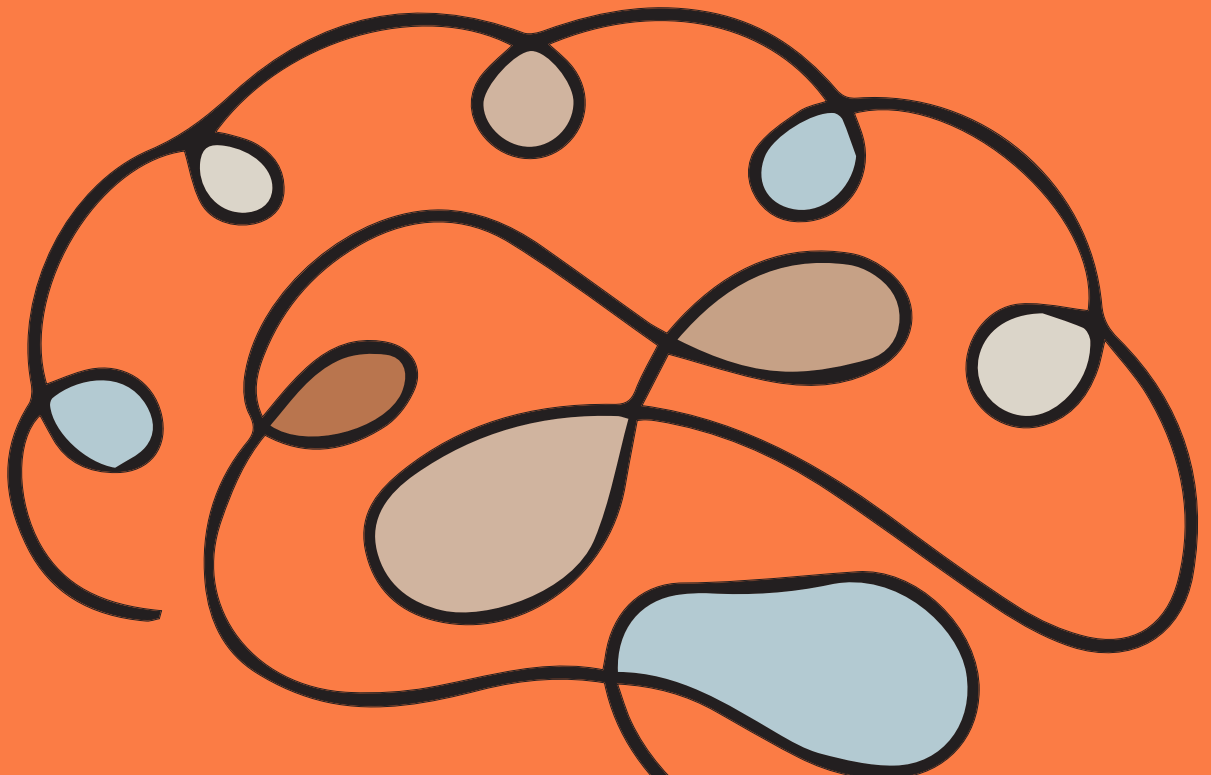




Pratiksha Trust Initiative on Brain, Computation and Data Science



Activities
2019

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Overview

The Brain, Computation and Data Science initiative is the brainchild of Mr. Kris Gopalakrishnan and Mrs. Sudha Gopalakrishnan, founders of the Pratiksha Trust, Bangalore. In June 2015, the Pratiksha Trust set up three Distinguished Chair Professorships at the Indian Institute of Science, Bangalore. The purpose of these Chair Professorships is to bring frontline researchers in the areas of neuromorphic computing, computational neuroscience, machine learning and data science to the IISc campus to help strengthen research and international collaboration in these important emerging areas. The mission of this initiative is to foster intense research collaboration leading to capacity building, ecosystem creation, and high impact research outcomes in brain, computation and data science in IISc and India.

The participating departments and centres of IISc include:

Computer Science and Automation, Centre for Neuroscience, Electrical Communication Engineering, Electrical Engineering, Electronic Systems Engineering, Mathematics, Molecular Biophysics and Computational and Data Science.

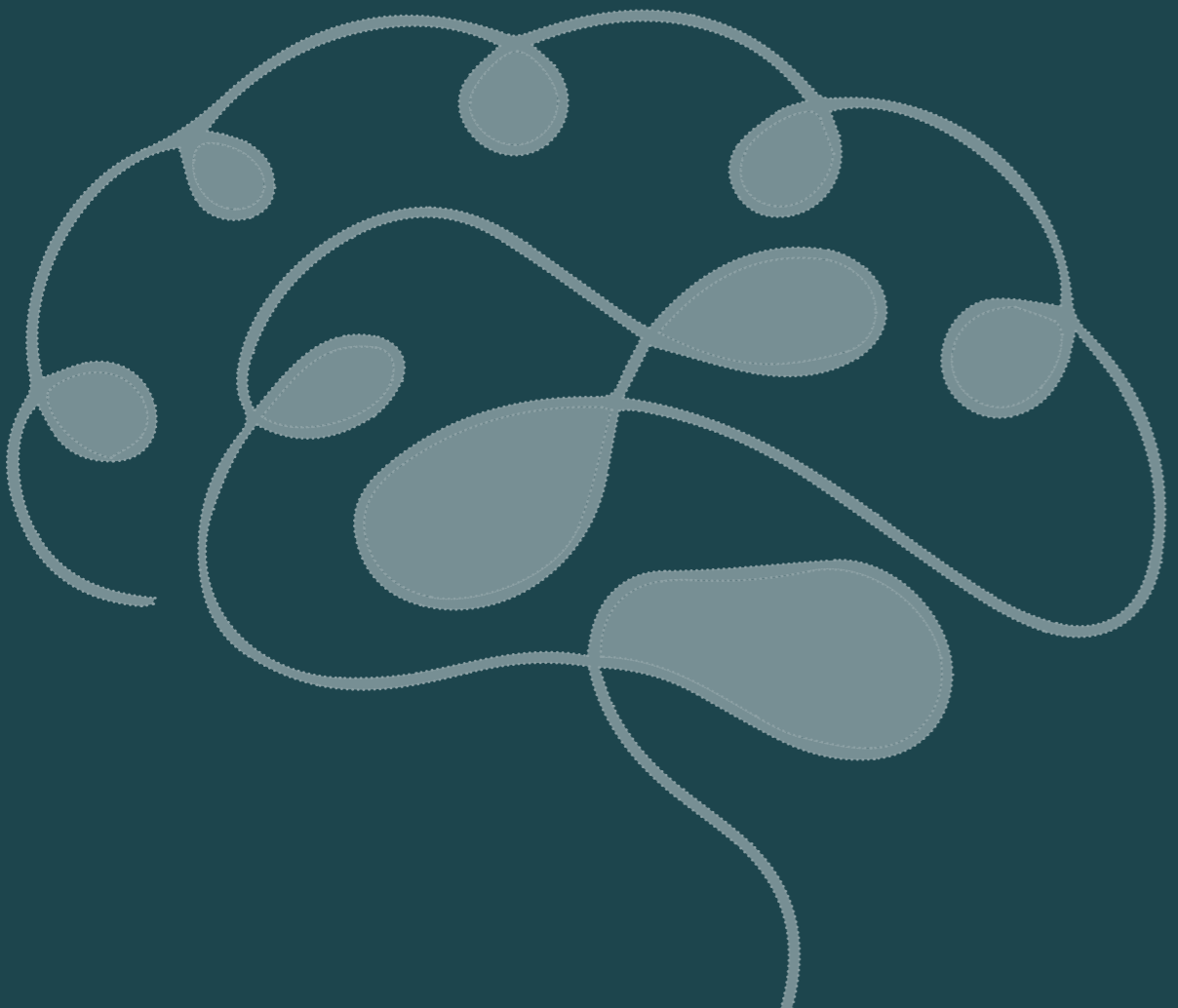
A parallel initiative has also been set up at the Indian Institute of Technology – Madras, Chennai, where also 3 chair professorships have been set up in this area.

This booklet provides a bird's eye view of the activities undertaken as a part of this initiative in IISc during 2019.

Research Areas

Computational Neuroscience
Neuromorphic Computing and
Engineering
Data Science

Machine Learning
Brain Inspired Algorithms
Signal Processing
Image Analysis



From Director, IISc

“We are immensely grateful to Shri. Kris Gopalakrishnan and Smt. Sudha Gopalakrishnan for choosing the Indian Institute of Science for these generously endowed chair professorships. These chairs intend to invigorate and accelerate extremely important emerging interdisciplinary research areas. I am sure the chair professors will add a new dimension to research collaboration between IISc researchers and star contributors to these areas anywhere in the world.”



Anurag Kumar
Director, Indian Institute of
Science, Bangalore

From Pratiksha Trust Founders

“We hope the launching of these distinguished chair positions will help push the frontiers in brain inspired research. It would be excellent if the collaborations lead to highly creative new computing architectures and algorithms inspired by the functioning of the brain.”



Kris Gopalakrishnan
Founder, Pratiksha Trust,
Bangalore



Sudha Gopalakrishnan
Founder, Pratiksha Trust,
Bangalore

IISc Team

Admin Committee

K.V.S. Hari, ECE
Jayant Haritsa, CSA
Y. Narahari, CSA (Convener)
G. Rangarajan, MATH
Vijayalakshmi Ravindranath, CNS
P.S. Sastry, EE

Scientific Advisory Committee

S. Bhatnagar, CSA
K.V.S. Hari, ECE
Aditya Murthy, CNS
M.N. Murty, CSA
Rishikesh Narayanan, MBU
P.S. Sastry, EE (Convener)

Faculty Team (Brain, Computation and Data Science Group)

D. Ambedkar, CSA
Bharadwaj Amrutur, ECE
S.P. Arun, CNS
R. Venkatesh Babu, CDS
Siddharth Barman, CSA
Anand Louis, CSA
Sundeeep Chepuri, ECE
Shalabh Bhatnagar, CSA

Arnab Bhattacharyya, CSA
Anirban Chakraborty, CDS
Sridharan Devarajan, CNS
Sriram Ganapathy, EE
Santanu Mahapatra, ESE
Prasanta Kumar Ghosh, EE
K.V.S. Hari, ECE
Aditya Murthy, CNS
Chandra Murthy, ECE
Rishikesh Narayanan, MBU
Hardik Pandya, ESE
T.V. Prabhakar, ESE
A.G. Ramakrishnan, EE
Supratim Ray, CNS
P.S. Sastry, EE
Chandra Sekhar Seelamantula, EE
Shirish Shevade, CSA
S.K. Sikdar, MBU
Yogesh Simmhan, CDS
Shayan G. Srinivasa, ESE
Mayank Srivastava, ESE
Rajesh Sundaresan, ECE
Partha Talukdar, CDS
Chetan Thakur, ESE
Phaneendra Yalavarthy, CDS
and all other interested faculty members

Shri K. Vaidyanathan Distinguished Chair



**Professor Shihab
Shamma**

Professor, Institute of
Systems Research,
Univ. of Maryland

Education

BS – Imperial College – 1976

MS – Stanford University – 1977

Ph.D. – Stanford University – 1980

Expertise

Speech models of brain

Neural signal processing

Computational neuroscience

Robust control systems

Neuromorphic engineering

Awards and Distinction

Fellow, IEEE

Fellow, Acoustical Society of USA

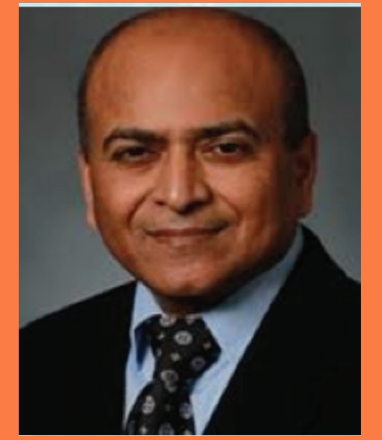
ISR Outstanding Faculty Award

NIH Advisory Board

PI of Advanced ERC Grant

Blaise Pascal Intl. Research Chair

Smt. Sudha Murty Distinguished Chair



**Prof. Vasant
Honavar,**

Pennsylvania State
University
Director: Center for Big
Data Analytics
Director: Artificial
Intelligence Research
Laboratory

Education

BE – BMS College, Bangalore, 1982, Electronics Engg

MS – Drexel, 1984, Electrical and Computer Engg

MS, PhD – Wisconsin, Madison, 1990, Computer Science

Expertise

Artificial Intelligence

Machine Learning

Knowledge Representation

Bioinformatics

Data Science

Health Informatics Neurocomputing

Awards and Distinction

National Science Foundation Director's Award for Superior Accomplishment

Edward Frymoyer Endowed Professorship

CRA Computing Community Consortium Council Member

Iowa State Univ. Regents Award for Faculty Excellence

Univ. Wisconsin ECE 125 People of Impact

Pratiksha Trust Distinguished Chair Professor



**Prof. Christos
Papadimitriou,**
Donovan Family Professor
of Computer Science
Columbia University, New
York, USA

Education

B.S Athens polytechnic, 1972

MS Princeton University, 1974

Ph.D., Princeton University, 1976

Expertise

Theory of algorithms and complexity and its applications to optimization, databases, control, AI, robotics, economics and game theory, the Internet, evolution and the brain

