brain-age gap correlated significantly with both latent factors 1 and 2 (Factor 1: $r = 0.19$, $p < 0.05$; Factor 2: $r = 0.220$, $p < 0.005$, controlling for age). dMRI-based connectivity and structural brain features may thus serve as reliable markers of age-related cognitive decline in healthy individuals as well as in cognitive decline due to neurological disorders such as Alzheimer's disease.

Student Presentation 8: Sparsification of reaction-diffusion complex networks

Abhishek Ajayakumar and Soumyendu Raha

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

Complex networks are graphs with underlying dynamics cast upon them. Considering a reaction-diffusion equation on the network, we try to sparsify or reduce the number of edges in the network with minimal effect on the dynamics of the sparsified network. The resulting sparsified graph would then produce a response which would be an ε approximation to the response produced by the original graph. In the first part of our work, we provide a framework to sparsify a reaction-diffusion complex network using the adjoint method for data assimilation using dimensionality reduction techniques like Proper orthogonal decomposition(POD) or Karhunen-Loeve decomposition. The second part of our work focuses on preserving the diffusion equation based on the Laplacian matrix on the graph using a second-order conic programming(SOCP) formulation.

Graph sparsification is an area of interest in mathematics and computer science. At first, we start by casting the problem of sparsification of the complex network as a data assimilation problem by considering the snapshot reaction-diffusion observations in a reduced subspace with a reduced order

model dynamics modelled on the graph using the principles of POD. We incorporate connectivity constraints in the traditional adjoint method cost function using the barrier function approach in optimization to preserve the new network's stability. We also use regression terms in the cost function to avoid overfitting. The weight vector found is used to construct the new Laplacian matrix.

In the later part of our work, we use the estimate based on sampling edges by effective resistances to find upper bounds on edge weights which forms constraints of the SOCP. We also impose non-negativity of edge weights as constraints. Certain cut constraints also form constraints for the problem. We use concepts from the theory of compressed sensing to formulate the objective function of the SOCP, with several conic constraints coming from the snapshot observations. We are investigating ways to make this approach computationally feasible using techniques like random projections to reduce the number of constraints in the SOCP.

We evaluated our procedures on several random graphs, and we obtained graphs with a reduced number of edges on the graphs tested.

Student Presentation 9: High-Throughput Computational Techniques for Discovery of Application-Specific Two-Dimensional Materials

Arnab Kabiraj and Santanu Mahapatra

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

Two-dimensional (2D) materials have revolutionized the field of materials science since the successful exfoliation of graphene in 2004. Consequently, the advances in computational science have resulted in massive generic databases for 2D materials, where the structure and the basic properties are predicted using density functional theory (DFT). However, discovering material for a given application from these vast databases is a challenging feat. As part of my PhD, we have developed various automated high-throughput computational pipelines combining DFT and machine learning (ML) to assess the suitability of 2D materials for specific applications. Methods have also been developed to draw valuable insights into what makes these materials suitable for these applications. The assessed properties include suitability for energy storage in the form of Li-ion battery (LIB) and supercapacitor electrodes, along with high-temperature ferromagnetism and the presence of exotic charge density waves (CDW). The ultra-large surface-to-mass ratio of 2D materials has made them an ideal choice for electrodes of compact LIBs and supercapacitors. We combine explicit-ion and implicit-solvent formalisms to develop the high-throughput pipeline and define four descriptors to map â€œcomputationally softâ€. single-Li-ion adsorption to â€œcomputationally hardâ€. multiple-Li-ion-adsorbed configuration located at global minima for insight finding and rapid screening. Leveraging this large dataset, we also develop crystal-graph-based ML models for the accelerated discovery of potential candidates. A reactivity test with commercial electrolytes is further performed for wet experiments. Our unique approach, which predicts both Li-ion storage and supercapacitive properties and hence identifies various important electrode materials common to both devices, may pave the way for next-generation energy storage systems. The discovery of 2D ferromagnets with high Curie temperature is challenging since its calculation involves a manually intensive complex process. We develop a Metropolis Monte-Carlo based pipeline and conduct a high-throughput scan of 786 materials from a database to discover 26 materials with a Curie point

beyond 400â€‰K. For rapid data mining; we further use these results to develop an end-to-end ML model with generalized chemical features through an exhaustive search of the model space as well as the hyperparameters. We discover a few more high Curie point materials from different sources using this data-driven model. CDW materials are an important subclass of two-dimensional materials exhibiting significant resistivity switching with the application of external energy. We combine a first-principles-based structure-searching technique and unsupervised machine learning to develop a high-throughput pipeline, which identifies CDW phases from a unit cell with an inherited Kohn anomaly. The proposed methodology not only rediscovers the known CDW phases but also predicts a host of easily exfoliable CDW materials (30 materials and 114 phases) along with associated electronic structures.

Student Presentation 10: A scalable asynchronous computing approach for discontinuous-Galerkin method based PDE solvers

Shubham K. Goswami, Konduri Aditya

Department of Computational and Data Sciences,
Indian Institute of Science

Abstract

Due to the ability to provide high-order accurate solutions in complex geometries, the discontinuous-Galerkin (DG) method has received broad interest in developing partial differential equation (PDE) solvers, particularly for equations with hyperbolic nature. In addition, the method also provides high arithmetic intensity and, in an explicit formulation, avoids global linear solves, making it suitable for high-performance computing platforms. However, massively parallel simulations based on the DG method show poor scalability of solvers. This is mainly attributed to data communication and synchronization between different processing elements (PEs). Recently, an asynchronous computing approach was proposed based on finite differences that relax communication/synchronization at a mathematical level. In this approach, computations at PEs can proceed regardless of the communication status between the PEs, thus improving the scalability of PDE solvers. In this work, we extend the asynchronous computing approach to the DG method for improving its scalability at extreme scales. We investigate the numerical properties of standard DG schemes under relaxed communication synchronization and show that their accuracy drops to first order. Subsequently, we develop new asynchrony-tolerant fluxes that result in solutions of any arbitrary order of accuracy. Results from simulations of one-dimensional linear and nonlinear equations will be presented to demonstrate the accuracy of the asynchronous DG method.

Faculty Talk: How does the brain crack CAPTCHAs?

Speaker: SP Arun, CNS/ECE, IISc

Abstract

It was famously remarked in the 1980s that a major question for AI is "What is the letter A?". Surprisingly, even today, the simple act of recognizing text is so challenging for computers that we continue to use distorted letter CAPTCHAs to validate a user as human. So how does the brain crack CAPTCHAs? In the monkey inferior temporal cortex, an area critical for recognition, we show that single neurons encode distorted letter strings according to highly systematic rules that enable perfect distorted letter decoding. Remarkably, the same rules were present in neural networks trained for

text recognition. I will describe this and some related findings elucidating object recognition at the behavioral, neuronal and computational levels.

