

Celebrating The Generosity of

**Shri Kris Gopalakrishnan
and
Smt. Sudha Gopalakrishnan**



IMPACT OF YOUR GIVING IN
2023



INDIAN INSTITUTE OF TECHNOLOGY MADRAS
OFFICE OF ALUMNI AND CORPORATE RELATIONS

Director's Message

Prof. Kamakoti Veezhinathan

Director, IITM



Greetings!

IIT Madras continues to retain her top position for the eighth consecutive year, in the National Institute Ranking Framework, thanks to the world-class research of its faculty and students. The contribution and support of *Alumni and well-wishers like you* has crucially helped this standing and stature. Our achievements in research, education, innovation and entrepreneurship have also earned us the recognition of an 'Institute of Eminence' as well as the top position in the Atal Innovation Ranking from the Government of India.

The institute is making an indelible mark with her '*research with impact*' in several areas including quantum computing, drinking water technology, industrially relevant mathematical models for governance, rendering cancer-cure more effective. Our centres of excellence, the Center for Innovation, Nirmaan – the pre-incubator, the Incubation Cell, technology centres such as '*IITM-Pravartak*' and others, work in unison for not just our nation's building, but societies *world-wide*. We aspire to be locally impactful and globally relevant through all these efforts.

Towards exploring new research frontiers, a Department of Medical Sciences and Technology has been launched to conjoin medicine and engineering. Similarly, a School of Sustainability is on the horizon to research sustainable practices in the Global South. The campus is moving towards 'carbon-net-zero' goal through water conservation by 100% recycling, efficient garbage disposal, and electrification of vehicles. The traditional education system is undergoing a paradigm shift, with our online Bachelor of Science programme in Data Sciences and the National Program of Technology Enhanced Learning, that have won Gold in the 'Lifelong Learning' category and Silver in the 'Best Online Program' category of the Wharton-QS Reimagine Education Awards 2022 respectively. IIT Madras is leading this revolution from the front.

Such achievements are not possible without the deep-rooted faith and support of alumni and well-wishers such as yourself. We are indebted to you for your generous, bountiful, and impactful contributions. On behalf of IIT Madras, I offer you our deepest gratitude for continuing to strengthen the Institute. Together with your support, we are confident of building an IIT Madras that is more inclusive, diverse, and enabled by an ecosystem to be nationally relevant and globally recognised. Thank you!

Dean's Message

Prof. Mahesh Panchagnula

Dean, Alumni & Corporate Relations, IITM



Greetings!

I express my heartfelt gratitude to you for your generous support to IIT Madras. We appreciate your passion in supporting the causes you do and I assure you that your contributions will be optimally utilized. This report has been compiled to convey how your largesse has touched lives and made a difference at IIT Madras. In keeping with the rapid, contemporary strides in science, technology we have set ambitious goals for ourselves - your continued enthusiasm and support will help us greatly in these endeavors.

IIT Madras is far more diverse in its set of pursuits, more green and more research-focused. And yet, it remains unchanged over these years, it is still the best Institute in the country, and attracts the best students that India has to offer to come and make a mark. I also cordially invite you to visit your campus to see for yourself, the impact of your contribution, and the growth and transformation the Institute has undergone over the years.

We can never express our gratitude enough for all that you have done - Thank You!



Shri Kris Gopalakrishnan

[1977/M. Sc/PH] & [1979/MT/CS]