Awards and Distinction

Member of National Academy of Sciences, USA

Member of National Academy of Engineering, USA

Member, American Academy of Arts and Sciences

Knuth prize, Gödel Prize

von Neumann Medal

Kalai prize for CS in Game Theory

EATCS Award (European Association for Theoretical Computer Science)

Author of Novels: "Turing", "Logicomix" and "Independence"

Honorary Doctorates from Nine Universities

Pratiksha Trust Distinguished Chairs at IIT-Madras



Prof. H.N. Mahabala Chair

Prof. Partha Mitra
Cold Spring Harbor Lab



**Dr. N.R.Narayana Murthy
Chair**

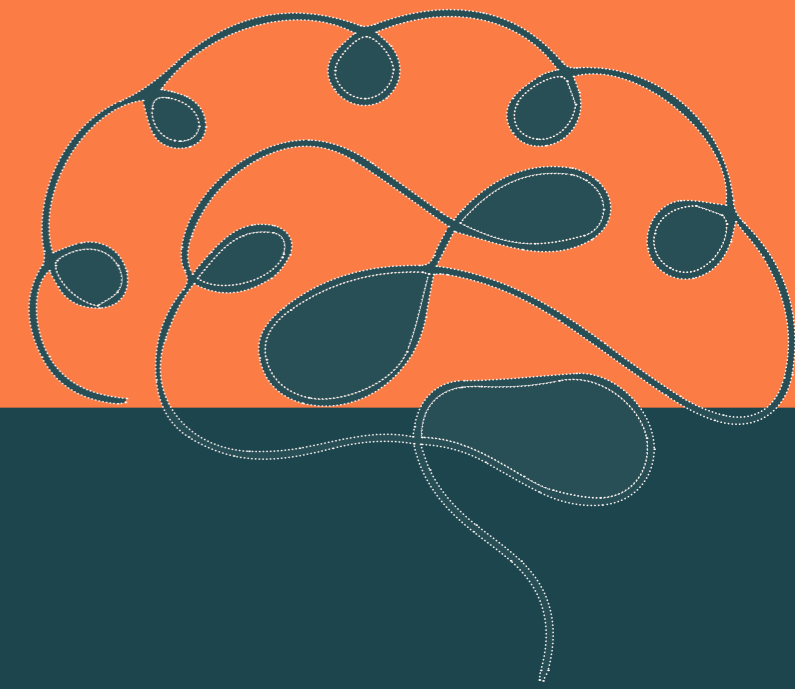
Prof. Mriganka Sur
Massachusetts Institute of
Technology



Prof. Muthukrishnan Chair

Prof. Anand Raghunathan
Purdue University

Pratiksha Trust Young Investigators



Pratiksha Trust Young Investigators

These awards have been instituted to recognize and reward the accomplishments of young faculty members or prospective faculty members. The Pratiksha endowment now supports the award of up to five Young Investigator awards at any time. The awardees receive, for two years, a top-up salary of Rs 25000 per month and a research grant of Rs. 3 lakhs per year. Recognition as a Young Investigator will be based on academic achievement at the highest national and international level. Following is list of Pratiksha Trust YIs.

1. Dr. Sriram Ganapathy, Department of Electrical Engineering (2017-19)
2. Dr. Prasanta Kumar Ghosh, Department of Electrical Engineering (2017-19)
3. Dr. Sridharan Devarajan, Centre for Neuroscience (2017-19)
4. Dr. Chetan Singh Thakur, Department of Electronic Systems Engineering (2017-19)
5. Dr. Siddharth Barman, Department of Computer Science and Automation (2018-20)
6. Dr. Anirban Chakraborty, Department of Computational and Data Sciences (2018-20)
7. Dr. Anand Louis, Department of Computer Science and Automation (2019-21)
8. Dr. Sundeeprakash Chepuri, Department of Electrical Communication Engineering (2019-21)

Sriram Ganapathy



<http://leap.ee.iisc.ac.in/sriram/>

Sriram Ganapathy is an Assistant Professor at the Department of Electrical Engineering, Indian Institute of Science, Bangalore. Previously, he was a research staff member at the IBM Watson Research Center from 2011-2015. He received his PhD from the Center of Language and Speech Processing, Johns Hopkins University in 2011. Currently, he serves as the subject editor for Elsevier Speech Communication journal and was the recipient of early career awards from DST and DAE. He is a member of the ISCA and a senior member of the IEEE.

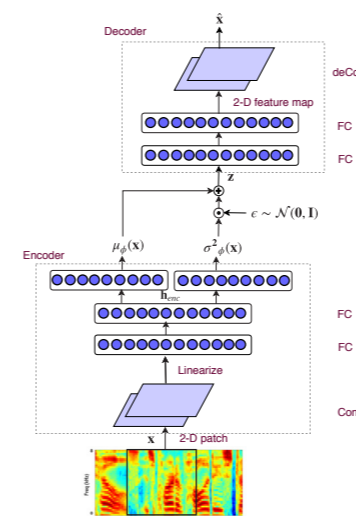
Research Highlight

Our lab, named LEAP (learning and extraction of acoustic patterns), works on the interface between signal processing, machine learning and neuroscience all within the domain of speech processing. From the neuroscience perspective, we design experiments to probe how the brain representations are evolving when new words from a foreign language are learnt. The analysis is performed with subjects engaged in a language learning task under an Electroencephalography (EEG) scanner. We are also interested in understanding the human processing of multi-talker speech where high efficiency is achieved by humans with relative ease.

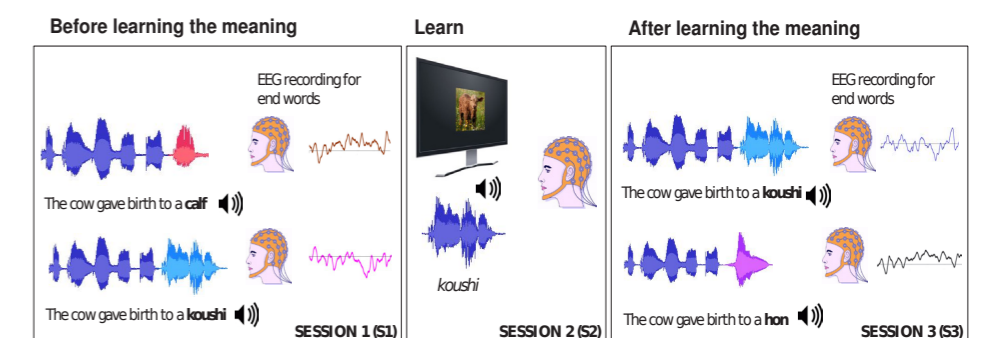
On the machine learning side, we try to develop techniques for unsupervised representation learning and data driven features from audio which are beneficial for robust speech recognition. For scenarios like low data resource languages, we are interested in active learning and other semi-supervised learning that are based on deep end-to-end models. Our interests also span into automatic speaker clustering in multi-talker speech and biometric applications of speech like speaker and language verification. We actively participate in international grand challenges in these problems and collaborate with industry and other academic institutions.

The overarching vision of the lab is to improve the current technology by understanding the human speech processing and to apply technology and big data to improve the understanding of the brain.

Unsupervised Representation Learning From Raw Audio using Variational Autoencoders.



Language learning and EEG



Prasanta Kumar Ghosh

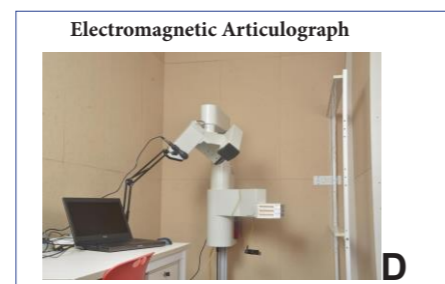


<http://www.ee.iisc.ac.in/people/faculty/prasantg/>

Prasanta Kumar Ghosh received his Ph.D. in Electrical Engineering from the University of Southern California (USC), Los Angeles, USA in 2011. Prior to that he obtained his M.Sc.(Engineering) in Electrical Communication Engineering from Indian Institute of Science (IISc), Bangalore and B.E.(ETCE) in Electronics from Jadavpur University, Kolkata in 2006 and 2003 respectively. During 2011-2012 he was with IBM India Research Lab (IRL) as a researcher. He is a recipient of the INSPIRE Faculty award 2012 by the Department of Science and Technology, Govt. of India. He has also received the Young Investigator award by Pratiksha Trust in 2017 and the SERB start-up research grant for Young Scientists in Engineering Sciences in 2015. Currently, he is an assistant professor in the department of Electrical Engineering (EE) at IISc and heads the Signal Processing, Interpretation and REpresentation (SPIRE) Laboratory. The research activities in the SPIRE Laboratory have been at the intersection of speech science, engineering, and applications. Understanding & developing engineering models for various aspects in human speech production through multi-modal sensing and its applications in the area of healthcare and language learning have been the focus of the research activity. These include novel findings from basic scientific analyses of multi-modal speech production data, developing robust signal processing techniques & models that aid to meaningful interpretations of acoustic and associated gesture data, developing machine learning algorithms and tools for language tutoring as well as clinical applications including neuro-motor, respiratory & speech disorders.

Research Highlight

Human speech is produced as a result of speech articulation which involves choreographed movements of vocal folds, speech articulators including velum, epiglottis, tongue, lips, jaw. Head and facial gestures are an integral part of human speech production. For example, research using Motion Capture facility (Figure A) at SPIRE Lab shows how motion of head varies with style of speaking and the degree of synchrony between head gestures and speech. Using videostroboscopy (Figure B), SPIRE Lab researchers have analyzed the glottal vibration involved in speech production, in particular automatically segmenting the glottis for assisting in the treatment of patients with voice disorders. Signal processing techniques have been developed to convert speech from patients with voice disorder to healthy voice, which would be useful to aid to their speech based communication in everyday life. For speech production research, articulatory motion data acquisition techniques such as electromagnetic articulograph (EMA) (Figure D) and real time magnetic resonance imaging (rtMRI) (Figure C) have been used for the research work carried out in SPIRE Lab. Studies have been conducted to investigate the relation between articulatory and acoustic representations by estimating the articulatory motion from acoustics using novel inversion schemes. Research at SPIRE Lab shows how articulatory motion alters in patients with neuro-moto disease compared to a healthy individual.



Sridharan Devarajan



<http://cns.iisc.ac.in/sridhar/>

Sridharan Devarajan received his Bachelors and Masters degrees in engineering from the Indian Institute of Technology (IIT), Madras. He completed his PhD at Stanford University where, as a Stanford Graduate Fellow, he studied the neural dynamics of attention and executive control with functional neuroimaging. In the second part of his PhD he built neuromorphic computational models of the brain in the lab of Prof. Kwabena Boahen. He completed his post-doctoral training as a Dean's Postdoctoral Fellow at Stanford's School of Medicine with Prof. Eric Knudsen, investigating neural circuit mechanisms of attention. He is now an Assistant Professor at the Centre for Neuroscience, and an Associate Faculty of the Department of Computer Science and Automation, at IISc, Bangalore. Recent awards include a Wellcome Trust-DBT India Alliance Fellowship, SERB Early Career Award, and a Pratiksha Trusts Young Investigator grant.

Research Highlight

Diffusion imaging (dMRI) is a non-invasive technique for measuring the diffusion of water molecules in the brain's white matter. Tractography algorithms are applied to dMRI data to infer structural connections between different brain regions in the living human brain. We seek to highlight here two studies involving computational approaches to diffusion imaging and tractography that were published at prestigious venues earlier this year.

First, we developed a potentially useful resource for diffusion imaging and tractography. Conventional tractography algorithms often estimate spurious connections between brain regions. Linear Fascicle Evaluation (LiFE) is a state-of-the-art approach for pruning spurious connections, but imposes heavy demands on computing time (Pestilli et al, Nature Methods, 2014). We developed a GPU-based implementation of LiFE that achieves 50-100x speedups over LiFE, and estimates sparser, more accurate, connectomes. This work was presented at the 33rd AAAI conference on Artificial Intelligence (A* conference), and was selected as one of 1,150 full-length papers from over 7,700 submissions (15% acceptance rate). (conference publication: Kumar S, Sreenivasan V, Talukdar P, Pestilli F & Sridharan D. AAAI Proceedings, 2019; <https://doi.org/10.1609/aaai.v33i01.3301630>).

Second, leveraging the tools described above, we sought to understand brain-behavior relationships in the context of attention. We analyzed diffusion imaging (dMRI) data from n=22 subjects at IISc (data acquired from the scanner at HCG Hospital, Bangalore) and n=60 subjects from the Human Connectome Project (HCP) database. We discovered a striking relationship between connectivity in a key midbrain region – the superior colliculus (SC) – and key metrics of attention behaviors. Taken together with our previous findings, this study showed that the SC could be a key node in an evolutionarily conserved network for controlling visuospatial attention (journal publication: Sreenivasan V & Sridharan D. Proc. Natl. Acad. Sci. USA, 2019; <https://doi.org/10.1073/pnas.1902704116>).