Bio
SP Arun trained as an electrical engineer, read too much science fiction for his own good and became a neuroscientist. He is fascinated by how the brain transforms sensation into perception, and studies this in his lab at the Centre for Neuroscience, Indian Institute of Science, Bangalore.

3.1.8 Cluster: Microelectronics

Cluster Coordinator: Chetan Singh Thakur (ESE)
Student Organizer: Shreeparna, Lokesh, Rishikesh
Faculty Organizer: Arup Polley
Location: ECE MP-20

Cluster Overview

Cluster Overview			
Time	Event	Speaker	Affiliation
14:30pm-15:00pm	Invited Talk 1	Dr. Manish Goel	Samsung
15:00pm-15:30pm	Invited Talk 2	Vinod Menezes	Texas Instruments (India) Ltd
15:30pm-16:00pm	Invited Talk 3	Sai Gunaranjan Pelluri	Steradian Semiconductors
16:00pm-16:15pm	Student Presentations	Pratik Kumar	ESE,IISc
16:15pm-16:30pm		Rabindra Biswas	ECE,IISc
16:30pm-16:45pm		Faheem Ahmad	ECE,IISc
16:45pm-17:00pm		Suman Chatterjee	ECE,IISc
17:00pm-17:15pm		Nithin Abraham	ECE,IISc
17:15pm-17:30pm		Anil Vishnu G K	ESE,IISc
17:30pm-17:45pm		Alekya B	ESE,IISc
17:45pm-18:00pm		Jogesh Chandra Dash	ECE,IISc
18:00pm-18:15pm		Shantharam Kalipatnapu	ECE,IISc
18:30pm-18:45pm		Kiran R	ECE,IISc
18:45pm-19:00pm		Arif Mohd. Kamal	ESE,IISc

Invited Talk 1 : Image Sensors and Multimedia

Speaker: Dr. Manish Goel, Senior Director, Business head for Sensors and LSI.

Abstract

We will discuss key challenges for image processing systems for mobile use cases.

Bio

Manish got his B.Tech from IITD in 1994 and MS and PhD from Univ of Illinois at Urbana-Champaign in 2000. Manish worked at Texas Instruments Dallas for 14 years and was elevated to Distinguished Member to Technical Staff. Manish has been working in Samsung for last 8 years, first 4 years in Dallas and recent 4 years at SSIR. Manish received UIUC Young Alumni Achievement Award in 2011. Manish's research interests are in signal processing architectures, communication and multimedia systems. Manish has 60+ US patents granted under his name.

Invited Talk 2 : Analog design in the sub-threshold

Speaker: Vinod Menezes, Texas Instruments (India) Ltd

Abstract

Sub-threshold analog design has made inroads into industrial class products. This is one area were winners can boast about the lowest Iq in the industry. One usually associates designing in the subthreshold as giving up performance, or giving up robustness, and hence are perceived as best avoided for industrial designs. This talk is about the key care about's, pitfalls, approaches for analog design in the sub-threshold, while balancing performance and robustness.

Bio

Vinod Menezes, holds a BE(CSE) from RVCE Bangalore, MSc(Eng)(ECE) IISc Bangalore. He joined Texas Instruments (TI) in 1990. He is currently a Distinguished Member of the Technical Staff (DMTS) in the Analog Power Products group. He is involved in the definition development of Technology and Circuit IP for Linear Power products. His work has spanned 0.8um to 28nm CMOS nodes.

Invited Talk 3 : High Resolution Imaging Radar

Speaker: Sai Gunaranjan Pelluri

Abstract

Many important modern-day applications such as autonomous driving, traffic monitoring, surveillance etc. warrant the use of Imaging radars - that offer high detection accuracy and resolution while maintaining privacy. Imaging radars need to act as more than 4-D imaging devices that not only detect range, Doppler and direction-of-arrival (in Azimuth and Elevation) with high accuracy, but

also provide information on object classification, etc. Considering state-of-the-art IC, MIMO antenna array and signal processing systems that reinforce each other in bringing out high resolution imaging at optimal cost.

Bio

Sai Gunaranjan Pelluri received his Master's(Research) degree from IISc, Bangalore in 2017 specializing in signal processing and joint spectro-temporal analysis. Post his Master's, he joined Texas Instruments, India as a Systems Engineer working on on-chip RADAR systems. At TI, his work primarily involved gauging the performance of RF parameters of the RADAR SoC. In 2018, he joined Steradian Semiconductors, a startup developing Radar Transceivers and complete Radar Sensor Systems for Imaging applications. In Steradian Semiconductors, he currently works as a Lead Design Engineer and is responsible for developing efficient signal processing algorithms for generating a point cloud image from RADAR measurements. He has worked on several schemes like Time Division Multiplexing, Code Division Multiplexing, High-Resolution spectral estimation algorithms to improve both accuracy and resolution aspects of various RADAR parameters such as Range, Velocity, Angle. His interests include signal processing, stochastic processes, matrix theory, and machine learning among others. He is passionate about reading.

Student Presentation 1: Micro-Watts Analog Processor for Machine Learning at the Edge.

Pratik Kumar

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

Machine learning has become a part of our everyday lives: from social media that learn over time our customized preferences to self-driving cars that demand reliable accuracy. However, implying such learning techniques at resource-constrained edge devices had posed a significant challenge. These smart algorithms feed on huge data sets and require complex networks that demand extensive hardware and power. State-of-the-art digital implementations offer a boost in performance while trading it off with area and power. However, the potential of analog circuits to provide energy and performance boost stands unparalleled despite its low immunity to non-idealities. In this regard, we present the first in-house fully analog AI processor based on a novel shape-based approximate computing framework that accounts for the non-ideal effects. This AI processor is fabricated on CMOS 180nm technology and can be operated across different regimes of MOS operation, and is also scalable through temperatures. The processor can be tuned to perform at nine orders of magnitude (1uA to 1pA), thus providing a wider choice for power. We utilized the novel computational blocks to show standard classification and regression tasks.

Student Presentation 2: Nonlinear nanophotonics in a two-dimensional material

Rabindra Biswas

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Two-dimensional (2D) materials have emerged as an excellent platform for building ultra-thin nonlinear photonics devices due to their high refractive index and strong nonlinear response. These materials are known to have layer dependent, electrically tunable optical properties with relaxed lattice and thermal mismatch requirement. 2D materials can also be used in various applications, such as wavelength converter, saturable absorber, optical modulator, and parametric down-converter.