Co-founder Infosys, Chairman of Axilor Ventures

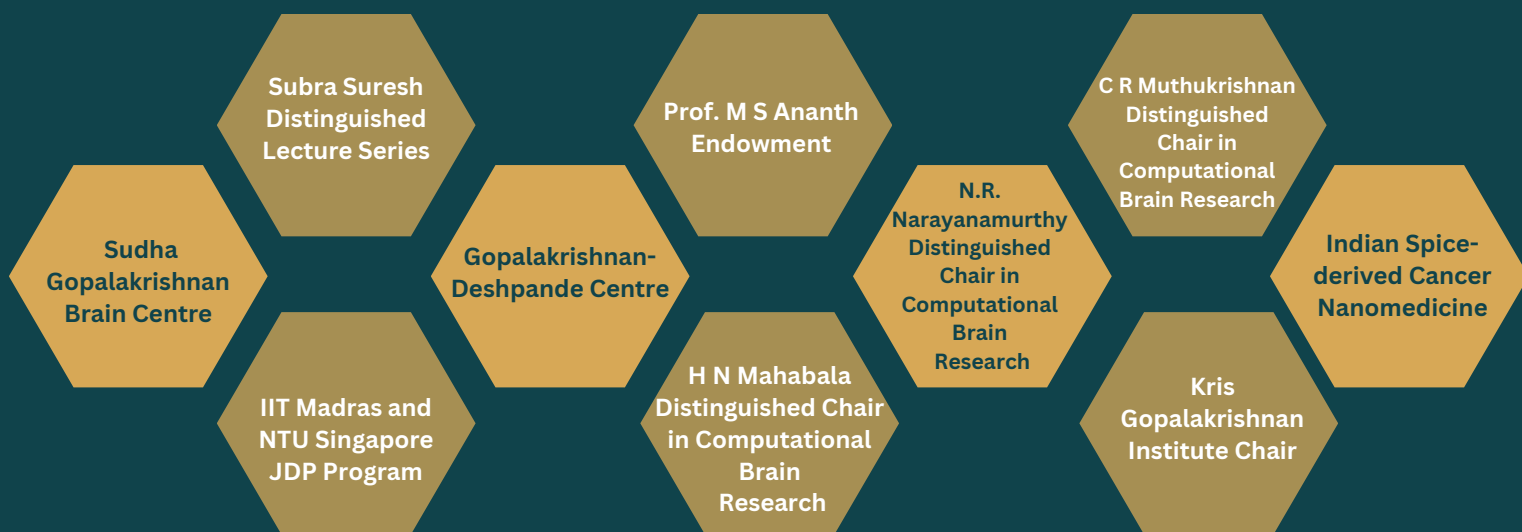


Shri Senapathy 'Kris Gopalakrishnan' is a revered figure renowned as a global business and technology thought leader. With a distinguished educational background, he holds a Master of Technology (M. Tech) in Computer Science and a Master of Science (MSc) in Physics from the prestigious Indian Institute of Technology, Madras. Over the course of his illustrious career, he has made significant contributions to the field of technology and business.

Having spent 33 years at Infosys, one of India's leading IT companies, Shri Gopalakrishnan held various key positions at Infosys, including Executive Vice Chairman and Co-Founder. During his tenure, he played a pivotal role in steering the company towards success and establishing its reputation on a global scale. Recognised for his exceptional leadership skills, Institutional Investor voted him the top CEO in the IT Services category. He was among the winners of the Asian Corporate Director Recognition Awards by Corporate Governance Asia. He served as the President of the Confederation of Indian Industry (CII) for the 2013-14 term and acted as one of the co-chairs at the World Economic Forum in Davos. Additionally, he was appointed as a member of the reconstituted United Nations Global Compact Board and has received esteemed accolades, such as the Padma Bhushan, India's third-highest civilian honour.

Additionally, as the Chairman of Axilor Ventures and through his leadership positions at renowned academic institutions like the Indian Institute of Information Technology and Management (IIITM) in Kerala and the International Institute of Information Technology (IIIT) in Bangalore, he continues to shape and support the growth of the technology and business ecosystem.

The report will present a thorough assessment of the impact that your contributions have made towards the causes outlined below:



Sudha Gopalakrishnan Brain Centre

01

Objective

The Sudha Gopalakrishnan Brain Centre at IIT Madras, made possible by generous funding from Shri Kris Gopalakrishnan, was established in March 2022 with the primary objective of conducting large-scale, multi-disciplinary research to map the human brain at the cellular level. The centre aims to become a globally leading institution in human brain research. It seeks to have a transformative impact on science, technology, computing, and medicine.

02

Current Progress

The Brain Centre has made significant progress in its endeavours, driven by the visionary support of Shri Kris Gopalakrishnan. It has established strong collaborations with more than 20 renowned researchers and institutions worldwide, spanning countries such as the United States, Germany, Croatia, Romania, South Africa, and Australia. Additionally, the centre has formed deep linkages with leading medical institutions in India. With a dedicated team of over 70 research staff, including experts in neurobiology, biomedical instrumentation, systems engineering, large-scale computing, machine learning, molecular biology, and bioinformatics, as well as guidance from 15+ faculty members with profound expertise in these areas, the centre is actively engaged in research. Furthermore, it benefits from the involvement of over 20 esteemed clinicians specialising in various fields related to neurosciences and medicine. The Brain Centre operates from a state-of-the-art facility spanning 6000 square feet, strategically located on the IIT Madras campus.