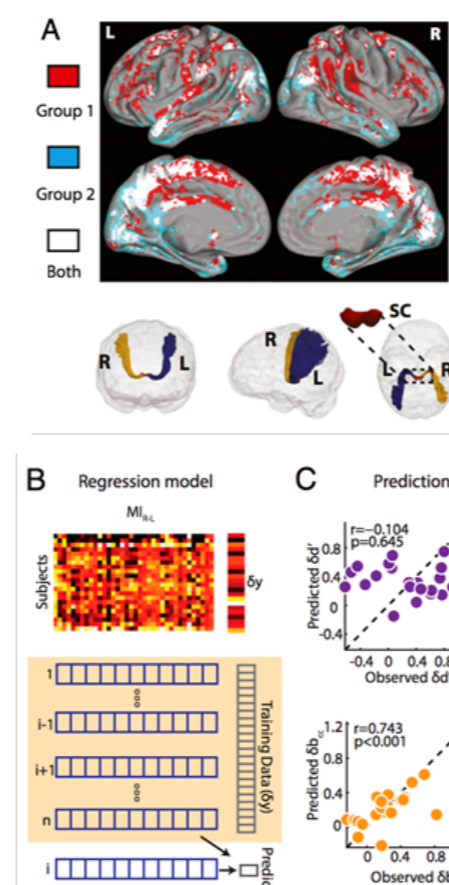


Figure. (A) Connectivity of the superior colliculus (SC) with other brain regions in the neocortex. (B) Regression model for predicting attention behavior components based on SC connectivity. (C) SC connectivity strongly predicts a decisional component of attention (choice bias, b_{cc}), but not the perceptual component (sensitivity, d'). Adapted from Sreenivasan and Sridharan, PNAS, 2019.

Chetan Singh Thakur



<http://neurronics.dese.iisc.ac.in/dr-chetan-singh-thakur/>

Chetan Singh Thakur joined the Indian Institute of Science, Bangalore as an Assistant Professor in May 2017. He is also an adjunct faculty at International Center for Neuromorphic Systems, Sydney. He received his PhD in neuromorphic engineering at the MARCS Research Institute, Western Sydney University, Australia. He then worked as a research fellow for Defence Science and Technology, Australia and the Johns Hopkins University, USA. In addition, Dr. Thakur has extensive industrial experience, he worked for 6 years with Texas Instruments Singapore as a senior IC Design Engineer, designing flagship mobile processors. His research interest lies in brain-inspired computing, mixed signal VLSI systems, computational neuroscience and machine learning for edge computing. His research interest is to understand the signal processing aspects of the brain and apply those to build novel intelligent systems. He is a recipient of the Inspire Faculty Award 2016 by the Department of Science and Technology, India. He has also received the Young Investigator Award by Pratiksha Trust and "Early Career Research Award" from Science and Engineering Research Board, Government of India. He has received several research grants from Industry and Government sources including DST, SERB, Ashok Leyland, Qualcomm, WIPRO, Texas Instruments.

Research Highlight

Due to the proliferation of internet-of-things (IoT) in the areas of ubiquitous sensing there has been an increased demand towards integrating intelligence directly onto the IoT hardware platform. The machine learning (ML) architecture embedded into these platforms needs to be as energy-efficient as possible. We have recently developed low-power CMOS-Memristor based neuromorphic architectures, which utilizes promising features from the neuromorphic analog architecture, memristor synaptic memory, and the hardware-friendly learning algorithm. We have also developed another novel computational framework for designing support vector machines (SVMs), which does not impose restriction on the SVM kernel to be positive-definite and allows the user to define memory constraint in terms of fixed template vectors. This makes the framework scalable and enables its implementation for low-power, high-density and memory constrained embedded application.

In another research theme, we explore neuromorphic sensors (currently, vision and auditory modalities) to build various intelligent systems that could be used for various robotics and military applications. Neuromorphic silicon retinas aim to mimic the features of biological retinas to sense and process the visual world. We have developed several Neuromorphic event-based algorithms such as for high-speed activity detection for autonomous vehicle, 3D reconstruction etc using neuromorphic sensor.

Recently, we are working on to develop fundamentally new machine learning architectures using simple computational primitives. We propose an alternate hardware-software codesign of ML and neural network architectures where instead of using matrix-vector-multiplications (MVM) operations and non-linear activation functions, the architecture only uses simple addition and thresholding operations to implement inference and learning. This will result in significant improvement in computational complexity and hence energy cost.

Siddharth Barman



<https://www.csa.iisc.ac.in/~barman/>

Siddharth Barman is an assistant professor in the Department of Computer Science and Automation at the Indian Institute of Science. Before joining IISc, he was a post-doctoral scholar at Caltech and obtained his Ph.D. in Computer Science at the University of Wisconsin-Madison. Siddharth is a Ramanujan Fellow and a recipient of the Young Engineering Award, conferred by the Indian National Academy of Engineering (INAE). He is also an associate of the Indian Academy of Sciences (IASc).

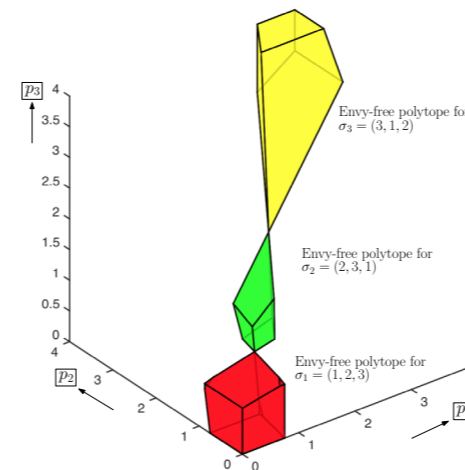
Siddharth's research lies at the interface of Computer Science and Microeconomics. His work spans the forefront of multiple areas such as Approximation Algorithms, Game Theory, and Machine Learning. Siddharth's current work addresses fairness in the context of algorithmic decision making. Here, a specific goal of his research is to quantify tradeoffs between efficiency and fairness.

Research Highlight

Fairness is a fundamental consideration in many resource-allocation settings. A substantive body of work in Economics and Mathematics is aimed at quantitatively understanding fairness and establishing existential results. Such provable guarantees, and the accompanying framework, have guided the design of (fair) allocation policies in contexts such as border disputes, course allocation, and cloud computing. However, to be useful in practice, one also requires scalable methods that explicitly find the underlying fair allocations. Motivated by this consideration, Siddharth's current research addresses algorithmic aspects of fair division.

Specifically, a recent joint work [1] of Siddharth shows that, in a relevant model, economic efficiency is not sacrificed by imposing fairness. This work is conceptually surprising since it shows that the seemingly incompatible properties of fairness and economic efficiency can be achieved together. The result has practical implications since it carries with it an algorithm for finding allocations that are both fair and (Pareto) efficient.

Another joint work Siddharth [2] is focused on fairness in settings that entail resource sharing with monetary transfers. This framework has been studied in Microeconomics for over three decades and is referred to as fair rent division, since it captures (as a stylized example) the problem of fairly dividing an apartment's rent among the roommates. The result [2] provides the first efficient algorithm for this classic problem and relies on an interesting geometric insight: in this setup, even though the underlying "feasible set" is non-convex, it is always composed of a chain of convex sets (see appended Figure). Siddharth's group is also working towards Blockchain implementations of fair-division algorithms.



[1] *Fully Polynomial-Time Approximation Schemes for Fair Rent Division*. Eshwar Arunachaleswaran, Siddharth Barman, and Nidhi Rathi. ACM-SIAM Symposium on Discrete Algorithms (SODA), 2019.

[2] *Finding Fair and Efficient Allocations*. Siddharth Barman, Sanath Krishnamurthy, and Rohit Vaish. ACM Conference on Economics and Computation (EC), 2018.

Anirban Chakraborty



<http://visual-computing.in/wp-content/uploads/2017/08/anirban-chakraborty.html>

Anirban Chakraborty received his Ph.D. in Electrical Engineering from the University of California, Riverside in 2014. Subsequently, he held research fellow positions with the National University of Singapore and Nanyang Technological University. After that, Anirban worked as a computer vision researcher at the Robert Bosch Research and Technology Centre, India. Currently, he is an assistant professor at the Dept. of Computational and Data Sciences, Indian Institute of Science. His research interests lie in the broad areas of computer vision, machine learning, optimization etc. and their applications in problems such as data association over large graphs, data fusion, video surveillance problems, video-based biometrics, multimedia etc. He is also keen to explore how visual analytics can be utilized in answering some of the most fundamental questions in biology and healthcare.

Research Highlight

Person search and retrieval from a camera network is one of the important problems in video surveillance. Often the search query comes in the form of unstructured textual description of the target of interest, and a list of candidate image observations are retrieved from different CCTV camera footages. Once the image of the target is identified in any of the cameras, the same can be used to search the rest of the network - a task popularly known as person re-identification. In a series of recent works, we have explored these problems and proposed solutions towards building a deployable video surveillance pipeline. In the text-based person search problem we aimed to create semantics-preserving embeddings by adding an additional task of attribute prediction and proposed an approach by learning an attribute-driven space along with a class-information driven space and utilized both for obtaining the retrieval results. Experiments showed that learning the attribute-space not only helps us in reporting state-of-the-art performance, but also yields humanly interpretable features.

Given a target image as query, person re-id systems retrieve a ranked list of candidate matches on a per-camera basis. In deployed re-id systems, a human operator scans these lists and labels sighted targets by touch or mouse-based selection. However, in an existing set-up, target identifications by operator in a subset of cameras cannot be utilized to improve ranking of the target in the remaining set of network cameras. To address this shortcoming, we proposed a novel sequential multi-camera re-id approach, which could accommodate human operator inputs and provide early gains via a monotonic improvement in target ranking. At the heart of our approach is a fusion function which operates on deep feature representations of query and candidate matches. Besides reporting improved results over traditional re-id baselines, we also conducted a comparative subject-based study of human operator performance. The superior operator performance enabled by our approach makes a compelling case for its integration into deployable video-surveillance systems.



A man wearing a pink and white stripe shirt, a pair of blue shorts and a pair of brown sandals.

The woman is wearing a gray shirt with black pants and light coloured shoes. She is carrying a light blue pures on her right shoulder. She is also carrying a light coloured umbrella.

Anand Louis

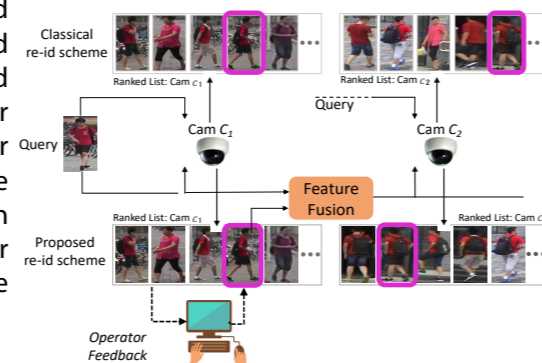


<https://www.csa.iisc.ac.in/~anand/>

Anand Louis is an Assistant Professor in the Department of Computer Science and Automation, IISc since September 2016. He obtained his Ph.D. in "Algorithms, Combinatorics and Optimization" from the Georgia Institute of Technology in 2014. Following this he spent two years as a Postdoctoral Research Associate in the Department of Computer Science in Princeton University before starting his current position in CSA. His research interests lie in algorithms and optimization.

Research Highlight

Anand's primary focus of research has been in bridging the gap between theory and practice in the study of algorithms. For many computational problems, the best known algorithms provide a somewhat underwhelming performance guarantee, however simple heuristics perform remarkably well in practice. A possible explanation for this phenomenon could be that the instances arising in practice tend to have some inherent structure that makes them "easier" than the worst-case instances. Many attempts have been made to understand the structural properties of these instances, and to use them in designing algorithms specifically for such instances, which could perform much better than algorithms for general instances. This includes modelling real-world instances as families of random and semi-random instances, identifying certain structural properties that real-world instances typically satisfy, etc.



Sundeep Prabhakar Chepuri



<https://ece.iisc.ac.in/~spchepuri/>

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

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

Research Highlight

The main themes of my research are *sensing, representation, learning, and statistical inference* for high-dimensional data with applications in communications, network and data sciences, and computational imaging.

Pervasive sensors collect massive amounts of data. As a consequence, it is becoming increasingly challenging to locally store and transport the acquired data to a central location for signal/data processing (i.e., for inference). To alleviate these problems, it is evident that we need to significantly reduce the sensing (hardware) cost as well as the related memory and communications requirements by developing unconventional sensing mechanisms to extract as much information as possible yet collecting fewer data. If we had some prior knowledge about the task we want to perform on the data samples, then just a small portion of that data might be sufficient to reach a desired inference accuracy, thereby significantly reducing the amount of sampled and transported data. To this end, we have developed a data acquisition framework called *sparse sensing*, in which the goal is to optimally design a deterministic and structured sensing function to achieve a desired inference performance. The results developed in this research are applied to *environmental monitoring using sensor networks, indoor localization, medical ultrasound imaging, and radar systems, to name a few*.