Firstly, we characterized the nonlinear properties of multi-layered Tin Diselenide ($SnSe_2$). We investigated up-conversion of 1550 nm incident light using third-harmonic generation (THG) in multi-layered $SnSe_2$, with the help of a multiphoton nonlinear microscopy setup. We have also studied its thickness dependence by simultaneously acquiring spatially resolved images in the forward and backward propagation direction. Next, we demonstrated strong second-harmonic generation (SHG) from a 2H polytype of multilayer Tin Diselenide. In the absence of excitonic resonance, the strong SHG from $SnSe_2$ is attributed to the dominant band to band transition close to the indirect band edge. The SHG intensity was compared with a monolayer Molybdenum disulphide (MoS_2) and is found to be ≈ 34 and 3.4 times higher, for excitation wavelengths of 1040 nm and 1550 nm, respectively. This work highlights the applicability of multi-layered 2D materials for building photonic devices despite having no excitonic resonance.

Next, to make use of the strong nonlinear response, we numerically and experimentally demonstrated an optimized multilayer fabry-perot based dual-resonance structure to simultaneously enhance the fundamental and second harmonic field. This, in turn results in strong SHG signal generated from a multilayer Gallium Selenide (GaSe). The optimal vertical superlattice structure obtained using a hybrid evolutionary optimization numerical approach results in ≈ 400 times enhancement in the SHG signal in the backward direction, compared to a single layer GaSe on 300nm Si-SiO_2 substrate. The planer geometry of the optimized structure makes it perfectly compatible with CMOS backend integration.

Student Presentation 3: Optical System Design for Indoor Visible Light Communication system

Faheem Ahmad, Sathisha Ramachandrapura Nagaraju, Jyothsna K. M and Varun Raghunathan

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Indoor visible light communication (VLC) is seen as a promising high bandwidth access technology for emerging heterogeneous wireless networks for meeting the increasing data bandwidth requirements from mobile personal devices. Stand-alone VLC links making use of white or multicolor light-emitting diodes (LED), blue laser down-converted white light, and multicolor lasers as transmitters have been used to demonstrated multigigabit communication performance. In our lab we work on optical

system design, such as VLC transmitter to serve both illumination and communication, path-loss optimization for variable link length, mechanical and non-mechanical beam steering, and mobile receiver tracking system for the indoor giga-bit class VLC system.

Path-Loss Optimization: We discuss an optical ray-tracing approach for minimizing path-loss in a variable link length indoor blue laser down-converted white light visible light communication (VLC) system. For a given link length, minimum path-loss is achieved by finding optimum positions of transmitter and receiver lenses relative to phosphor and detector respectively such that collection efficiency is maximized. The designed VLC system is experimentally implemented for two different optimized link lengths of 25 and 300 cm. The illumination beam profile and propagation characteristics are found to be in good agreement with optical simulations. Communication experiments with on-off modulation at 1.5 Gbps achieved BER of 3 × 10-3 for the optimized link, which is below the forward-error correction threshold.

Closed-Loop Non-Mechanical Beam Steering System: In this experiment, we demonstrate a hybrid Laser-LED transmitter module for indoor optical wireless communication with closed-loop, non-mechanical beam steering capability. The hybrid transmitter module consists of a near infrared laser diode for data communication and white LED array for illumination, combined on a diffuser surface. Dual-axis non-mechanical beam steering of the laser beam is implemented using two off-centered liquid lenses. The diffused laser beam directed towards the receiver is steered over an angular range of -7.6° to 7.6° (-1.7° to 2.6°) along the horizontal (vertical) axes spanning -200 to 200 mm (-44 to 67 mm) at the receiver placed 1.5-meter from the transmitter. M-QAM/OFDM in combination with adaptive bit-and power-loading is utilized to achieve a total data throughput of 5.15 Gbps for the diffused laser beam with steering. Laser intensity levels as measured at the receiver plane are kept below the maximum permissible exposure limit for indoor usage across the entire beam steering range. Closed-loop beam steering is also demonstrated by scanning the transmitted laser beam horizontally, measuring the signal strength using a low bandwidth photodetector and locking the laser beam to the receiver position for data-communication. Such hybrid transmitters offer the benefit of decoupling the data communication and illumination requirements of the indoor optical link, thereby tailoring the individual light emitter's performance to specific use-case.

Student Presentation 4: Trion-trion annihilation in monolayer WS2

Suman Chatterjee and Kausik Majumdar

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Strong Coulomb interaction in monolayer transition metal dichalcogenides can facilitate nontrivial many-body effects among excitonic complexes. Many-body effects like exciton-exciton annihilation (EEA) have been widely explored in this material system. However, a similar effect for charged excitons (or trions), that is, trion-trion annihilation (TTA), is expected to be relatively suppressed due to repulsive like-charges, and has not been hitherto observed in such layered semiconductors. By a gate-dependent tuning of the spectral overlap between the trion and the charged biexciton through an "anti-crossing"-like behaviour in monolayer WS_2, here we present an experimental observation of an anomalous suppression of the trion emission intensity with an increase in gate voltage. The results strongly correlate with time-resolved measurements, and are inferred as a direct evidence of a nontrivial TTA resulting from non-radiative Auger recombination of a bright trion, and the

corresponding energy resonantly promoting a dark trion to a charged biexciton state. The extracted Auger coefficient for the process is found to be tunable ten-fold through a gate-dependent tuning of the spectral overlap.

Student Presentation 5: Astability *versus* Bistability in van der Waals Tunnel Diode for Voltage Controlled Oscillator and Memory Applications

Nithin Abraham and Kausik Majumdar

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

Van der Waals (vdW) tunnel junctions are attractive due to their atomically sharp interface, gate tunablity, and robustness against lattice mismatch between the successive layers. However, the negative differential resistance (NDR) demonstrated in this class of tunnel diodes often exhibits noisy behaviour with low peak current density, and lacks robustness and repeatability, limiting their practical circuit applications. Here we propose a strategy of using a 1L-WS as an optimum tunnel barrier sandwiched in a broken gap tunnel junction of highly doped black phosphorus (BP) and SnSe. We achieve high yield tunnel diodes exhibiting highly repeatable, ultra-clean, and gate tunable NDR characteristics with a signature of intrinsic oscillation, and a large peak-to-valley current ratio (PVCR) of 3.6 at 300 K (4.6 at 7 K), making them suitable for practical applications. We show that the thermodynamic stability of the vdW tunnel diode circuit can be tuned from astability to bistability by altering the constraint through choosing a voltage or a current bias, respectively. In the astable mode under voltage bias, we demonstrate a compact, voltage controlled oscillator without the need for an external tank circuit. In the bistable mode under current bias, we demonstrate a highly scalable, single element one-bit memory cell that is promising for dense random access memory applications in memory intensive computation architectures.