03

Achievements

- One notable achievement of the Brain Centre is the development of a high-throughput histology pipeline capable of processing whole human brains into high-resolution digital images and petabyte-scale data sets.
- This pioneering technology, funded by the Office of Principal Scientific Adviser, Government of India, and Shri Gopalakrishnan, has gained international recognition.
- Its comprehensive workflow includes brain freezing, block face imaging, cryosectioning, tape-based tissue-section transfer, automated slide staining, automated coverslipping, high-resolution digital scanning, quality control and assurance, petabyte-scale online data storage, atlas annotation, multi-modal registration, cell segmentation, and multi-scale data analytics.
- The centre's unique platform has attracted global leaders to collaborate closely with the Brain Centre, including distinguished visiting professorships and collaborative research opportunities.
- Sudha Gopalakrishnan Brain Centre was honoured to host a visit from the esteemed Union Minister for Education and Skill Development and Entrepreneurship, Shri Dharmendra Pradhan. During his visit, the Minister had the opportunity to immerse himself in the research activities and initiatives carried out at the centre.
- He actively engaged with the researchers, attentively listening to their presentations and discussions on the groundbreaking projects focused on advancing the field of neuroscience.

04

Future Plans

Utilizing the proprietary technology platform, the Brain Centre is currently engaged in imaging post-mortem human brains of various types and ages. It has successfully generated high-resolution, cell-resolution volumes of 25 whole brains, comprising over 2000 sections with 20 μ m thickness and 0.5 μ m in-plane resolution. The centre has an ongoing pipeline of approximately 50 different brains for imaging. This pioneering effort, made possible by the generous support of Shri Kris Gopalakrishnan, represents the first-ever generation of such a large volume of high-resolution sections of entire human brains. The Brain Centre aims to image over 100 brains in the coming years, creating the world's largest and most comprehensive high-resolution human brain data resource, serving as a definitive reference for future research. Additionally, the centre is establishing a molecular arm for spatially-mapped single-cell/nucleus transcriptomics, which will be integrated into their histology pipeline. To support the processing, storage, and analysis of these vast amounts of high-resolution human brain data, the Brain Centre is developing a world-class computing platform capable of handling tens to hundreds of petabytes. The Pratiksha Trust, in gratitude to Shri Gopalakrishnan's support, has provided further funding for the next five years to facilitate the achievement of these ambitious goals.

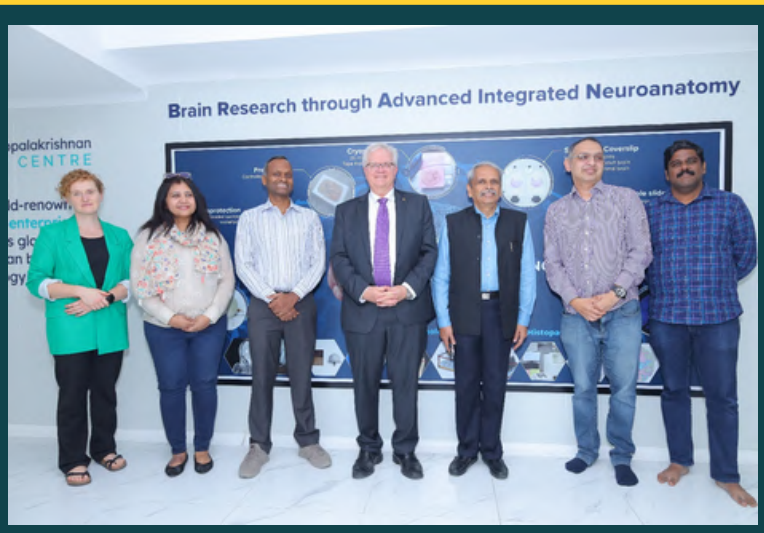


Shri Dharmendra Pradhan, Hon'ble Education Minister of India visiting the Sudha Gopalakrishnan Brain Centre - 19th September 2022



Prof. Brian Schmidt visiting the Sudha Gopalakrishnan Brain Centre - 2nd March 2023

G20 dignitaries visiting the Sudha Gopalakrishnan Brain Centre - 31st January 2023



Subra Suresh Distinguished Lecture Series

The Subra Suresh Distinguished Lecture Series was created to honor Prof. Subra Suresh, an IIT Madras alumnus, and the 4th President of Nanyang Technological University, Singapore. The lecture series was made possible by a generous gift from Shri Kris Gopalakrishnan.