Many science applications deal with datasets that have an underlying graph structure, e.g., datasets related to social networks, transportation networks, brain networks, sensor networks, chemical synthesis, protein-protein interactions, and meshed surfaces in computer graphics, to list a few. These datasets are complex. They are complex because of their massive volumes and because they are collected on manifolds, networks, or other irregular non-Euclidean domains. In the context of graph-data processing, we have developed mathematical tools for graph sampling and recovery, i.e., to estimate graph-structured data using observations from a few graph nodes. Having a good quality graph is central to any graph-based signal processing or machine learning. To this end, we have developed tools for graph learning, i.e., to estimate the underlying graph that best explains the available data. These mathematical and computational tools impact a wide variety of applications across multiple disciplines, ranging from classifying structured datasets to processing EEG/fMRI recordings, and from environmental monitoring to recommender systems, to list a few.

Exploratory Research Projects with support from Pratiksha Trust



Characterizing spatiotemporal transformations between facial myoelectric signals and articulatory behavior during regular speech, silent speech and silent reading

Investigators:

Dr. Prasanta Kumar Ghosh

Department of EE, IISc (<http://www.ee.iisc.ac.in/people/faculty/prasantg/>)

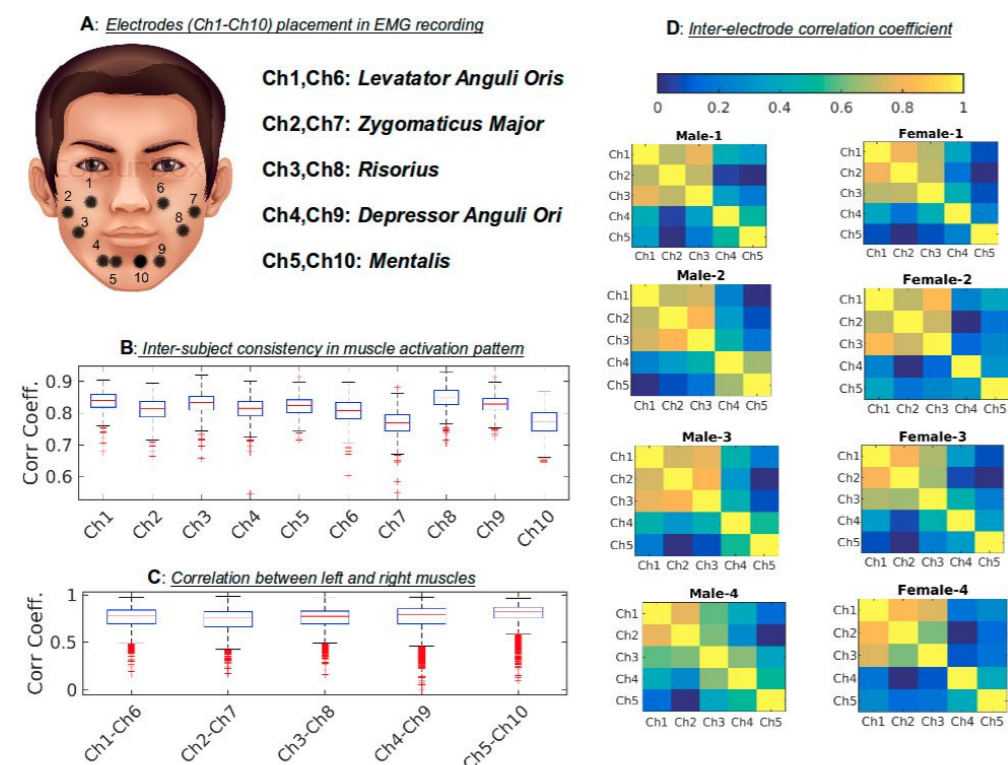
Prof. Aditya Murthy

Center for Neuroscience, IISc (<http://www.cns.iisc.ac.in/aditya/>)

The relation between muscle activation and speech articulatory behavior is not well understood. By characterizing muscle activity patterns as muscle synergies, we hope to leverage principles underlying the neural control of movements to understand the essential spatiotemporal transformations underlying speech processing. We anticipate that the successful outcome of this research will be to enable us to reconstruct speech from incomplete and highly attenuated muscle activation signals even when a subject is not speaking but rather in silent reading. This can potentially lead to novel interfaces for BCI applications when speech is compromised.

Preliminary analysis on ten electrodes (Ch1-Ch10) electro-myograph (EMG) recordings from five muscles on either side of the face (as shown in Figure A below) from eight subjects (4 Male + 4Female) show that there is a consistency in the muscle activation pattern across subjects reading the same set of 460 sentences (as indicated by high correlations in Figure B). Additionally, the same muscles on either side of the face also show highly correlated activation pattern (Figure C).

However, correlation among five electrodes' activations (Figure D) show that although there is a subject specific variations, there is little correlation between depressor anguli ori (Ch4) and mentalis (Ch5) even though they are spatially very close to each other on the face. This indicates that these spatially close muscles could be involved in the production of different sounds. Factorizing all muscle activations onto functional synergies could reveal fundamental motor control patterns during speech production.



HPC Framework for large scale study of brain networks

Investigators:

Prof. Sathish Vadhiyar

Department of CDS, IISc (<http://cds.iisc.ac.in/faculty/vss/>)

Dr. Ambedkar Dukkipati

Department of CSA, IISc (<https://www.csa.iisc.ac.in/~ambedkar/>)

The work focuses on the following aspects:

- A study and analysis of unsupervised learning algorithms to obtain brain network embeddings (from brain graphs) and using clustering algorithms (ex, k-means) on these graph embeddings, to discover clusters or groups.
- Using the existing algorithms on community detection (ex, Louvain algorithm) on large scale brain graphs to discover communities, and comparing the two results to choose the better one for studying brain networks.
- To develop HPC frameworks to realize and implement the above chosen algorithms for large scale brain graphs.

Current progress:

- Obtained fMRI data from Human Connectome Project. (<https://db.humanconnectome.org>)
- Implemented a GPU code for obtaining brain graphs from brain data.
- Considered each voxel as node (a total of 96,854)
 - Used pearson correlation coefficient over all node pairs to generate edges
- Investigating the use of various existing graph embedding algorithms like Node2vec[1], GraphVite[2] for generating graph embeddings.
- Investigating the use of parallel Louvain community detection algorithm to detect communities.

References:

- [1] A. Grover and J. Leskovec, "Node2vec: Scalable feature learning for networks," in Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, 2016, vol. 13-17-Aug, pp. 855–864.
- [2] Z. Zhu, S. Xu, M. Qu, and J. Tang, "GraphVite: A High-Performance CPU-GPU Hybrid System for Node Embedding," in The World Wide Web Conference, 2019, pp. 2494–2504.

Planned workflow for our project:

- Obtain fMRI data from trusted sources
- Generate brain graphs from the obtained data
- Develop an efficient method to obtain clusters. One can follow one of the two methods below
 - Use existing parallel community detection methods like modularity maximization (Louvain's algorithm).
 - Use an efficient parallel graph embedding technique to represent nodes as vectors and run a known clustering algorithm on obtained embeddings.
- Choose the better one, to perform clustering task over all the brain graphs in the ensemble. Here we need to develop and employ HPC framework as we need to perform large scale computations
- Develop tools to auto-analyse the evolution of communities in brain graphs.

Deep neural networks for unsupervised 3D object reconstruction from 2D images

Investigators:

Venkatesh Babu Radhakrishnan

Department of CDS, IISc (<http://cds.iisc.ac.in/faculty/venky/>)

Vijay Natarajan

Department of CSA, IISc (<https://www.csa.iisc.ac.in/~vijayn/>)

Reconstruction of a 3D structure from a single 2D image is a crucial and significant problem. We humans can understand a scene from a 2D image easily. But for a machine, understanding an image or reconstructing 3D shape from an image is a very difficult problem. As we lose one dimension when we capture the image, reconstructing a 3D object from a 2D image is an ill-posed problem. Here we use data driven deep learning based techniques to reconstruct a 3D object from a given single image. Recent works on 3D reconstruction will either use 3D models or multiple images as supervisory signal. Whereas in our recent work, we architect a framework which uses a single RGB image to reconstruct 3D object in a self supervised manner. We briefly explain below the approach that we have taken.

Between different 3D representations such as voxel-based, mesh-based, point cloud-based representations, we used point cloud as it is information rich and efficient. We proposed a cyclic consistency based approach for reconstructing a 3D object from a single view. Our network architecture consists of a pair of encoder-decoder module. Image is fed to this encoder decoder module and a point cloud is generated as output. We have an additional pose network for predicting the camera pose from the input image. Point clouds obtained from encoder-decoder architecture is rendered to 2D image using the predicted pose by a differentiable rendering module along with silhouette loss and image loss. Further, predicted point cloud is projected to multiple random viewpoints. These images are passed through encoder decoder architecture, which predicts the point cloud. This reconstruction network is trained by the 3D cyclic consistency loss between the point clouds generated from the given image and the rendered image. Rendered images are also passed through the the pose network and we enforce a pose consistency loss between random poses used for rendering and the predicted poses for training the pose network. We have also utilized the images with similar 3D shapes as pseudo multiple viewpoints for improving the point-cloud reconstruction.

We have observed dense 3D correspondences in the reconstructed point clouds even though we didn't enforce correspondence explicitly. We have visualized the point cloud correspondence by using UV mapping. This dense correspondence has been utilized for part segmentation by utilizing a single part segmented ground truth image.

Fabricating novel micro-electrode cannula arrays to design neuroprotective therapies for acute stroke and epilepsy

Investigators:

Hardik J. Pandya Department of ESE, IISc (<http://beeslab.dese.iisc.ac.in/team/>)

Mahesh Jayachandra Centre for Bio-Systems Science & Engineering (BSSE), IISc

Siddharth Jhunjunwala Centre for Bio-Systems Science & Engineering (BSSE), IISc (<http://www.be.iisc.ernet.in/~siddharth/>)

Realistic physiological models and stringent Neuro-physiological metrics are critical for developing a therapy for brain diseases. The present project is focused on design, fabrication and in vivo testing of new class of micro-electrode cannula arrays (MECA) for recording electrical signals from deep brain structures of a rat model.

Epilepsy will be induced chemically, using topical application of known convulsants and that will be suppressed by applying standard AEDs locally over the epileptic focus. The fabricated device will help us to monitor the electro-physiological changes with the application of drugs. The stroke will be induced to rat model by permanent bilateral vertebral artery occlusions, followed by transient bilateral carotid artery occlusion. We will dissect the effects of the acute stroke on different neocortical layers using fabricated electrodes for physiologically realistic therapeutic interventions of stroke.

The MECA chips with 13, 15, and 17 electrodes (linearly arranged with an inter-electrode spacing of 100 μ m, 50 μ m, 25 μ m respectively) are fabricated to record bio-potential from deep brain structures. The images of the fabricated devices are shown in Figure 1. The electrical signals will be recorded and analyzed at a high sampling frequency (~10 kHz).

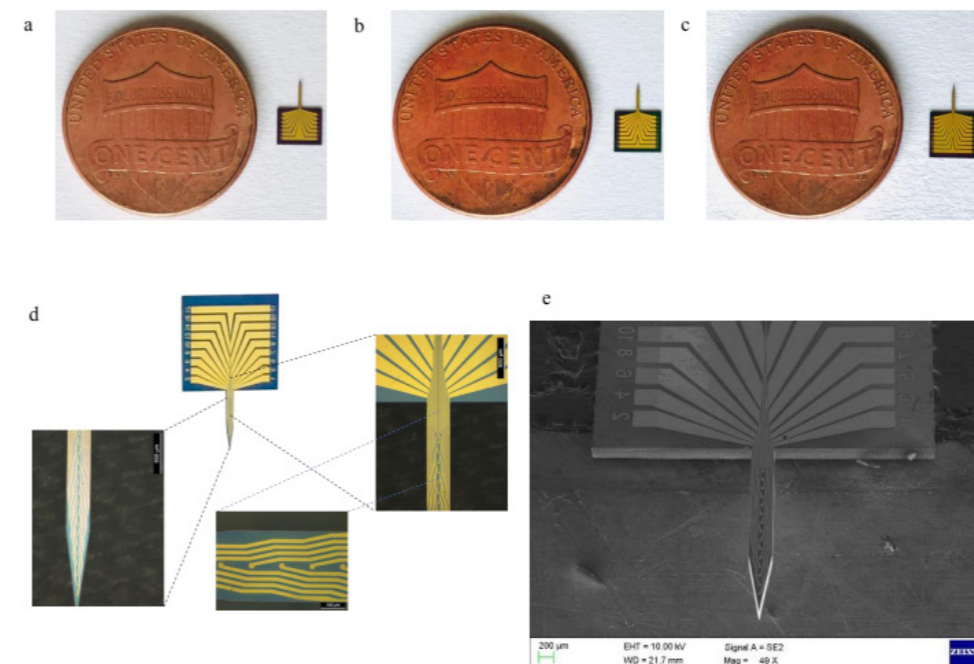


Figure 1: (a) MECA device with 13 recording electrodes; (b) MECA device with 15 recording electrodes; (c) MECA device with 17 recording electrodes; (d) Image of the MECA device with 17 recording electrodes under microscope; (e) SEM image of MECA device with 15 recording electrodes.