Student Presentation 6: A point-of-care lab-on-PCB for detection of protein-protein interactions using bioimpedance measurements

Anil Vishnu G K, Anju Joshi, Hari R. S., Aniket Das Gupta, Siddhartha Sinha Roy, and Hardik J. Pandya*

Department of Electronic Systems Engineering,
Indian Institute of Science
**Corresponding author (email id: hjpandya@iisc.ac.in)*

Abstract

Accurate detection of sub-nanogram levels of proteins from body fluids and tissues is a cornerstone of clinical diagnostics and guiding treatment strategies. Detection of pathological levels of specific proteins finds applications in infectious diseases, cancer diagnostics, and cardiovascular diseases, to name a few. The existing gold standard techniques for highly sensitive detection are the enzyme-linked immunosorbent assay (ELISA) and reverse transcriptase-polymerase chain reaction (RT-PCR) tests. In contrast, colorimetry-based lateral flow assays are used for point-of-care rapid testing. ELISA and RT-PCR, though highly sensitive and specific, are time-consuming, expensive, and require trained personnel to perform the tests. However, colorimetry-based rapid tests have

high false-negative rates and can only detect highly expressed levels of proteins. We report the development and validation of a point-of-care system and a novel methodology for high-throughput and sensitive detection of protein-protein interactions (antigen-antibody binding) by electrical impedance sensing. Microchips fabricated on industry-compatible ENIG and soft gold finish printed circuit board (PCB) are chemically modified for enhanced antibody immobilization and antigen capture by the antibodies. The microchips are interfaced with a field-programmable gate array (FPGA)-based bioimpedance measurement module for detecting antigen-antibody binding events through changes in measured impedance and phase. A statistically significant reduction in impedance with respect to the control (only antibody) at 10 kHz was observed for analyte concentrations from 40 pg to 200 pg ($30.1 \pm 3.56\ \Omega$ (40 pg), $44.73 \pm 5.63\ \Omega$ (120 pg), and $66.5 \pm 6.1\ \Omega$ (200 pg)). The assay has a limit of detection of 40 pg and can detect antigens with microlitre (20 – 40 μL) volumes of the analyte.

Student Presentation 7: Sensorized Catheter for Quantitative Assessment of the Airway Caliber

Alekya B and Hardik J.Pandya

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

This work reports the design and development of a sensorized intubation catheter for chronic airway management. Central airway obstruction remains a diagnostic and therapeutic challenge in clinical practice. Severely constricted airways often warrant continuous monitoring as resistance to flow increases to fourth power for every one-degree reduction in tracheal patency. The complexities and impediments with conventional diagnostic tools such as misclassification on the degree of narrowing and long radiation exposure make them sub-optimal for diagnosis. Therefore, it is of utmost clinical interest to develop tools and methods that can provide diagnostic solutions with a fast turnaround time. The catheter is integrated with an array of flow and tactile sensors along with a smart helical spring actuator for manoeuvring the catheter. Flow distribution is measured in excised sheep tracheal tissues at 15, 30, 50, 65, and 80 l/min for multisegmental and varying grades of tracheal stenosis. Even mild reduction in lumen area generated unique peaks corresponding to the obstruction site. For a 50% tracheal obliteration, the sensor closest to stenosis showed a 2.4-fold increase in velocity when tested for reciprocating flows. From axial compression load test, the stiffness of tracheal segments such as the cartilage and smooth muscle tissue measured using the tactile sensor are 23±1.39 N/m and 14.02±0.76 N/m at 30% strain rate. Also, the tissue relaxation behavior and its regional dependence recorded using the sensor reveal smooth muscle tissues' highly compliant behaviour. While the flow patterns allow for locating stenosis, the tactile sensors can determine the target tissue stiffness. Quantitative evaluation of alteration in the airway column biomechanics facilitates targeted diagnosis and expedites on-site decision making.

Student Presentation 8: Suppression of Higher Order Modes in a Four Element CSRR Loaded Multi-Antenna System and An Overview of Full-Duplex Antenna Design

Dr. Jogesh Chandra Dash

Department of Electrical Communication Engineering,

Indian Institute of Science

Abstract

A compact four-port dual-band microstrip-patch sub-array antenna with suppressed higher order modes (HOMs) for Massive-MIMO application is proposed. First, complementary split ring resonator (CSRR) loading is used on a square microstrip antenna to achieve simultaneous miniaturization and dual-band response. Next, the HOMs in the proposed CSRR loaded MIMO configuration are analysed using equivalent circuit model as well as surface current distribution plots. By placing a single shorting post close to antenna center line, these HOMs of the four-port dual-band MIMO antenna are then suppressed, while maintaining satisfactory mutual coupling (< -11 dB) and impedance matching (< -15 dB) performance in the operating band. Further, stating the effect of mutual coupling in a multi-antenna system for Full-Duplex (FD) communication we propose a closely spaced two-port microstrip patch antenna system with significant isolation enhancement (> 90 dB), which can be deployed for MIMO as well as FD transceiver systems. We deploy a resonant combination of rectangular defected ground structure (DGS) and a near-field decoupling structure (NFDS) in the vicinity of a closely spaced (inter-element spacing = $0.01\lambda_0$) two-port microstrip patch antenna system at 5.85 GHz. This drastically reduces the port-to-port mutual coupling (< -90 dB), which can help in self-interference cancellation for FD point of view without any additional circuitry, while still preserving desired impedance matching performance (< -15 dB). The proposed concepts are validated by full-wave simulation in CST Microwave Studio, as well as experimental results on fabricated prototype. Moreover, MIMO performance metrics such as total active reflection coefficient (*TARC*), envelop correlation coefficient (*ECC*) and channel capacity loss (*CCL*) are analysed using simulation and measurement.

Student Presentation 9: Generation of Control Signals using Second-Nyquist zone technique for Superconducting Qubit Devices

Shantharam Kalipatnapu

Department of Electronic system Engineering,
Indian Institute of Science

Abstract

There is growing interest in developing integrated room temperature control electronics for the control and measurement of superconducting devices for quantum computing applications. With the availability of faster DACs, it has become possible to generate microwave signals with amplitude and phase controls directly without requiring any analog mixer. In this report, we use the evaluation kit ZCU111 to generate vector microwave pulses using the second-Nyquist zone technique. We characterize the performance of the signal generation and measure amplitude variation across second Nyquist zone, single-sideband phase noise, and spurious-free dynamic range. We further perform various time-domain measurements to characterize a superconducting transmon qubit and benchmark our results against traditionally used analog mixer setups.

Student Presentation 10: Stochastic Algorithms for Radial Point Interpolation Method Based Computational Electromagnetic Solvers

Kiran R

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract

A time-domain stochastic radial point interpolation method (SRPIM) is developed for uncertainty quantification of electromagnetic systems. Fabrication processes cause uncertainty in dielectric constant in engineered systems. Similar variations in properties are evident in biological tissues. Derivatives of field quantities in Maxwell's equations are obtained using radial basis function, and stochasticity in dielectric constant are incorporated through polynomial chaos expansion (PCE).