Dr. Brian P Schmidt, an American-Australian astrophysicist and cosmologist, was the keynote speaker of the second edition of the Subra Suresh Distinguished Lecture Series. This edition of the lecture series consisted of two lectures, one popular lecture open to the public, and one technical lecture for the IIT Madras community. He was awarded the Nobel Prize in Physics in 2011 for his work on the accelerating expansion of the universe. He is currently the Vice-Chancellor of the Australian National University (ANU) since 2016.

The popular lecture serves the purpose of being more accessible and suitable for audiences of all ages, while the technical lecture's aim is to promote in-depth discussions with a more informed audience - students and faculty of IIT Madras.



Overview

Prof. Brian Schmidt spoke about two topics - 'The Universe from Beginning to End' (public) and '3 Big Questions for Astronomy' (technical). The common theme in both lectures was the expansion of the universe and his efforts towards finding the age of the universe. During the public lecture, Prof. Schmidt spoke more about the journey that made him a Nobel laureate. The technical lecture was exclusively for the IITM fraternity and hence opened to more specific and analytical discussions.



Engagement

The public lecture was attended by over 1000 participants. The amphitheatre near the D7 Auditorium was booked in anticipation of a large crowd. The guests in the amphitheatre were shown a live stream of the lecture taking place inside the auditorium.

There were Q&A sessions on both days, with various students from different schools and colleges participating in the public lecture. The second lecture was a more technical discussion and received a wide range of questions from students and faculty alike and was answered by the speaker in-depth and delivered in a casual, accessible manner. Following both lectures, the audience was much interested in interacting with the speaker. Due to the program's schedule, all engagements with the audience were limited beyond the lecture.



Feedback

Both lectures received positive feedback from the audience - the public lecture, despite being about a scientific topic, was well received by the students who found it accessible. The technical lecture was lauded for being nuanced and comprehensive. Since both lectures were about a popular topic, some audience members from the live screenings wished to participate in the live Q&A session happening in the main venue and suggested that we host the event in a larger venue.



Interactions with Dignitaries

On March 2nd, Dr. Schmidt met the Director, Prof. Kamakoti Veezhinathan, at the director's conference room in the presence of Prof. Koshy Varghese (Dean Admin), Prof. Raghunathan Rengaswamy (Dean Global Engagement), and Prof. Mahesh Panchagnula (Dean Alumni and Corporate Relations). Following the meeting, the guest left for the IITM Research Park to deliver the first lecture.

At the lecture, the guest interacted with the dignitaries who attended the public lecture. The embassies and high commissions in Chennai were invited to attend the public event and the lunch that followed. The dignitaries who joined include:

- Australian Consul General - Ms. Sarah Kirlew
- Russian Consul General - Mr. Oleg N. Avdeev
- Honorary Consul for Myanmar - Prof. Ranganathan J.
- Economic Officer, U.S. Consulate General - Mr. Dustin R. Bickel

The Australian Consul General invited Dr. Schmidt to dinner with other guests invited by the Australian embassy at the Madras Club. Prof. Mahesh Panchagnula, Prof. Smita Srivastava, and Mr. Vinoth from IITM joined the dinner along with the guest.

On March 3rd, Dr. Schmidt had a meeting with Prof. Raghunathan Rengaswamy in the IC&SR building. Following the meeting, the guest visited the Department of Physics, where Prof. Arul Lakshminarayan and Prof. L. Sriramkumar welcomed him and introduced him to over 20 faculty members of the department.

The guest was given a tour of the IITM Research Park, the newly inaugurated Centre for Innovation, and the Sudha Gopalakrishnan Brain Centre, following an interaction with the faculty members with Shri Kris Gopalakrishnan joining him at the Brain Centre.

Dr. Schmidt joined the gala dinner at ITC Grand Chola hosted by the Office of Alumni and Corporate Relations with IITM Faculty, leadership, and other guests following the technical lecture.



IIT Madras and NTU Singapore Joint Doctoral Programme

A Joint Doctoral Degree programme with two of the prestigious research institutions, IIT Madras and NTU Singapore provides a unique opportunity and international platform for scholars to perform and assess the research work with the utilization of facilities of two of the pioneering institutes. Moreover, the guidance from two expertise faculties combined together gives an overwhelming and prodigious research experience. Such exposure to cutting-edge research is a great motivation and helps in growing self-confidence. So far 8 beneficiaries have benefitted through this program till the year 2022, and three more scholars have been identified to avail of this fellowship for the year 2023 who are mentioned below.