Neuromorphic fringe projection profilometry

Investigators:

Chandra Sekhar Seelamantula

Department of EE, IISc (<https://sites.google.com/site/chandrasekharseelamantula/home>)

Chetan Singh Thakur

Department of ESE, IISc (<http://neuronics.dese.iisc.ac.in/dr-chetan-singh-thakur/>)

Neuromorphic cameras are vision sensors inspired by the magno-cellular pathways in human vision, which specialize in detecting high-rate transient events. This is in contrast to the parvo-cellular pathways, which are slow and are characterized by their ability to detect sustained stimuli. Neuromorphic cameras differ from frame-based ones in the same spirit as magno-cellular pathways differ from parvo-cellular pathways. In addition, neuromorphic cameras are fast and asynchronous.

We address the problem of 3-D reconstruction using neuromorphic cameras. These cameras are becoming increasingly popular for solving image processing and computer vision problems. Compared with conventional frame-based cameras, the data rates are significantly lower in neuromorphic cameras. In particular, we have developed a Neuromorphic-camera-based Fringe Projection Profilometry (NFPP) system. We use the Dynamic Vision Sensor (DVS) in the DAVIS346 neuromorphic camera for acquiring measurements. NFPP is faster than a single line-scanning method. Unlike frame-based FPP, the efficacy of the proposed method is not limited by the background while acquiring the measurement. The working principle of the DVS also allows one to efficiently handle shadows thus preventing ambiguities during 2-D phase unwrapping.

The 3-D imaging setup consists of a DAVIS346 camera and a Texas Instruments Digital Light Projector (DLP) LightCrafter 4500 projector module arranged in a stereo setup. Light projected on the DLP's micromirror array gets reflected into a lens to generate an image on the screen, from which the depth has to be estimated. The key innovations in our work are: (i) the use of neuromorphic cameras to perform 3-D scanning starting from sparse measurements; (ii) imaging with moving fringe patterns instead of static ones; and (iii) the reconstruction algorithm. The results presented in the figure below show that the exploration is indeed successful and opens up a new direction of research in 3-D scanning.

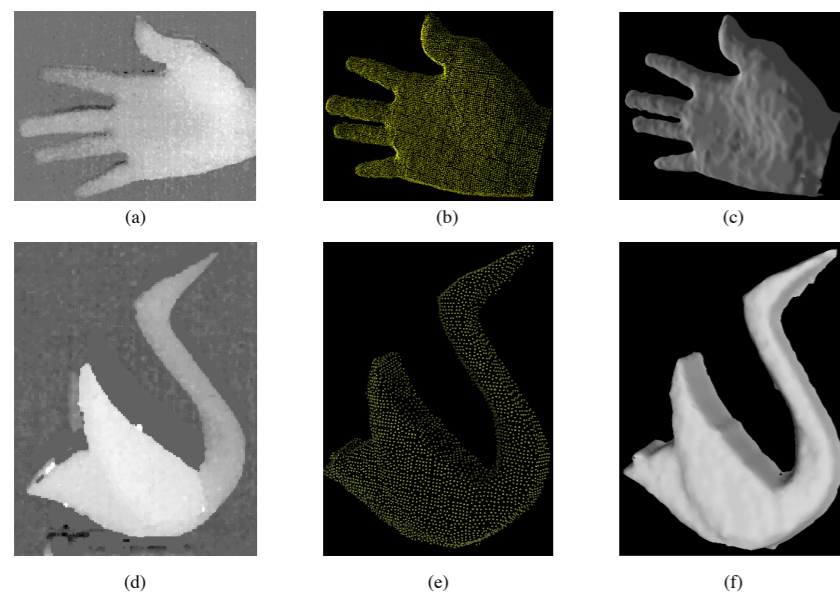


Fig. 1: Examples of scans of objects obtained using the NFPP system: (a) and (d) show the depth maps; (b) and (e) the corresponding 3-D point clouds; (c) and (f) the corresponding meshes.

Predicting the naturalness of artificially generated videos

Investigators:

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S P Arun

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Problem Statement

We consider the problem of predicting the naturalness of artificially generated videos. In the first phase of this project, we particularly look at approaches in which future frames of videos are predicted based on past frames popularly using convolutional neural networks (CNN). These approaches can lead to videos with several distortions. Note that when multiple future trajectories are possible given the past frames, a reference future may not be meaningful for quality comparisons. Further, we also observe inexplicable predictions such as the sudden appearance or disappearance of objects. Our main progress so far is in the design of a 'first of its kind' database of videos which are artificially generated and a subjective study to assess the perceptual naturalness of the generated videos. The database will be useful for both benchmarking current naturalness prediction algorithms and also propose new designs which correlate well with the subjective ratings.

Database and Subjective Study

We create a database of 300 artificially generated videos in which future frames are predicted based on past frames. The videos are all 5 seconds long played at a frame rate of 4 frames per second. The videos are sourced from several datasets used for video prediction including Berkeley Artificial Intelligence Research Dataset, KTH Human Action Dataset, UCF Action Recognition Dataset, and the KITTI Dataset for autonomous driving. The predicted videos are generated from several prediction algorithms including those that are designed by employing an error with respect to a given future as well those using an adversarial framework. The resulting distortions include blur, shape distortion, color changes and inexplicable appearance or disappearance of objects. Some examples of distorted frames are shown in Figure 1. We have also started conducting a subjective study to understand human responses to the generated videos. We adopt a two stimulus user study as shown in Figure 1, where a generated video is shown along with a natural video in a similar setting to remove any biases due to the video resolution. Around 40 subjects have already taken part in the study.



Figure 1: Database and Subjective Study

Next steps

The next steps involve benchmarking currently used cost functions for video prediction models including adversarial models. We wish to explore the relevance of video features learnt in action recognition and image recognition based features for naturalness prediction. Further we believe that a successful naturalness prediction index needs to track the shape trajectory of moving objects to capture any shape distortions. We also wish to create another database to evaluate the success of video prediction algorithms in learning the physics of the world and how humans would perceive their performance.

Rapid, large-scale connectome estimation for mapping structure-function relationships in healthy and diseased brains

Investigators:

Sridharan Devarajan

Center for Neuroscience, IISc (<http://www.cns.iisc.ac.in/sridhar/>)

Partha Talukdar

Department of CDS, IISc (<http://talukdar.net/>)

Diffusion imaging (dMRI) is a non-invasive technique for measuring the diffusion of water molecules in the brain's white matter. Tractography algorithms are applied to dMRI data to infer structural connections between different brain regions in the living human brain. We seek to highlight here two studies involving computational approaches to diffusion imaging and tractography that were published at prestigious venues earlier this year.

First, we developed a potentially useful resource for diffusion imaging and tractography. Conventional tractography algorithms often estimate spurious connections between brain regions. Linear Fascicle Evaluation (LiFE) is a state-of-the-art approach for pruning spurious connections, but imposes heavy demands on computing time (Pestilli et al, Nature Methods, 2014). We developed a GPU-based implementation of LiFE that achieves 50-100x speedups over LiFE, and estimates sparser, more accurate, connectomes. This work was presented at the 33rd AAAI conference on Artificial Intelligence (A* conference), and was selected as one of 1,150 full-length papers from over 7,700 submissions (15% acceptance rate). (conference publication: Kumar S, Sreenivasan V, Talukdar P, Pestilli F & Sridharan D. AAAI Proceedings, 2019; <https://doi.org/10.1609/aaai.v33i01.3301630>).

Second, leveraging the tools described above, we sought to understand brain-behavior relationships in the context of attention. We analyzed diffusion imaging (dMRI) data from n=22 subjects at IISc (data acquired from the scanner at HCG Hospital, Bangalore) and n=60 subjects from the Human Connectome Project (HCP) database. We discovered a striking relationship between connectivity in a key midbrain region – the superior colliculus (SC) – and key metrics of attention behaviors. Taken together with our previous findings, this study showed that the SC could be a key node in an evolutionarily conserved network for controlling visuospatial attention (journal publication: Sreenivasan V & Sridharan D. Proc. Natl. Acad. Sci. USA, 2019; <https://doi.org/10.1073/pnas.1902704116>).

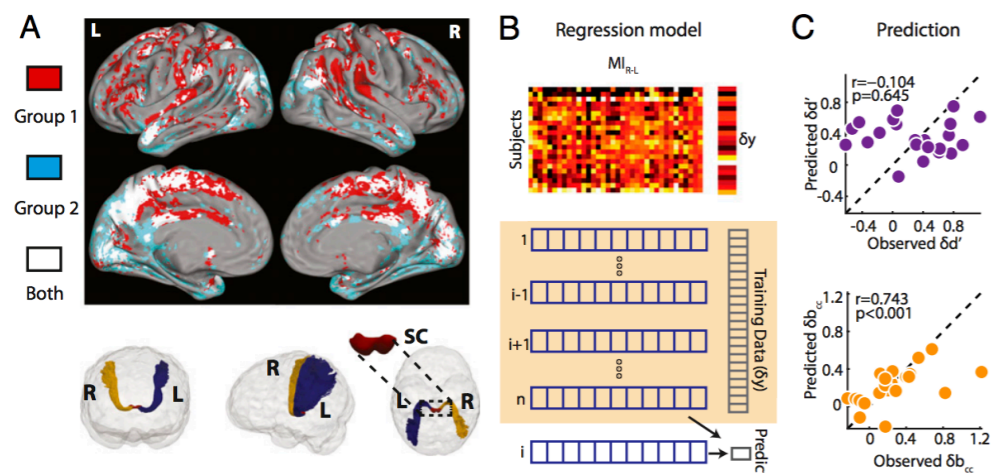


Figure. (A) Connectivity of the superior colliculus (SC) with other brain regions in the neocortex. (B) Regression model for predicting attention behavior components based on SC connectivity. (C) SC connectivity strongly predicts a decisional component of attention (choice bias, b_{sc}), but not the perceptual component (sensitivity, d'). Adapted from Sreenivasan and Sridharan, PNAS, 2019.

Compositionality of auditory units in speech perception - an EEG based study

Investigators:

Sriram Ganapathy

Department of EE, IISc (<http://leap.ee.iisc.ac.in/sriram/>)

S P Arun

Center for Neuroscience, IISc (<http://www.cns.iisc.ac.in/home/people/sp-arun/>)

Summary

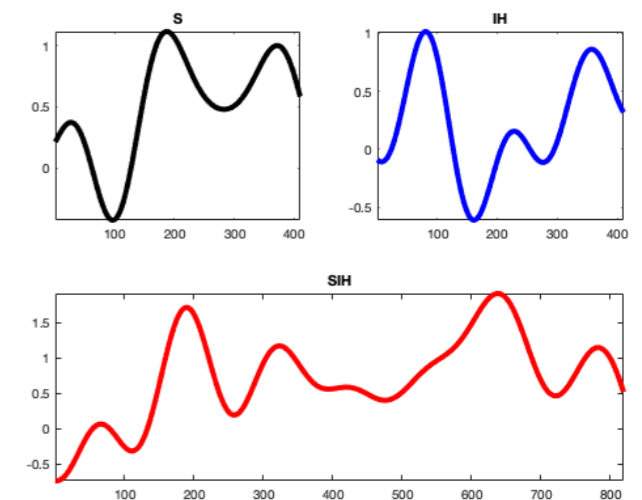
For understanding the brain processes involved in the perception of complex auditory or visual stimuli, one of the fundamental questions to answer is whether the brain performs compositional operations. This would mean that the representation in the brain for complex stimuli can be broken down into a composition of the representations for simpler basic stimuli units. In this project, we attempt to probe this question for the auditory stimuli. In automatic processing of speech, the fundamental unit of speech is a phoneme which is typically 80-100ms in duration. The main hypothesis in the proposed study is that the compositionality can be observed in EEG recordings obtained for a continuous speech listening task.

Materials and Methods

The first step in data preparation was the analysis of English phonemes to figure out 3 most / least probable consonants and vowels. From a data analysis on a speech database, the three most probable consonants were found to be (/s/, /n/, /r/) and least probable ones were (/jh/, /ch/, /g/). Similar list for vowels were (/ih/, /iy/, /ae/) and (/ah/, /ey/, /ow/) respectively. Several words were formed using the most/least probable consonant-vowel (CV) combinations and stimuli sentences were generated that contain these words. These sentence stimuli were then read by a single speaker to generate 90 sentences from most/least probable CV set. These form the audio stimuli for the EEG experiments. Using these sentences pilot EEG data was recorded for 2 subjects, when the subjects were listening to these audio stimuli.