SRPIM is further made faster by utilizing the linearization of product of Hermite polynomials, which reduces PCE coefficient matrix and thereby eliminating a good number of multi-dimensional integrations. This will avoid considerable computations in the stochastic implementation, and the computational gain increases with the dimensionality of the problem. This is validated by choosing the example of an implanted cardioverter defibrillator where the effect of electromagnetic interference from a mobile phone placed in its close proximity is modeled and the uncertainty is quantified. Such uncertainty quantification may help regulatory agencies to issue appropriate guidelines for users.

Accuracy of these simulations are validated using Kolmogorov Smirnov test, with Monte Carlo (MC) simulation as the reference. Computation time of the proposed methods are found significantly better than MC . The proposed methods perform well even for large stochastic variations.

Student Presentation 11: Design and Development of an Intraoperative Probe to Delineate Cancer from Adjacent Normal Breast Biopsy Tissue

Arif Mohd.Kamal and Hardik J.Pandya

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

This work reports the design and development of diffuse reflectance spectroscopy (DRS) based intraoperative handheld probe (Multispectral-Pen) to characterize cancerous tissues from adjacent normal tissues and accurately determine the tumor margin. The assessment of tumor margin is a crucial challenge during breast-conserving surgery. The clinician extracts the malignant core region and a margin (up to a few millimeters) from the adjacent normal regions to ensure complete tumor resection. The frozen section-based histopathological analysis guides the clinician to confirm a clear margin. Even though highly accurate, this technique suffers from concerns such as being time-consuming and requiring additional sample preparations, resulting in sampling errors and being expensive. We have developed a novel handheld probe that can study the changes in the cancerous tissue compared to adjacent normal tissue based on the detected voltage. The higher value of detected voltage observed for cancerous tissue compared to the adjacent normal tissue at the operating wavelength of 850 nm (3.58 ± 0.07, 2.82 ± 0.12), 940 nm (3.89 ± 0.06, 3.19 ± 0.10), and 1050 nm (3.78 ± 0.04, 3.32 ± 0.07), respectively. The detected voltage values can be further used to quantify the absorption and reduced scattering coefficients of the malignant and adjacent normal tissues, a basis for on-site tumor delineation.

3.1.9 Cluster: Power

Chair: Mr. Giridharan Shanmugavel **Cluster Coordinator**: Udaya Kumar (EE), Narayanan Gopalaratnam (EE), Umanand L (ESE)
Student Organizer: Dharani, Utkarsh
Faculty Organizer: Vishnu M Iyer, EE
Location: ECE 1.08

Cluster Overview

Cluster Overview			
Time	Event	Speaker	Affiliation
14:35 - 14:55pm		Anwesha Mukhopahyay	EE, IISc
14:56 - 15:16pm		Manish Tathode	EE, IISc
15:17 - 15:37pm		Subhas Chandra Das	EE, IISc
15:38 - 15:58pm		P Sidharthan	EE, IISc
15:59 - 16:19pm		Vishwabandhu Uttam	EE, IISc
16:20 - 16:40pm	Student Presentations	Mohammed Imthias	ESE, IISc
16:41 - 15:01pm		Souradeep Pal	ESE, IISc
15:02 - 17:22pm		Ruman Kalyan Mahapatra	ESE, IISc
18:00 - 18:19pm		Sayan Paul	EE, IISc
18:20 - 18:39pm		Ashiq Muhammed	EE, IISc
18:40 - 19:00pm		Sayantan Das	EE, IISc

Student Presentation 1: DC Bus Second Harmonic LC Filter with Solid-State Tuning Restorer

Anwesha Mukhopadhyay

Department of Electrical Engineering,
Indian Institute of Science

Abstract
Single-phase voltage source converters (VSC) find wide applications as an inverter, which integrates renewable sources, e.g., solar PV, fuel cell or battery storage system, into the grid. Also, different variable frequency drives, e.g., traction drives in electric locomotives, use single-phase VSC as the front end stage. However, there is always a mismatch between dc side power and instantaneous ac side power in single-phase VSCs. The difference power is oscillatory, with a frequency twice the ac side frequency. This oscillatory power affects the health and lifespan of dc sources adversely and causes torque oscillations in drives applications. To prevent this, various passive, active and hybrid filtering techniques are adopted to handle the difference power. Passive filter, consisting only of capacitor, necessitates large capacitor bank to keep double frequency voltage ripple across dc source within the limits. As traditionally used electrolytic capacitors have reliability concerns, the use of more reliable plastic film capacitors appears to be reasonable in applications, demanding greater availability. However, the large capacitance requirement often makes the filter size impracticable to be realized with film capacitors. The use of passive tuned LC filter reduces capacitance requirement, but can become ineffective if it gets detuned due to variation in filter parameters or grid frequency. As a result, the voltage across the dc source can exhibit a significant double frequency ripple. Active

filters offer consistent and superior performance at the cost of additional switches, usually of rating comparable to those of the main VSCs. Also, the main VSC functions satisfactorily as long as the added switches are functional. The above concerns are addressed by the proposed hybrid filter configuration, which employs an auxiliary converter to enhance the performance of LC-tuned filters while using switches of much lower ratings. Moreover, the failure or non-availability of the auxiliary converter does not completely disrupt the operation of the main converter. The performance of the proposed filter is verified in an experimental prototype which shows effective second harmonic filtering.

Student Presentation 2: Maximum Current Cell Voltage Equalization with Phase-shift Based Control for Multi-active Half-bridge Equalizer

Manish Tathode

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Lithium-ion battery stacks maintain the continuity of power supply in the solar powered satellites. The series connected battery stacks are often operated at high charging and discharging current levels to minimize the weight. The initial imbalance in the individual cell voltages of the stack, which can be due to manufacturing tolerances, different operating temperatures,etc., grows faster as the number of the high-current-charge-discharge cycles increases. The increased imbalance results either in the early failure of the undercharged cells or in the under-utilization of overcharged cells. Voltage equalization of the stack is performed to bring all the cell voltages in a narrow band by charging the undercharged cells by the overcharged cells. Out of many equalization methods, multicell-to-multicell equalization offers higher rate by simultaneously charging-discharging all the un-equalized cells. Phase Shifted Multi Active Half-Bridge (PS-MAHB) equalizer is one of the multicell to multicell, open-loop equalizers. It maintains high levels of equalization current throughout the equalization offering fast equalization unlike commonly known Switched-Capacitor and multi-winding transformer based equalizers. A dynamic phase shift based control is proposed to maintain the equalization current through the cells at maximum throughout the cell voltage variation during the charge-discharge cycle. The proposed control increases the rate of equalization still further than the existing static phase shift based control. The higher rate of equalization offered by PS-MAHB equalizer as compared to commonly known Switched-Capacitor and multi-winding transformer based equalizers with the existing control and further increased rate with proposed control is verified in the simulation.