Beneficiaries of the year 2023:



Barathula Venkata Sreeram Sarmab

ME19D039

Ph.D., Mechanical Engineering

Research Topic: Classification of pool boiling regimes based on the acoustics and vibration characterisation with the application of machine learning methods

The research classifies pool boiling regimes by characterising acoustics and vibrations using machine learning methods. It aims to enhance the safety and real-time monitoring of high-power generation systems and cooling systems. By accurately classifying boiling regimes and leveraging boiling acoustics, potential deviations from the design plan can be promptly identified, allowing for timely responses to maintain stable operating conditions. Collaborative efforts between experts in boiling heat transfer and acoustic characterisation maximise the output and impact of the research while expanding networks and fostering interdisciplinary collaborations. This research presents an opportunity to gain new perspectives, develop creative problem-solving skills, and contribute to the scientific community's understanding of boiling acoustics and related fields.

Loheshwaran C

ME21D045

Ph.D., Mechanical Engineering

Research Topic: Micro Metamaterial Based Super Resolution Ultrasonic Imaging



The research project focuses on developing micro metamaterial-based super-resolution ultrasonic imaging techniques. By utilising micro-metalens, the resolution of ultrasonic imaging can be significantly improved, enabling imaging at deep-subwavelength scales. The metalens, designed based on Fabry-Pérot transmission resonance, amplifies and transfers high-frequency evanescent waves to the far field for imaging purposes. The proposed methodology has the potential to revolutionise acoustic imaging, particularly in biomedical endoscopic applications, non-destructive detection on irregular surfaces, and noise control in architectural acoustics. A special microscopic metasurface is proposed to manipulate near-field evanescent waves for sub-diffraction acoustic focusing, offering edge detection, subsurface crack characterisation, and compressed sensing benefits. These advancements open new possibilities for super-resolving scenarios in acoustic applications.



Gopalakrishnan Deshpande Centre



Objective and progress

GDC (Global Discovery Centre) has achieved remarkable milestones in the past year, strongly focusing on fostering entrepreneurship and innovation within India's academic and STEM research community. Despite the challenges posed by the pandemic, GDC successfully transitioned to an online model, allowing for increased scalability and outreach. Through their flagship programs, including I-NCUBATE, I-NSPIRE, and I-NITIATE, GDC has engaged with various colleges and universities, furthering its mission of building entrepreneurial thinking and business acumen.

The engagement with colleges and universities has been extensive, with over 57 STEM institutions and 25 incubators across India actively participating in GDC's programs. This extensive cooperation has been essential to expand GDC's vision and swiftly accomplishing its goals. Additionally, GDC introduced the I-NITIATE program, a revenue-based initiative, which saw success and positive outcomes in its maiden cohort conducted at CVR College of Engineering, Hyderabad. The experiences gained from these programs have been invaluable, providing GDC with the knowledge and confidence to approach other private STEM universities and expand their reach even further.



Achievements

GDC's achievements have been recognised and celebrated by esteemed guests who attended the finale events of the various cohorts. Notable chief guests included Mr Srinath Narasimhan (then CEO, Tata Trusts), Ms Anita Gupta (CEO, NSTDB, DST), Prof. BS Murty (Director, IIT Hyderabad), Mr Bhaskar Bhatt (Director, Tata Sons), Mr Sivarajah R (Mission Director, TANSIM), and Prof. K.N. Satyanarayana (Director, IIT Tirupati).

During the reporting period, the Global Discovery Centre (GDC) achieved remarkable milestones and participated in significant events, showcasing its commitment to fostering entrepreneurship and innovation. GDC's efforts were recognised at the 11th Annual Deshpande Symposium, where they received the prestigious 'Exemplary Practice in Technology Commercialisation' award. Additionally, GDC's CEO, Mr R. Raghuttama Rao, chaired panel discussions at the "LAB to MARKET CONCLAVE" and delivered a keynote speech on "Innovation and Sustainability" at Ashok Leyland Limited's annual Technology Day, emphasising the importance of collaboration and rapid technology deployment for sustainable transport.