Preliminary Analysis

The EEG signal was pre-processed using standard EEG software. The average response to each phoneme and the EEG response to the combination is shown (from the CV /sih/ for one of the pilot subjects). The response to the CV (/sih/) is seen to be partly explained as a combination of EEG response to individual phonemes /s/ and /ih/. A time warping of the individual phoneme responses also occurs in the combination response. The next steps in the project include developing a mathematical model of the compositionality along with a larger scale data collection and analysis.





Activities for 2019

CSA50 - Pratiksha Trust Workshop on Theoretical Computer Science

January 2nd and 3rd, 2019

2019 marks the golden jubilee of Department of Computer Science and Automation at IISc. To recognize this milestone, the department organized a workshop on theoretical computer science on January 2 and 3, 2019. The workshop coincided with the visit of Prof. Christos Papadimitriou to IISc.

For any student of theoretical computer science this was an ideal start to a new year. These two days will awarded us the pleasure of listening to and interacting with some of the most influential thinkers of theoretical computer science. The institute got to hear from researchers who epitomize deep, impactful work. The talks inspired and challenged us to achieve greater heights.

The details of the workshop (including the list of talks) is available at: <https://events.csa.iisc.ac.in/wotcs2019/index.html#home>

As mentioned before, the list of speakers included some of the most prominent researchers of theoretical computer Science: Prof. Prasad Tetali, Prof. Ravi Kannan, Prof. Meena Mahajan, Prof. Jaikumar Radhakrishnan, Prof. Naveen Garg, Prof. Amit Kumar, Prof. Prahlahd Harsha, Dr. Needhara Misra, Dr. Bhavana Kanukurthi, Prof. Manoj Prabhakaran, Dr. Vinakaya Pandit, Prof. Mukund Thattai, and Prof. Ramesh Hariharan. This list includes multiple Bhatnagar awardees and fellows of multiple academies. The keynote talk was delivered by Prof. Christos Papadimitriou.



Keynote talk by Prof. Christos Papadimitriou



Prof. Kannan talking about foundational aspects of Machine Learning



An IISc memento for Prof. Prasad Tetali

The workshop also had a poster session wherein students, from across the country, presented their recent. In this session, we have participation from IIT Kanpur, IIT Kharagpur, ISI Kolkata, TIFR Bombay, PSG College of Technology, Nirma University, PSG College of Technology, and Tezpur University.

Overall, the workshop had around 150 participants from multiple institutes in the country as well as members of the IISc community, at large. All the talks were recorded and the CSA department plans on hosting these videos on its YouTube channel. The feedback from the attendees, in particular the graduate students from other institutes, was extremely positive.

The workshop had a panel discussion with a rewarding discussion around "Theoretical Computer Science in India."

The travel expenses of the invited speakers, their local hospitality (including the stay), and the food (for all the participants) during the workshop was covered via the support of the Pratiksha Trust.



Engaged audience



An IISc memento for Prof. Meena Mahajan



Participants at the poster session (over a coffee break)

IISc - Pennsylvania State University Joint Workshop on Data intensive Biomedical, Cognitive and Brain Sciences

January 7-8, 2019, Indian Institute of Science

Recent advances in technologies for data acquisition and processing across multiple sensing modalities and spatial and temporal scales offer unprecedented opportunities for understanding and predicting health risks and intervention outcomes, personalizing treatments, informing policy and healthcare practice, and ultimately enhancing health. With increasing longevity, neurodegenerative disorders and other diseases that afflict the elderly have become pressing population health challenges across the globe.

Addressing these challenges require acquisition of massive amounts of longitudinal data from a diverse population using sensors, sequencing and other omics technologies, imaging (e.g., fMRI for measuring brain activity) across multiple spatial and temporal scales covering everything from cellular function to physiology, behavior, cognitive function, and social interactions.



Against this background, Professor Vasant Honavar, working closely with colleagues at Pennsylvania State University and at IISc, organized this joint workshop to identify promising research topics of complementary interest as well as modes of interdisciplinary collaboration across the two institutions. The workshop brought together a small group of approximately a dozen faculty with complementary interests and expertise from the IISc and Pennsylvania State University to pursue a bold, ambitious, coordinated transdisciplinary research agenda aimed at:

- Understanding the complex set of interactions between genetic, environmental, behavioral, and socio-demographic factors exacerbate or shield against cognitive declines during aging and developing effective

personalized interventions that reduce the burden of dementia.

- Developing technologies, including those based on advances in artificial intelligence and neuromorphic computing, to augment and extend human intellect and abilities, including those susceptible to declines during aging.

The workshop consisted of:

- Introductory talks that introduced the research strengths of IISc and Pennsylvania State University and the institutional perspectives on collaboration.
- A set of short research presentations by IISc, PSU, CBR and NIMHANS faculties with deep expertise in some of the relevant areas, including Population Health Sciences (with emphasis on the scientific aims, design, and anticipated results of the longitudinal studies being carried out by the Center for Brain Research), Biomedical Data Sciences, Cognitive and Brain Sciences, Genomics and Life Sciences, Neuromorphic Computing and Assistive Technologies; and Artificial Intelligence and Machine Learning
- Breakout sessions were arranged on a set of relevant themes, e.g., on Machine Learning and Artificial Intelligence, Neuromorphic Computing, Cognitive and Brain Sciences, Genomics and Life Sciences, and Population Health to explore areas for fruitful collaboration.

The participating faculty outlined a plan of action for collaborative research organized around shared interests on at least 3 broad themes:

- Predictive and causal modeling and computational phenotyping of individual and population health risks and health outcomes from diverse types of data leading eventually to public health policy or personalized interventions. A number of concrete research topics in machine learning, artificial intelligence, and data sciences could fit within this theme.
- Characterization of the genetic diversity in the Indian population, identification of genetic risk factors, and development of cost-effective diagnostics.
- Development of assistive technologies for the aging population, by leveraging breakthroughs in artificial intelligence and machine learning on the one hand and energy efficient, neuromorphic computing devices and platforms on the other.

At the conclusion of the workshop to facilitate collaborative research, the faculty would like to pursue:

- Future workshops that drill down on specific areas of interest.
- Exchange of faculty, postdoctoral researchers, PhD students, Masters students, and undergraduate research interns.
- Joint supervision of PhD students and postdoctoral researchers by IISc and PSU faculty.
- Collaborative research proposals to funding agencies and philanthropic foundations.
- Creation of one or more thematically focused research networks or centers that span IISc, PSU, and perhaps other institutions.

Participants from Pennsylvania State University

Robert Crane, Office of Global Programs

Michele Diaz, Department of Psychology

Santhosh Girirajan, Department of Biochemistry and Molecular Biology

Vasant Honavar, College of Information Sciences and Technology

Vijay Narayanan, School of Electrical Engineering and Computer Science

Workshop on Neural Systems – Science and Engineering

January 23 - 25, 2019

Faculty Hall, Indian Institute of
Science, Bangalore

THEME

Understanding the processes involved in brain functions like audition and vision forms an important and growing area of interdisciplinary research. These approaches and associated techniques have acted as a melting pot for researchers from disparate disciplines to come together and address one of the grandest challenges of the 21st century. The grandness of the challenge and the requirement on diverse forms of expertise has deemed that such endeavors require synergistic interactions among neurobiologists, electrical engineers and computer scientists. Over the past decade or two, neurobiologists have made significant conceptual advances in our understanding of the brain through technical breakthroughs that have yielded unprecedented opportunities to gather large-scale structural and functional data. Learning and understanding thesis tools would enable computer scientists and data analysts to develop exceptional tools to address questions in machine learning and signal processing, tools that are not only helpful in emulating brain function, but also are radically transforming many applications in information and communication technologies.



This workshop titled “Neural Systems - Science and Engineering” falls under the broader theme of activities in IISc under the banner of Brain Computation and Learning (BCL) . This workshop was aimed at creating this useful dialogue between neurobiologists and computer scientists and educating research students of each area with relevant topics of the other. A prominent goal of this workshop is to promote synergistic interactions among neuroscientists, electrical engineers, and computer scientists. The workshop would allow young researchers to understand the diverse themes of research and appreciate the close relationships between these apparently distinct themes.

INVITED SPEAKERS

Prof. Lori Holt
(Carnegie Mellon University)

Prof. Mounya Elhilali
(Johns Hopkins University)

Prof. Shantanu Chakrabartty
(Washington University St. Louis)

Prof. Barbara Shinn-Cunningham
(Carnegie Mellon University)

Dr. Ying Xu
(Western Sydney University)

Dr. Neeraj Sharma
(Carnegie Mellon University and Indian
Institute of Science)

Prof. Shayan Garani Srinivasa
(Indian Institute of Science)

Prof. Shihab Shamma
(University of Maryland)

Prof. S. P. Arun
(Indian Institute of Science)

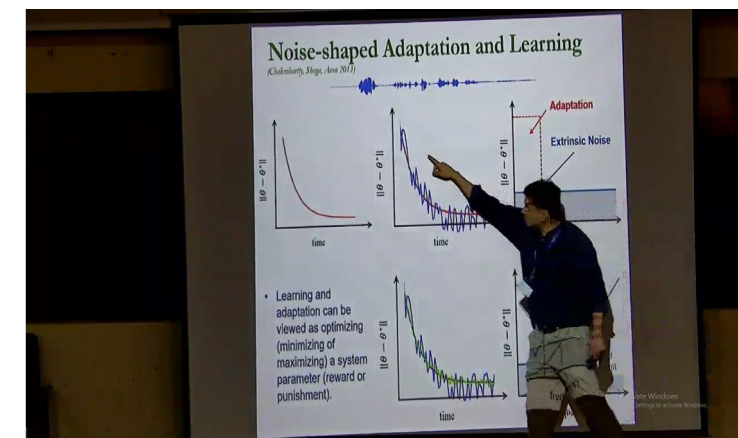
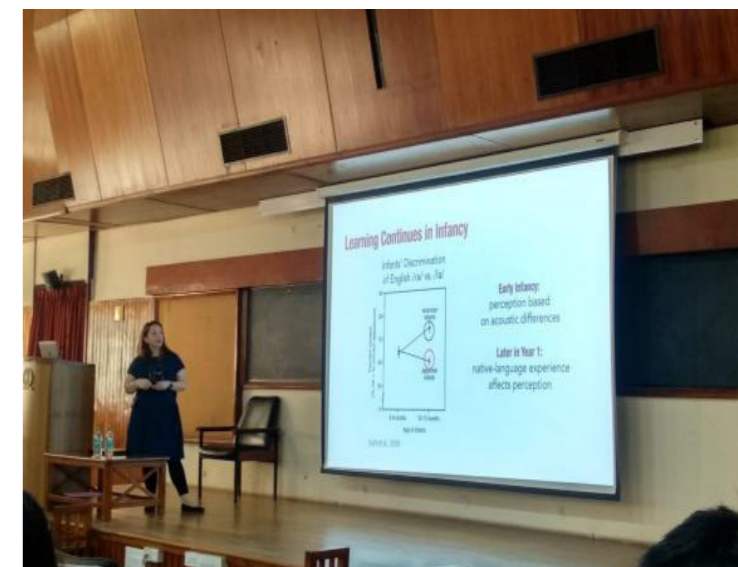
PARTICIPANTS

There were total of 300 participants of different institutions from all over India and from different departments of Indian Institute of Science. The participants were from interdisciplinary nature with many from science and engineering backgrounds. The sessions were very lively with many Q&A discussions during the talks.

FEEDBACK FROM ANONYMOUS PARTICIPANTS

Immensely satisfied with the arrangements.

- Contents delivered by speakers were very informative.



Signing of MOU between Indian Institute of Science and Western Sydney University, Australia

The Indian Institute of Science (IISc), Bangalore, and Western Sydney University (WSU), Australia signed a MOU for expanding their ongoing partnership to support cutting-edge research in the area of neuromorphic engineering. This alliance will enable collaborative research and exchange of students between the International Centre for Neuromorphic Systems (ICNS) at WSU and the Brain, Computation and Data Science (BCD) Group at IISc. ICNS constitutes a core research concentration within WSU's internationally renowned MARCS Institute for Brain, Behaviour and Development. It distinguishes itself from other neuromorphic engineering research groups through its core focus on the applications of neuromorphic technology. The research and capacity building that will be realized through this ICNS – BCD alliance will position both IISc and WSU at the forefront of this highly interdisciplinary endeavour.

The MoU was signed in the presence of Prof. André van Schaik, Director of the International Centre for Neuromorphic Systems, Western Sydney University; Prof. Barney Glover, Vice Chancellor of Western Sydney University; and Prof. Jayant Modak, Deputy Director, IISc.