Student Presentation 3: Experimental Study of Sensitivity of IGBT Turn-on and Turn-off Delay Times and their Sub-intervals

Subhas Chandra Das

Department of Electrical Engineering,
Indian Institute of Science

Abstract

This paper examines the junction temperature sensitivity of the turn-on and turn-off delay times during IGBT switching transitions. The study is carried out with experimental measurements of switching transitions on different IGBTs of comparable ratings. For each device test, the junction temperature is varied in the range from -35°C to 125°C. The study, through a large body of experimental data, confirms that the turn-off delay time, $t_{d,off}$, increases with junction temperature, T_j. However, unlike $t_{d,off}$, the turn-on delay time, $t_{d,on}$, seems to have divergent trend for different IGBT devices. Further, $t_{d,on}$ is split into two intervals, namely $t_{d,on,1}$ and $t_{d,on,2}$. During the first interval $t_{d,on,1}$, the gate voltage rises from IGBT off-state gate voltage, $V_{GE(off)}$ to 10% of the on-state gate voltage, i.e., $0.1V_{GE(on)}$. And the time duration, during which, the gate voltage rises from $0.1V_{GE(on)}$ to threshold voltage, v_{th} during the second interval $t_{d,on,2}$. Experimental study shows, the delay time $t_{d,on,1}$ marginally increases with increase in T_j. On the other hand, $t_{d,on,2}$ reduces significantly with increase in T_j. The experimental study suggests that $t_{d,on,1}$ could be used as a temperature sensitive parameter for indirect measurement of IGBT junction temperatures.

Student Presentation 4: Stored Energy-Limited High-Voltage Power Supply for Travelling Wave Tube Application

P Sidharthan

Department of Electrical Engineering,
Indian Institute of Science

Abstract

Travelling Wave Tubes are amplifiers capable of operating over multiple octave bandwidths, finding applications in civilian communication, weather radars, air traffic control, etc., and for military requirements like search radars, electronic warfare, missile guidance and tracking, etc. On account of metal to ceramic joints with high voltage presence across them inside the tube's vacuum envelop, there exists a partial or severe arcing possibility during the operation of the TWT. Therefore, the high voltage power supply powering the TWT is designed to withstand and limit the energy that may be discharged through the tube under expected operating conditions to prevent temporary or permanent damages arising out of high voltage arcing. This presentation describes the development of a compact power supply for a TWT demanding high voltage DC power of the order of 500W @ 4.3kV for the operation. Development of compact high voltage planar transformer, techniques to contain the EMI through the physical layout of the power converter switches, soft-switching, power line decoupling, selection of rectifiers for low loss and ripple, etc., are briefly touched upon in the presentation. The presentation also touches upon the challenges in using the latest GaN MOSFETs in high frequency-switched power converters from the output voltage ripple and EMI generation perspectives.

Student Presentation 5: A Unified Modeling Approach for a Triple Active Bridge Converter

Vishwabandhu Uttam

Department of Electrical Engineering,
Indian Institute of Science

Abstract

This talk introduces a systematic methodology to develop a unified model for a multi-port Triple Active Bridge (TAB) converter. The proposed model accurately predicts the AC port currents in a TAB converter. The model can be used to compute performance metrices of the TAB converter such as the peak and RMS currents at the AC ports, and the average currents at the DC ports. One of the features of the proposed model is that it can predict the impact of transformer magnetizing inductance on the AC and DC port currents. The proposed model is valid for all operating modes and modulation strategies of the TAB converter. The accuracy of the model has been verified against extensive switching circuit simulations for a variety of operating conditions. Experimental results from a TAB converter laboratory prototype are also presented to showcase the impact of magnetizing inductance variation on TAB converter performance.

Student Presentation 6: Minimisation of Switched-Capacitor Voltage Ripple in a 12-Sided Polygonal Space Vector Structure for Induction Motor Drives

Mohammed Imthias and Umanand L

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract
A multilevel 12-sided polygonal voltage space vector generation scheme for variable-speed drive applications with a single DC-link operation requires an enormous capacitance value for cascaded H-bridge (CHB) filters when operated at lower speeds. The multilevel 12-sided polygonal structure is obtained in existing schemes by cascading a flying capacitor inverter with a CHB. This paper proposes a new scheme to minimise the capacitance requirement for full-speed operation by creating vector redundancies using modular and equal voltage CHBs. Also, an algorithm has been developed to optimise the selection of vector redundancies among the CHBs to minimise the floating capacitors' voltage ripple. The algorithm computes the optimal vector redundancies by considering the instantaneous capacitor voltages and the phase currents. The effectiveness of the proposed algorithm is verified in both the simulation and the experiment.

Student Presentation 7: An investigation on increasing the modulation range linearly in hybrid multilevel inverter fed induction machine drives regardless of load power factor.

Souradeep Pal and Umanand L

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract
IN last decade multilevel inverters (MLIs) have become very popular in high power applications namely variable speed drives, high voltage DC transmission, renewable energy and electric vehicles. It offers many advantages such as low harmonic distortion in voltage and current, low dv/dt across motor phase terminals, less bulky filter size, operation at low switching frequency etc. There are three popular MLI topologies - Neutral point clamp (NPC), Flying Capacitor (FC) and Cascaded H-Bridge (CHB) which are widely discussed in the literature. MLIs can also be realised by a dual inverter structure feeding an open-end winding induction motor (OEWIM) where either end of stator terminals are connected to two separate inverters. Among several dual inverter topologies,

recently, the dual inverter with a single DC-link has become popular. Here the primary inverter is supplied by a DC link, and the secondary inverter is fed from a floating capacitor. This configuration aids in increasing the phase voltage levels with a reduced number of switches besides the benefit of reliability and fault-tolerant capability. These two inverters together can generate a combined hexagonal multilevel space vector structure (SVS) of radius Vdc similar to a 2-level inverter single hexagonal structure feeding the IM from one end using a DC-link voltage of Vdc. For any hexagonal SVS, the maximum peak phase fundamental voltage that can be attained from a DC link of Vdc is 0.637Vdc (correspond to the full base speed operation of the IM drive), when the inverter operates in six-step mode. But the generic SVPWM mode operation can achieve a peak phase fundamental of 0.577Vdc in extreme linear modulation range (LMR). Here the maximum radius of the rotating voltage space vector (SV) is 0.866Vdc which can be inscribed within the hexagonal SVS. Further increasing of the modulation range above 0.577Vdc will result in all the lower order harmonics (predominantly 5 th , 7 th , 11th and 13th) appearing in the motor phase voltage. These harmonic contents cause low-frequency torque pulsations that may even break the motor shaft. Hence, these lower-order harmonics need to be eliminated to operate the motor seamlessly till full base speed.