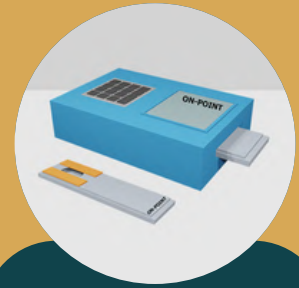
Team Meraki
IISc Bangalore



Team Robo Rehab
KJ Somaiya College
Mumbai



Team Tan90
IIT Madras



Team Tattva Shodh
ICT, Mumbai



Team Pico Distribute
Amrita Vishwa
Vidyapeetham



Team Theevanam
IIT Madras



Team Thermelgy
IIT Madras



Team Aakash
Vellore Institute of
Technology

GDC's impact extended beyond awards and engagements. They formed a knowledge partnership with the Carbon Zero Challenge 2022, conducting an intensive three-week I-NSPIRE Bootcamp that trained 30 startup teams. Furthermore, GDC hosted a well-attended seminar on sparking a Lab to Market transformation in India with deep-tech startups, attracting participants from various sectors, including students, entrepreneurs, researchers, and industry experts. These initiatives exemplify GDC's dedication to knowledge dissemination and creating a culture of innovation.

GDC's commitment to its mission was demonstrated globally as well. They showcased their work at the G20 Education Working Group meeting, highlighting their efforts in fostering innovation-driven entrepreneurship. As part of the Prime Minister's Research Fellows (PMRF) Annual Symposium, GDC organised a workshop on "Entrepreneurship - Catalyzing 'Lab to Market' Innovation," introducing PMRF participants to entrepreneurship and research commercialisation. Through these activities, GDC exemplifies the donor's vision of supporting impactful programs that make a lasting difference.



Gopalakrishnan Deshpande Centre for Innovation and Entrepreneurship was inaugurated by Dr. Deshpande, Smt. Jaishree Deshpande and Shri Kris Gopalakrishnan in the new Innovation hub on Feb 28, 2023



Prof. M S Ananth Endowment Fund

This Endowment Fund was established to honor Prof. M. S. Ananth, who served as the Director of IIT Madras from 2001 to 2011. He was well-known for his contributions to science and teaching, as well as his tireless efforts to develop higher education and research in India.

The following activities are supported through this endowment fund:

- To support socially relevant projects.
- To support the educational needs of the children of staff members of self-help organizations who work on the IITM campus.

1. Socially Relevant Projects:

Total no of projects accomplished over the years.



In 2022 alone, the institute successfully executed four impactful projects.



Prof. Nikhil Bugalia

Dept. of Civil Engineering

Project name: Construction and Demolition (C&D) Waste Management and the Role of the Informal Unorganized Sector in India: Case of New Delhi

The objective of the project: Identifying early-stage demolition projects in different parts of the City and various stakeholders involved in the identified projects to understand their roles in an informal/formal C&D waste management system through interviews.

Result: Results indicate significant environmental and economic benefits contributed by the informal sectors as they engage in deconstruction, salvaging several materials otherwise considered waste, and adding value to the formal recycling process through their selective demolition practices.



Prof. Madhu Mutayam

Dept. of Computer Science Engineering

Project name: Tracking Beehive Health Using IoT Technology

The objective of the project: The objective of the work is to build an IoT-based tracking system to monitor the health of a beehive.

Result: It helps minimize manual inspection of the beehives so that beekeepers can handle a larger number of beehives at the same time, which can improve their income level.



Prof. Sreeram K. Kalpathy

Dept. of Metallurgical and Materials Engineering

Project name: Farmer-friendly, point-of-use, portable heavy metal sensors with cell phone interface: A new technical aid for the agricultural sector

The objective of the project: Analyzing water quality and heavy metal presence in water samples collected from several temple tanks in Rameswaram, Tamil Nadu using the ICP-OES facility at SAIF- IIT Madras.

Result: The project is aimed at helping farmers and agricultural cooperatives to decide on soil quality, by measuring soil salinity and heavy metal presence detection, so that they can sow crops in the right location and maximize crop yields