Exhibit 1: Meeting at the council room IISc before the MoU signing ceremony, including delegates from Western Sydney University, Chairs of the IISc EECS departments, EECS Divisional Chair and the BCD group members

IISc-WSU agreement provides details of a specific program between International Centre for Neuromorphic Systems (ICNS) at WSU and Brain, Computation and Data Science group at IISc Bangalore to develop academic collaboration by following activities:

1. WSU to host IISc Masters projects.
2. WSU to host IISc PhD students.
3. IISc to host WSU PhD students.
4. WSU to establish the IISc-WSU Neuromorphic Systems PhD Scholarship.
5. Make joint approaches to international industry partners to expand the program.
6. WSU and IISc to consider establishing a regular regional academic meeting for neuromorphic systems.

Exhibit 2: Left to Right-> Prof. André van Schaik (Director of ICNS, WSU), Prof. Anurag Kumar (Director, IISc), Prof. Barney Glover (Vice Chancellor, WSU), Dr. Chetan Singh Thakur (Head of the NeuRonICS lab at IISc) during the lunch session.



Third Workshop on Brain, Computation, and Learning

June 24-28, 2019

Computational approaches to understanding brain function form an important and growing area of interdisciplinary research. These approaches and associated techniques have acted as a melting pot for researchers from disparate disciplines to come together and address one of the grandest challenges of the 21st century. The grandness of the challenge and the requirement on diverse forms of expertise has deemed that such endeavors require synergistic interactions among neurobiologists, electrical engineers, and computer scientists. Over the past decade or two, neurobiologists have made significant conceptual advances in our understanding of the brain through technical breakthroughs that have yielded unprecedented opportunities to gather large-scale structural and functional data. On the other hand, over the same period, electrical engineers and computer scientists have developed exceptional tools to address questions in signal processing, machine learning and data analytics, tools that are not only helpful in emulating brain function, but also are radically transforming many applications in information and communication technologies. The workshops on Brain Computation and Learning are aimed at creating the useful dialogue between neurobiologists, electrical engineers, and computer scientists and educating research students of each area with relevant topics of the other topics. While there are several conferences and workshops that focus solely on neuroscience or on artificial intelligence, the unique selling point of the BCL series of workshops has been its ability to bring together a diverse set of speakers and audience who span the continuum encompassing neurobiology and machine intelligence research

The Third in the series of workshops was organized in the Faculty Hall, Indian Institute of Science, during June 24-28, 2019. The sessions were on the following themes:

- Multi-Scale Neuroscience
- Machine Learning

- Neuromorphic Computation and Olfaction Information Encoding
- Deep Learning Systems
- Neural Circuits and Plasticity
- Adaptive Learning Systems
- Manifolds of Learning and Cognition
- Panel Discussion on AI and Neuroscience

The invited speakers

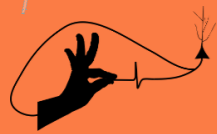
included the following:

- Mayank Mehta, University of California, Los Angeles: *Learning In Neurons, Networks and Organisms*
- Vatsala Thirumalai, National Centre for Biological Sciences, Bangalore: *Connecting the Dots: Single Neurons, Populations, and Behavior*
- Maneesh Sahani, University College of London: *Learning to Compute with Distributed Distributional Representations of Uncertainty*
- Vasant Honavar, The Pennsylvania State University, University Park: *On the Importance of Causal Models in Making Sense of Big Data*
- Baranidharan Raman, Washington University, St Louis: *A Computational Logic for Olfaction*
- Shantanu Chakrabartty, Washington University, St Louis: *Growth Transform Neural Networks: A Scalable Neuromorphic Machine Learning Framework to Address Neuron-to-Network Performance Gap*
- Chetan Singh Thakur, Indian Institute of Science: *Low Power Neuromorphic Systems for Edge Computing*
- Anirvan Nandy, Yale University School of Medicine, New Haven: *Neural Mechanisms of Flexible Information Selection*
- Stephen David, Oregon Health & Science University, Portland: *Influence of Behavioral State on Coding by Neural Populations in Auditory Cortex*
- Vineeth Balasubramanian, Indian Institute of Technology, Hyderabad: *Explaining Neural Networks: A Causal Perspective*

- Vinay Namboodiri, Indian Institute of Technology, Kanpur: *Towards Interpreting Vision and Language Based Learning*
- Venkatesh Babu, Indian Institute of Science, Bangalore: *Bright and Dark Sides of Deep Learning*
- Mark van Rossum, The University of Nottingham: *Energy Efficient Synaptic Plasticity*
- Sachin Deshmukh, Indian Institute of Science: *Space, Complexity, and the Entorhinal- Hippocampal Network*
- Julian Jara-Ettinger, Yale University, New Haven: *Computational Principles Underlying Commonsense Psychology*
- S. P. Arun, Indian Institute of Science: *Reading is Enabled by a Compositional Shape Code*
- Pulkit Agrawal, Massachusetts Institute of Technology, Cambridge: *Continually Evolving Machines: Learning by Experimenting*
- Srikanth Padmala, Indian Institute of Science: *Interactions between Emotion, Motivation, and Cognition in the Human Brain*
- Kishore Kuchibhotla, Johns Hopkins University, Baltimore: *Dissociation of Task Acquisition from Expression during Learning Reveals Latent Knowledge*
- Arvind Kumar, KTH Royal Institute of Technology, Stockholm: *Manifolds of Brain Activity and Their Implications for Learning*

The workshop was a resounding success with a host of leading researchers from all over the world delivering expert talks. More than 200 Masters and Doctoral students and young researchers from all over India benefited from the proceedings of the workshop. The technical program included keynote talks, research talks, wrapup discussions at the end of conclusion of every day's proceedings and a panel discussion on AI and Neuroscience.

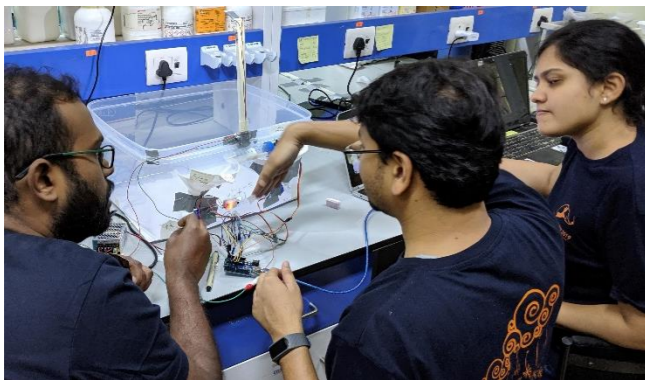




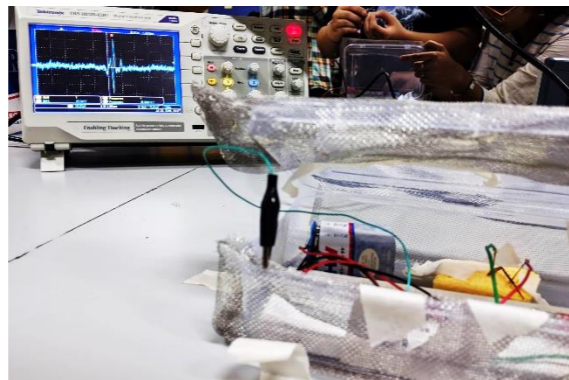
Monsoon Workshop on Experimental Neuroscience - 2019 July 21 - 25, 2019



MonsoonWEN was conceived as a workshop where early career scientists (Masters and PhD students as well as postdoctoral researchers) could gain *hands-on* experience in experimental Neuroscience. The guiding philosophy at the workshop is that the best learning comes from doing things with your own hands. At the workshop, students learned by doing a series of carefully designed exercises, which culminated in them designing, building, debugging and using their own custom-built, experimental setups for recording neuronal activity and performing behavioural experiments.



designing a rodent behaviour arena



built an amplifier to record action potentials from a cockroach leg

Testimonials

Student A

"...With absolutely no background in electronics or coding I still could understand and execute the basic workings of electrophysiology experiments and this would help me a lot in my future...
...The fun and engaging part of the workshop was also maintained quite well and even though it continued till very late it never became saturating."

Student B

"I had amazing 5 days. The lectures, tutorials and exercises by TAs, hands-on sessions, discussions over tea-breaks, lunches and dinners...one could not have a better workshop than this..."

Pratiksha Trust Symposium on Brain, Computation and Data Science Date: 18th Oct, 2019, Time: 3-5PM Venue: ECE Golden Jubilee Hall

The Brain, Computation, and Data Science initiative, set up in June 2015, sprung out of the generous endowment provided by Mr. Kris Gopalakrishnan and Mrs. Sudha Gopalakrishnan, founders of the Pratiksha Trust, Bangalore. Award of Pratiksha Trust Young Investigator Positions to Assistant Professors is one of several initiatives by the Pratiksha Trust. This symposium featured talks by all the Pratiksha Trust Young Investigator awardees.

Mr. Kris Gopalakrishnan and Prof. Anurage Kumar, The Director, IISc attended the symposium. The symposium started with introductory remarks by Prof. Y Narahari. This was followed by presentations by eight Pratiksha Trust Young Investigators as follows:

- Computational neuroimaging of brain connectivity in health and disease, Dr. Sridharan Devarajan, Centre for Neuroscience, IISc
- The curious case of Multi-talker Speech Processing in Humans and its impact on Machines, Dr. Sriram Ganapathy, Department of EE, IISc
- Neuromorphic In Memory Computing Architecture using Memristor as a Synaptic Device, Dr. Chetan Singh Thakur, Department of ESE, IISc
- Dysarthria due to Parkinson's Disease vs Amyotrophic Lateral Sclerosis, Dr. Prasanta Kumar Ghosh, Department of EE, IISc
- Algorithm and Economies, Dr. Siddharth Barman, Department of CSA, IISc
- Deep Surveillance: Person Search and Retrieval Across Cameras and Modalities, Dr. Anirban Chakraborty, Department of CDS, IISc
- Learning over Graphs, Dr. Sundeep Prabhakar Chepuri, Department of ECE, IISc
- Biologically Plausible Neural Networks, Dr. Anand Louis, Department of CSA, IISc

The symposium ended with a high tea. The symposium was well attended by faculty, students of IISc as well as people from industry and research labs outside IISc. Feedback from attendees showed that they liked the symposium and overview of different research activities happening at IISc. They also like to see a longer version of such symposium in future.



Interdisciplinary Ph.D. Programme in Brain and Artificial Intelligence

This interdisciplinary PhD programme is aimed at promoting research at the intersection of neuroscience and artificial intelligence, by providing wholesome training that spans both fields and blurs their distinctions. Its focus would be on computational approaches to understanding brain function and their synergistic interactions with artificial intelligence paradigms. This unique offering will be commencing its operations from August 1, 2020. Each selected student will be working with two advisors belonging to two different departments, to ensure the interdisciplinary flavor of the program.

For more details of the group of faculty involved and the programme visit: <https://brain-computation.iisc.ac.in/>

Basic Qualification For Eligibility: M Sc or equivalent degree in any branch of Sciences or BE / B Tech or equivalent degree in any discipline or 4-year Bachelor of Science programmes.

Areas of Research: Brain Inspired Artificial Intelligence; Machine Learning; Signal Processing; Theoretical and Computational Neuroscience; Cellular, Systems and Cognitive Neuroscience; Sensory Systems: Vision, Speech; High-Level Cognitive Processes: Learning, Attention, Decision Making; Brain machine Interfaces; Neuromorphic Computation, Neuromorphic Hardware

It is proposed to start with an initial intake of 5 students per year, with the number steadily increasing to 10 over a period of 5 years. It is expected that in the steady-state, there will be 30 to 40 Ph.D. students on roll at any point of time. This unique program is expected to provide a significant boost to this important interdisciplinary area.



Research Publications

2020

Journals

Illa, Aravind, and Prasanta Kumar Ghosh. "Closed-set speaker conditioned acoustic-to-articulatory inversion using bi-directional long short term memory network." *The Journal of the Acoustical Society of America* 147.2 (2020): EL171-EL176.

Aravind Illa and P. K. Ghosh, "The impact of speaking rate on acoustic-to-articulatory inversion", *Computer Speech & Language*, January 2020, Volume 59, pages: 75-90.

Approximation Algorithms for Maximin Fair Division, Siddharth Barman and Sanath Kumar Krishnamurthy. *ACM Transactions on Economics and Computation (TEAC)*, to appear.

Conferences

Ajmera SA, Jain H, Sundaresan M & Sridharan D* (2020). Decoding task-specific cognitive states with slow, directed functional networks in the human brain. *eNeuro*.

Tight Approximation Bounds for Maximum Multi-Coverage, Siddharth Barman, Omar Fawzi, Suprovat Ghoshal, and Emirhan Gulpinar, *Conference on Integer Programming and Combinatorial Optimization (IPCO)*, 2020.

S. Rudresh, A. J. Kamath, and C. S. Seelamantula, "A time-based sampling framework for finite-rate-of-innovation signals," *Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, May 4-8, 2020.

Sravanti A., Gaurav N., Anirban C., and R. Venkatesh Babu, "DeGAN : Data-enriching GAN for retrieving Representative Samples from a Trained Classifier", in *AAAI 2020*.

2019

Preprints

A. Krishna, S. Rudresh, V. Shaw, H. R. Sabbella, C. S. Seelamantula, and C. S. Thakur, "Unlimited dynamic range analog-to-digital conversion," *arXiv:1911.09371*, 2019.