In this work, a 10-level dual inverter scheme is investigated to eliminate all the lower order harmonics (5 th ,7 th ,11th ,13th , etc.) while extending the LMR from 0.577Vdc to 0.637Vdc peak phase fundamental regardless of load power factor. The proposed inverter topology supplies an OEWIM where the primary side is a cascade of a 2-level inverter and HB while the secondary side is connected to a floating capacitor fed 2-level inverter cascaded with an HB. The proposed inverter structure will synthesize a hexagonal SVS of more than 9-levels. Those extra levels will be switched in a unique way to extend the modulation range without surpassing the maximum voltage SV amplitude of Vdc along A,B, C phases at any time. All the capacitors in this topology can be balanced simultaneously and independently using the concept of opposing vector redundancy of a Space Vector Point (SVP). The proposal to balance the capacitors, even at an extended modulation range (from 0.577Vdc to 0.637Vdc peak phase fundamental) for u.p.f load (since u.p.f is the worst case condition to charge balance all floating capacitors at the extreme modulation) is possible in the proposed scheme.

Student Presentation 8: A Galvanically Isolated Single-Phase Inverter Topology With Flux-Rate Control Based Harmonic Filtering Scheme

Ruman Kalyan Mahapatra and Umanand L

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract

This work presents a galvanically isolated single-phase inverter topology with a flux-rate control-based harmonic filtering scheme. The proposed topology consists of a high-power primary inverter that operates at low frequency and establishes the primary flux. A low-power secondary inverter that operates at high frequency is associated with another limb of the magnetic core, which controls the flux rate. The undesired harmonic components present in the primary flux are filtered by controlling the flux rate to provide a sinusoidal output voltage at the load. These two inverters and the load side of the proposed topology are associated with the three-limbed magnetic core. The load side of the proposed inverter topology is galvanically isolated from the rest of the circuit. That causes the

load side of the proposed inverter to be free from any power electronics components and passive filters. Hence, the inverter is suitable for medium to high voltage applications without modifying the power semiconductor device ratings. The proposed inverter is modeled using the popular bond-graph modeling technique, and the dynamic equations are obtained from the model. The derived dynamic model is simulated, and a lab build prototype is utilized to verify the working of the proposed inverter topology.

Student Presentation 9: Optimal Pulse-width Modulation Techniques of Asymmetrical Six-phase Machine in Linear and Overmodulation Regions

Sayan Paul

Department of Electrical Engineering,
Indian Institute of Science

Abstract

This work presents two pulse-width-modulation (PWM) techniques of a two-level inverter fed asymmetrical six-phase machine (ASPM) to reduce the drive system's loss and improve efficiency. The first PWM technique is applicable in the overmodulation region, and the second is relevant in the linear region.

Overmodulation (OVM) techniques of ASPM achieve higher DC-bus utilization by applying voltage in the non-energy transfer plane. This results in unwanted current and associated copper loss. The existing OVM technique minimizes this voltage from the space-vector perspective with a pre-defined set of four active vectors. To find the best technique, one needs to perform the above minimization problem with all possible sets of active vectors with which higher voltage gain can be attained. So, this requires evaluation of a large number of cases. This work formulates the above minimization problem in terms of average voltage vectors of two three-phase inverters, where active vectors need not be specified beforehand. Thus, the analysis is more general. Sixteen possible techniques with different active vectors are derived following the above analysis, which attains minimum voltage injection in the non-energy transfer plane.

Linear modulation techniques (LMTs) of an ASPM with two isolated neutral points synthesize the desired voltage vectors by applying at least five switching states. Different choices of applied voltage vectors, sequences in which they are used, distribution of dwell-times among the redundant switching states give rise to a large number of possible LMTs. These LMTs should avoid more than two transitions of a particular inverter leg within a carrier period. Only a subset of existing LMTs of ASPM follows this rule. This work finds a way to account for all possible infinitely many LMTs that follow the rule of at most two transitions per leg through an innovative approach. Another essential criterion for the selection of an LMT is its current-ripple performance. Therefore, through numerical optimization, the work finds optimal LMTs among the above infinite possible LMTs for all reference voltage vectors in the linear range and the whole feasible range of a machine parameter. This parameter is related to the leakage inductance of the machine and impacts the current ripple performance of ASPM. An optimal hybrid strategy is proposed with these optimal techniques, which outperforms all existing methods in terms of the current ripple.

The theoretical analysis of the above two PWM techniques is validated through simulation in Matlab and experiments performed up to 3.5 kW on a hardware prototype.

Student Presentation 10: The Phenomena of Standing Waves in Uniform Single Layer Coils

Ashiq Muhammed P E

Department of High Voltage Engineering,
Indian Institute of Science

Abstract

Accurate knowledge of the natural frequencies and shapes of corresponding standing waves are essential for gaining deeper insight into the nature of response of coils to impulse excitations. Most of the previous analytical studies on coils assumed shape of standing waves as sinusoidal but numerical circuit analysis and measurements suggest otherwise. Hence, this paper revisits the classical standing wave phenomenon in coils to ascertain reasons for this discrepancy and thereafter extends it by analytically deriving the exact mode shape of standing waves for both neutral open/short conditions. For this, the coil is modeled as a distributed network of elemental inductances and capacitances while spatial variation of mutual inductance between turns is described by an exponential function. Initially, an elegant derivation of the governing partial differential equation for surge distribution is presented which is then analytically solved, perhaps for the first time, by the variable-separable method to find the complete solution (sum of time and spatial terms). Hyperbolic terms in spatial part of solution have always been neglected but are included here, thus, yielding the exact mode shapes. Voltage standing waves gotten from analytical solution are plotted and compared with simulation results on a 100-section ladder network. The same is measured on a large-sized single layer coil. So, it emerges that, even in single layer coils, shape of standing waves deviates considerably from being sinusoidal and this deviation depends on spatial variation of mutual inductance, capacitive coupling, and order of standing waves.

Student Presentation 11: Modelling of bi-directional leader inception and propagation from aircraft

Sayantan Das and Udaya Kumar

Department of Electrical Engineering,
Indian Institute of Science

Abstract

A commercial aircraft can expect on an average one lightning strike per year i.e. one lightning strike in approximately 3000 hours of flight. Severity of damage due to lightning can range from minor burn mark, creation of holes on skin upto complete destruction of aircraft. Nowadays, use of less conducting composite materials for constructing structural elements of aircraft enhances possibility of physical damages. Increasing use of sensitive electronics components in on-board equipment of aircraft further makes it more vulnerable to indirect effect of lightning strike. Therefore, protection of aircraft against lightning is one of the major aspects of modern aircraft design.