Prof. Suresh Kumar Rayala

Dept. of Biotechnology

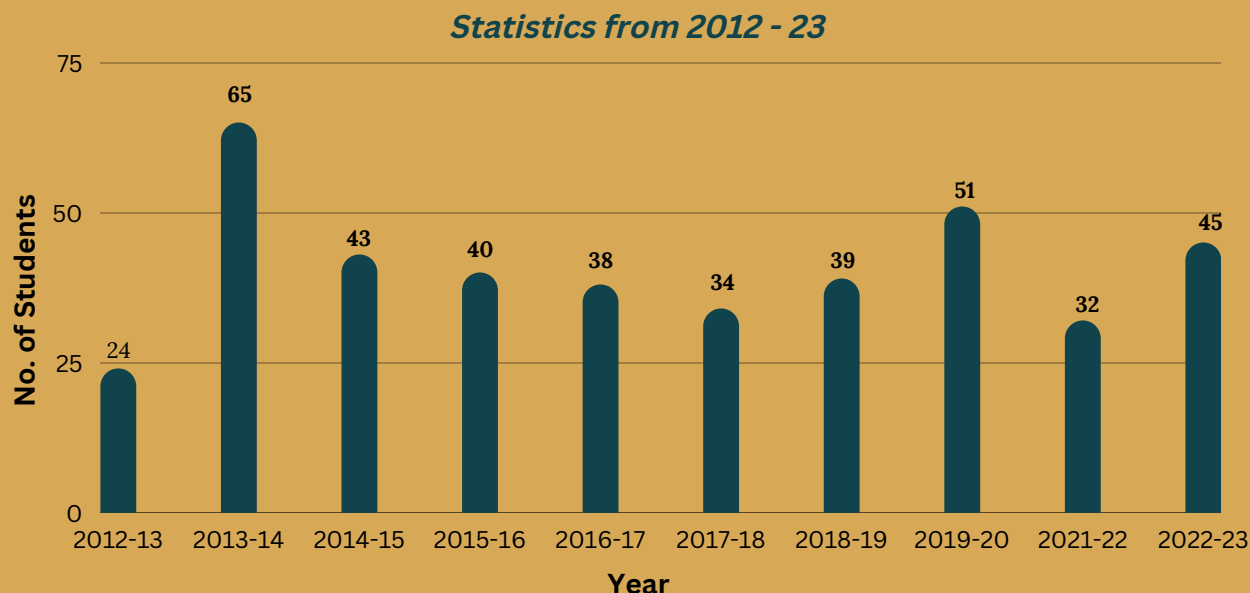
Project name: : Community Screening of “Kasimedu fisherwomen” for cervical cancer using a self-sampling kit and an indigenous innovative detection device

The objective of the project: This project is aimed at a community screening of cervical cancer in Kasimedu fisherwomen and the detection of an HR-HPV in these women by using an indigenous detection device (developed at IITM).

Result: Fabrication of point of care device for detection of HR-HPV and continuous field work – community screening by enrolling more women into the cervical cancer screen.

2. Support to children of staff members of the self-help organization who work in IITM:

The below graph depicts the number of students who have reaped the benefits.



In 2022, 45 children of the IIT Madras campus Self-Help group staff have been given support to their tuition fees through this scheme.

Gratitude Note from some of the beneficiaries:



R Karthikeyan

Respected Mam

I am Karthikeyan.R son of Abirami .you've gave a yearly fees That is Help for my Studies. so I was able to concentrate with my studies perfectly. and also fees IS not pending so thanku for your help very much. and also I am very happy. and thanku for all support.

Thanking you
by
R. KARTHIKEYAN



K. Dhanush Kumar

Good morning maam .

I am K.channamma's son .

Thank you so much maam for giving us money .

It has helped us .

We will be always thankful to you maam

We will never forget this .



K. Vinushiya

Respected madam

My self K.vinushya i am studying 10th standard.

My mother name K.Shanthi .I wish to thank you for the support and help my education .I wish to express my heartfelt gratitude for your help in financing my studies.



Nitish and Sharmila

சார் !

சூன்யா சஞ்சி வுதிகையது சாந்தாவழிநாள் சாந்தைய லகர்
 Y. திந்திஷ் VII படித்து வருகிறார். சாந்தைய லகர்
 சார்மிமா V படித்து வருகிறார் நாங்கள் கஷ்டப்பட்டு
 படிக்க வைக்கிறோம். சூன்யா சாந்தையக்கு
 பரிசு படிப்பதற்கு சீவ் செய்துக்கொடுக்கிறீர்கள்.

கிஷ்கி
 Y. Sathya



H N Mahabala Distinguished Chair in Computational Brain Research

Ongoing Research

1) High Throughput Computational Pipeline for Brain Image Registration:

The Center for Computational Brain Research (CCBR) at IIT Madras is developing a high throughput computational pipeline to register multimodal neuro-physiological images automatically. This project aims to enhance our understanding of the cellular architecture and connectivity in the human brain.

2) Automated Tools for Brain Structure Analysis:

IIT Madras is working on developing automated tools for analysing brain structures in the whole brain. By leveraging advanced computational techniques, researchers can gain valuable insights into the organisation and functioning of different brain regions.

3) Population Analysis of Neurons in Autism:

In collaboration with experts, IIT Madras is conducting a population analysis of neurons and associated structures in a mouse model of Autism. This research aims to shed light on the neural mechanisms underlying autism spectrum disorders and contribute to developing effective interventions.