Journals

Gupta S, Kumar P, Paul T, van Schaik A, Ghosh A, Thakur C S, (2019) "Low Power, CMOS-MoS2 Memtransistor based Neuromorphic Hybrid Architecture for Wake-Up Systems". *Scientific Reports (Nature Group)*

Achuth Rao MV and P. K. Ghosh. "Glottal Inverse Filtering Using Probabilistic Weighted Linear Prediction." *IEEE/ACM Transactions on Audio, Speech, and Language Processing* 27.1 (2019): 114-124.

Sreenivasan V & Sridharan D* (2019). Subcortical connectivity correlates selectively with attention's effects on spatial choice bias. *Proceedings of the National Academy of Sciences USA* 116 (39) 19711-19716.

Sagar V, Sengupta R & Sridharan D* (2019). Dissociable sensitivity and bias mechanisms mediate behavioral effects of exogenous attention. *Scientific Reports*, 9(1), 12657. doi: 10.1038/s41598-019-42759-w.

Banerjee S, Grover S, Ganesh S & Sridharan D* (2019). Sensory and decisional components of endogenous attention are dissociable. *Journal of Neurophysiology*, 122(4): 1538-1554. doi: 10.1152/jn.00257.2019.

Navaneet, K.L., Sarvadevabhatla, R.K., Shekhar, S., Babu, R.V. and Chakraborty, A., Operator-in-the-Loop Deep Sequential Multi-camera Feature Fusion for Person Re-identification. *IEEE Transactions on Information Forensics and Security*, 2019

P. Agrawal and S. Ganapathy, "Modulation Filter Learning Using Deep Variational Networks for Robust Speech Recognition", IEEE Journal of Selected Topics in Signal Processing (J-STSP), Special Issue on Data Science: Machine Learning for Audio Signal Processing, April 2019.

A. Soman, Madhavan C. R., K. Sarkar, and S. Ganapathy, "An EEG Study On The Brain Representations in Language Learning", IOP Journal on Biomedical Physics and Engineering Express, 5(2), 25-41, (2019).

S. Ramoji and S. Ganapathy, "Supervised I-vector Modeling for Language and Accent Recognition", Elsevier Journal on Computer, Speech and Language, Oct. 2019.

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B. R. Pradhan, Y. Bethi, S. Narayanan, A. Chakraborty, Thakur, C. S., "en-HAR: A Neuromorphic Event-Based Human Activity Recognition System Using Memory Surfaces". IEEE International Symposium on Circuits and Systems (ISCAS), 2019.

R. Sharma, S. Gupta, K. Kumar, P. Kumar, Thakur, C. S., "Real-Time Image Segmentation Using Neuromorphic Pixel Array". IEEE International Symposium on Circuits and Systems (ISCAS), 2019.

S. Gupta, P. Kumar, K. Kumar, S. Chakraborty, Thakur, C. S., "Low Power Neuromorphic Analog System based on Sub-Threshold Current Mode Circuits". IEEE International Symposium on Circuits and Systems (ISCAS), 2019.

A. Tripathi, M. Arabizadeh, S. Khandelwal, Thakur, C. S., "Analog Neuromorphic System based on Multi Input Floating Gate MOS Neuron Model". IEEE International Symposium on Circuits and Systems (ISCAS), 2019.

Suhas BN, Deep Patel, Nithin Rao, Yamini Belur, Pradeep Reddy, Nalini Atchayaram, Ravi Yadav, Dipanjan Gope and P. K. Ghosh, "Comparison of Speech Tasks and Recording Devices for Voice Based Automatic Classification of Healthy Subjects and Patients with Amyotrophic Lateral Sclerosis", in Interspeech 2019, Graz, Austria.

Manoj Kumar Ramanathi, Chiranjeevi Yarra and P. K. Ghosh, "ASR inspired syllable stress detection for pronunciation evaluation without using a supervised classifier and syllable level features", in Interspeech 2019, Graz, Austria.

Abinay Reddy Naini, Achuth Rao MV and P. K. Ghosh, "Whisper to neutral mapping using cosine similarity maximization in i-vector space for speaker verification", in Interspeech 2019, Graz, Austria.

Renuka Mannem, Jhansi Mallela, Aravind Illa and P. K. Ghosh, "Acoustic and articulatory feature based speech rate estimation using a convolutional dense neural network", in Interspeech 2019, Graz, Austria.

Atreyee Saha, Chiranjeevi Yarra and P. K. Ghosh, "Low resource automatic intonation classification using gated recurrent unit (GRU) networks pre-trained with synthesized pitch patterns", in Interspeech 2019, Graz, Austria.

Sweekar Sudhakara, Manoj Kumar Ramanathi, Chiranjeevi Yarra and P. K. Ghosh, "An improved goodness of pronunciation (GoP) measure for pronunciation evaluation with DNN-HMM system considering HMM transition probabilities", in Interspeech 2019, Graz, Austria.

Aravind Illa and P. K. Ghosh, "An investigation on speaker specific articulatory synthesis with speaker independent articulatory inversion", in Interspeech 2019, Graz, Austria.

Chiranjeevi Yarra, Aparna Srinivasan, Sravani Gottimukkala and P. K. Ghosh, "SPIRE-fluent: A self-learning app for tutoring oral fluency to second language English learners", in Interspeech 2019, Graz, Austria.

Aravind Illa and P. K. Ghosh, "Representation learning using convolution neural network for acoustic-to-articulatory inversion", In Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Brighton, UK, 2019, pages: 5931-5935.

Gokul Srinivasan, Aravind Illa and P. K. Ghosh, "A study on robustness of articulatory features for automatic speech recognition of neutral and whispered speech", In Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Brighton, UK, 2019, pages: 5936-5940.

Valliappan CA, Avinash Kumar, Renuka Mannem, Karthik Girija Ramesan, P. K. Ghosh, "An improved air tissue boundary segmentation technique for real time magnetic resonance imaging video using segnet", In Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Brighton, UK, 2019, pages: 5921-5925.

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encoder-decoder network", In Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Brighton, UK, 2019, pages: 5941-5945.

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Ajmera SA, Rajagopal S, Rehman R & Sridharan D* (2019). Infra-slow brain dynamics as a marker for cognitive function and decline. Advances in Neural Information Processing Systems (NeurIPS) Proceedings.

Kumar S, Sreenivasan V, Talukdar P, Pestilli, F & Sridharan D* (2019). ReAI-LiFE: Accelerating the discovery of individualized brain connectomes on GPUs. AAAI Conference on Artificial Intelligence Proceedings, 33(01), 630-638. doi: 10.1609/aaai.v33i01.3301630.

Fully Polynomial-Time Approximation Schemes for Fair Rent Division, Eshwar Arunachaleswaran, Siddharth Barman, and Nidhi Rathi. ACM-SIAM Symposium on Discrete Algorithms (SODA), 2019.

Fair Division with a Secretive Agent, Eshwar Arunachaleswaran, Siddharth Barman, and Nidhi Rathi. AAAI Conference on Artificial Intelligence, 2019.

On the Proximity of Markets with Integral Equilibria, Siddharth Barman and Sanath Krishnamurthy. AAAI Conference on Artificial Intelligence, 2019.

Fair Division of Indivisible Goods Among Strategic Agents, Siddharth Barman, Ganesh Ghalme, Shweta Jain, Pooja Kulkarni, and Shivika Narang. International Conference on Autonomous Agents and Multiagent Systems (Extended Abstract), 2019.

Fair and Efficient Cake Division with Connected Pieces, Eshwar Ram Arunachaleswaran, Siddharth Barman, Rachitesh Kumar, Nidhi Rathi. Conference on Web and Internet Economics (WINE), 2019.

Navaneet, K.L., Mandikal, P., Agarwal, M. and Babu, R.V., 2019, "CAPNet: Continuous approximation projection for 3D point cloud reconstruction using 2D supervision". In Proceedings of the AAAI Conference on Artificial Intelligence (Vol. 33, pp. 8819-8826).

K. Praveen, A. Gupta, A. Soman and S. Ganapathy "Second Language Transfer Learning in Humans and Machines Using Image Supervision", IEEE ASRU, Dec. 2019.

P. Agrawal and S. Ganapathy, "Unsupervised Raw Waveform Representation Learning for ASR", INTERSPEECH, 2019.

N. Sharma, S. Ganesh, S. Ganapathy and L. Holt, "Analyzing human reaction time for talker change detection", ICASSP, 2019.

P. Agrawal and S. Ganapathy, "Deep variational filter learning models for speech recognition", ICASSP, 2019.

2018 Journals

Thakur C. S., Jamal Molin, Gert Cauwenberghs, Giacomo Indiveri, Kundan Kumar, Ning Qiao, Johannes Schemmel, Runchun Wang, Elisabetta Chicca, Jennifer Olson Hasler, Jae-sun Seo, Shimeng Yu, Yu Cao, Andr  van Schaik, Ralph Etienne-Cummings (2018). Large-Scale Neuromorphic Spiking Array Processors: A quest to mimic the brain. Frontiers in Neuroscience.

G. Nisha Meenakshi and P. K. Ghosh, "Reconstruction of Articulatory Movements During Neutral Speech From Those During Whispered Speech", Journal of Acoustical Society of America, June 2018, 143 (6), page 3352-3364.

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Chakraborty S, P. Priyanka, Gupta S, Afshar S, Hamilton T, Thakur C S, "Neuromorphic Object Tracking Architecture Based on Compound Eye on FPGA" IEEE Midwest Symposium on Circuits and Systems (MWSCAS), 2018.

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G. Nisha Meenakshi and P. K. Ghosh, "Whispered speech to neutral speech conversion using bidirectional LSTMs", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 491-495.

Pavan Karjol and P. K. Ghosh, "Speech enhancement using deep mixture of experts based on hard expectation maximization", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 3254-3258.

Abinay Reddy N, Achuth Rao M V, G. Nisha Meenakshi and P. K. Ghosh, "Reconstructing Neutral Speech from Tracheoesophageal Speech", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 1541-1545.

Astha Singh, G. Nisha Meenakshi and P. K. Ghosh, "Relating articulatory motions in different speaking rates", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 2992-2996.

Chandana S, Chiranjeevi Yarra, Ritu Aggarwal, Sanjeev Kumar Mittal, Kausthubha NK, Raseena K T, Astha Singh and P. K. Ghosh, "Automatic visual augmentation for concatenation based synthesized articulatory videos from real-time MRI data for spoken language training", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 3127-3131.

Achuth Rao M V, Rahul Krishnamurthy, Pebbili Gopikishore, Veeramani Priyadarshini and P. K. Ghosh, "Automatic glottis localization and segmentation in stroboscopic videos using deep neural network", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 3007-3011. (Finalist for the best paper award)

Girija Ramesan Karthik, Parth Suresh and P. K. Ghosh, "Subband weighting for binaural speech source localization", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 861-865.

Valliappan CA, Renuka Mannem and P. K. Ghosh, "Air-Tissue Boundary Segmentation in Real-Time Magnetic Resonance Imaging Video using Semantic Segmentation with Fully Convolutional Networks", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 3132-3136.

Anand P A, Chiranjeevi Yarra, Kausthubha N K and P. K. Ghosh, "Intonation tutor by SPIRE (In-SPIRE): An online tool for an automatic feedback to the second language learners in learning intonation", In Proc. Interspeech, Hyderabad, India, 2018, Page(s): 546-547.

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Urvish Desai, Chiranjeevi Yarra and P. K. Ghosh, "Concatenative articulatory video synthesis using real-time MRI data for spoken language training", In Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2018, page(s): 4999-5003.

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Anurendra Kumar, Tanaya Guha and P. K. Ghosh, "A dynamic latent variable model for source separation", In Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2018, page(s): 2871-2875.

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Karthik Girija Ramesan and P. K. Ghosh, "Binaural speech source localization using template matching of interaural time difference patterns", In Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2018, page(s): 5164-5168

Finding Fair and Efficient Allocations, Siddharth Barman, Sanath Krishnamurthy, and Rohit Vaish. ACM Conference on Economics and Computation (EC), 2018.

Fair Division Under Cardinality Constraints, Siddharth Barman and Arpita Biswas. International Joint Conference on Artificial Intelligence (IJCAI), 2018.

Greedy Algorithms for Maximizing Nash Social Welfare, Siddharth Barman, Sanath Krishnamurthy, and Rohit Vaish. International Conference on Autonomous Agents and Multiagent Systems (AAMAS), 2018. Nominated for the Best-Paper Award.

Groupwise Maximin Fair Allocation of Indivisible Goods Siddharth Barman, Arpita Biswas, Sanath Krishnamurthy, and Y. Narahari. AAAI Conference on Artificial Intelligence, 2018.

Vivek B.S., M. Reddy and R. Venkatesh Babu, "Gray box Adversarial Training" in ECCV 2018.

P. Agrawal and S. Ganapathy, "Comparison of unsupervised modulation filter learning methods for ASR", INTERSPEECH, 2018.