An aircraft can be struck by lightning in two possible ways – aircraft-initiated lightning where the aircraft itself incepts bi-directional leaders. Aircraft-intercepted lightning where a cloud to ground lightning gets intercepted by aircraft. Recorded data from in-flight measurements suggest that almost 90% of events of lightning strike occurred due to aircraft-initiated leaders. Hence, the study will be limited only to aircraft-initiated lightning phenomena.

The first step of designing of lightning protection on aircraft is *Zoning* where the aircraft surface is divided into several distinct zones depending on the probability of lighting strike. Several methods have been suggested in standard (ARP5414) such as *Rolling Sphere Method (RSM)*, *Similarity Principle*, *Field based approach*. All these methods are either empirical or qualitative and lacks the physical basis of leader discharge from aircraft. For more accurate assessment of zoning, the discharge phenomena need to be modelled. Therefore, the purpose of this work is to develop a model for inception and propagation of bi-directional leader from cruising aircraft.

This presentation highlights the salient features of leader inceptions from cruising aircraft followed by brief description of the model developed and demonstration of propagation of connecting leaders from aircraft.

3.1.10 Cluster: Networking and IoT

Cluster Coordinator: Parimal Parag (ECE) and Prabhakar T V (ESE)
Student Organizer: Sameer, Sankalp
Faculty Organizer: Rahul Saladi, CSA
Location: ECE MP-30

Cluster Overview

Time	Event	Speaker	Affiliation
14:30 - 15:15pm	Invited Talk 1	Pravein Govindan Kannan	Research Scientist, IBM Research India (IRL)
15:30 - 15:50pm	Student Presentations	Rooji Jinan	ECE, IISc
15:50 - 16:10pm		Rathinamala Vijay	ESE, IISc
16:10 - 16:30pm		Zitha Sasindran	ESE, IISc

Invited Talk 1 : Programmable Networking and Applications

Speaker: Pravein Govindan Kannan

Abstract

Over the past few years, programmable networks have revolutionized networking by providing abstractions to program the control-plane and data-plane of networks. In this talk, I will be giving a brief introduction to programmable networks, and how it can be useful in designing : 1) 5G Fronthaul Slicing Architecture (FSA) which runs in the switch data plane and uses information from the wireless schedule to identify the slice of a fronthaul data packet at line-rate. It enables multipoint-to-multipoint routing as well as packet prioritization to provide multiplexing gains in the fronthaul and the C-RAN, making the system more scalable. 2) A "better" network debugger which enables "visibility", "retrospection" and "correlation" to debug transient network issues and achieving network-level observability.

Finally, I will be briefly talk about the current challenges in achieving end-to-end observability in microservices based applications which are typically deployed as containers and connected using multiple Container Network Interfaces (CNI).

Bio
Pravein is a Research Scientist at IBM Research India (IRL). His research interests are areas surrounding Networking, Data Center Networks and Cloud. Prior to joining IRL, he obtained his PhD from National University of Singapore (NUS). He has published several papers in top-tier conferences like SIGCOMM, NSDI, MOBICOM, Sensys, etc. His research has been recognized with the best paper award at ACM SOSR 2019 and Facebook research award.

Student Presentation 1: Low latency replication coded storage over memory-constrained servers

Rooji Jinan

Department of Electrical Communication Engineering,
Indian Institute of Science

Abstract
We consider a distributed storage system storing a single file, where the file is divided into equal sized fragments. The fragments are replicated with a common replication factor, and stored across servers with identical storage capacity. An incoming download request for this file is sent to all the servers, and it is considered serviced when all the unique fragments are downloaded. The download time for all fragments across all servers, is modeled as an independent and identically distributed (*i.i.d.*) random variable. The mean download time can be bounded in terms of the expected number of useful servers available after gathering each fragment. We find the mean number of useful servers after collecting each fragment, for a random storage scheme for replication codes. We show that the performance of the random storage for replication code achieves the upper bound for expected number of useful servers at every download asymptotically in number of servers for any storage capacity. Further, we show that the performance of this storage scheme is comparable to that of Maximum Distance Separable (MDS) coded storage.

Student Presentation 2: Measurement Aided Design of a Heterogeneous Network Testbed For Condition Monitoring Applications

Rathinamala Vijay

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract We propose a composite diagnostics solution for railway infrastructure monitoring. In particular, we address the issue of soft-fault detection in underground railway cables. We first demonstrate the feasibility of an orthogonal multitone time domain reflectometry based fault detection and location method for railway cabling infrastructure by implementing it using software defined radios. Our practical implementation, comprehensive measurement campaign, and our measurement results guide the design of our overall composite solution. With several diagnostics solutions available in the literature, our conglomerated method presents a technique to consolidate results from multiple diagnostics methods to provide an accurate assessment of underground cable health.

We present a Bayesian framework based cable health index computation technique that indicates the extent of degradation that a cable is subject to at any stage during its lifespan. We present the performance results of our proposed solution using real-world measurements to demonstrate its effectiveness.

Student Presentation 3: Word-level beam search decoding and correction algorithm (WLBS) for end-to-end ASR

Zitha Sasindran

Department of Electronic Systems Engineering,
Indian Institute of Science

Abstract A key challenge in resource-constrained speech recognition applications is the unavailability of a large, domain-specific audio corpus to train the models. In such scenarios, models may not be exposed to a wide range of domain-specific words and phrases. In this work, we propose an approach to improve the in-domain automatic speech recognition results using our word-level beam search decoding and correction algorithm (WLBS). We use a token-based language model to mitigate the data sparsity and the out of vocabulary issues in the corpus. We evaluate the proposed approach for airplane-cabin specific announcements use case. The experimental results show that the WLBS algorithm with its handling of misspellings and missing words achieves better performance than state-of-the-art beam search decoding and n-gram LMs. We report a WER of 11.48% on our airplane-cabin announcement test corpus.

4. List of Session Speakers

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13th EECS Research Students Symposium 2022

We are pleased to inform you that the Division of Electrical, Electronics, and Computer Sciences (EECS) at the Indian Institute of Science (IISc), Bengaluru is organising its 13th Research Students Symposium on the 8th and 9th of April, 2022. The Departments of Computational and Data Sciences (CDS), Computer Science and Automation (CSA), Electrical Communication Engineering (ECE), Electrical Engineering (EE), Electronic Systems Engineering (DESE) and the Robert Bosch Centre for Cyber-Physical Systems (RBCCPS) participate in the symposium. This annual event has served as an excellent forum for interaction among graduate students and leaders from the 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

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

Event webpage

We invite you to attend the event

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