4) Automated Brain Connectivity Extraction from Literature:

Utilising natural language processing (NLP) techniques, IIT Madras is developing automated methods to extract brain connectivity and relevant information from published literature. This innovative approach accelerates analysing and integrating vast amounts of scientific data for further insights into brain connectivity patterns.

5) Ultrasound Tomography for Brain Imaging:

IIT Madras is exploring using ultrasound tomography, a novel imaging technique, for studying the brain. This research has the potential to revolutionise brain imaging by providing non-invasive and high-resolution images, enabling a deeper understanding of brain structure and function.

Development

1) High-Resolution Imaging and Analysis of Human Brain:

IIT Madras is developing a high-resolution computational and experimental pipeline for imaging and analysing whole human brains at micron resolution. This ambitious project, supported by a Synergy grant application to the Government of India, aims to unlock new insights into the intricacies of the human brain.

2) Explainable Machine Learning for Computer Vision and Neuroscience:

IIT Madras is working on developing automated tools for analysing brain structures in the whole brain. By leveraging advanced computational techniques, researchers can gain valuable insights into the organisation and functioning of different brain regions.

Impact

The ongoing research projects at IIT Madras have made remarkable progress in understanding and treating brain-related diseases. Through extensive studies on conditions such as Dementia and Alzheimer's, researchers have gained new insights into the underlying mechanisms of these disorders. The development of advanced computational pipelines, automated analysis tools, and innovative imaging techniques has contributed to unravelling the complexities of the human brain, leading to potential breakthroughs in diagnosis, prevention, and treatment.

The impact of IIT Madras' research extends beyond academia, with tangible benefits for society. By leveraging cutting-edge technologies and interdisciplinary collaborations, researchers strive to address pressing challenges and improve the lives of individuals affected by neurological disorders. From developing high-resolution imaging techniques to extracting meaningful insights from vast scientific literature, these initiatives have the potential to revolutionise brain research and healthcare practices. The application of ultrasound tomography and the integration of machine learning and neuroscience pave the way for novel brain imaging and analysis approaches, offering hope for early detection, personalised treatment, and enhanced quality of life.

Automated detection of features

Image Courtesy: Jaikishan Jayakumar, Samik Banerjee, Prof Sukhendu Das, IIT Madras

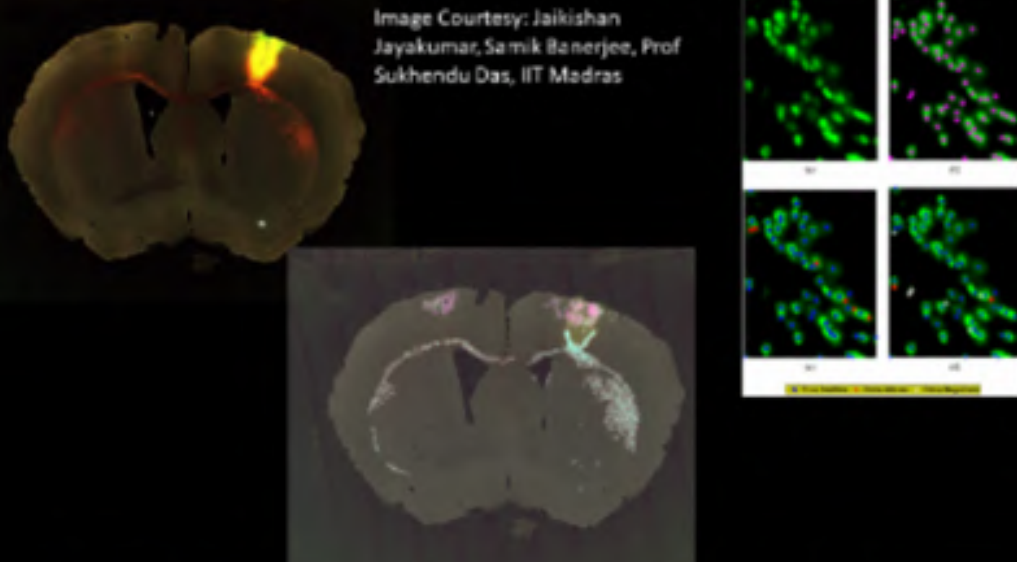


Figure 3 shows the outputs of the algorithms developed for the automated detected of features from a brain sample. The left and centre image correspond to the raw input image and the detected output of neuronal fibres and the right image shows the automatic detection results.

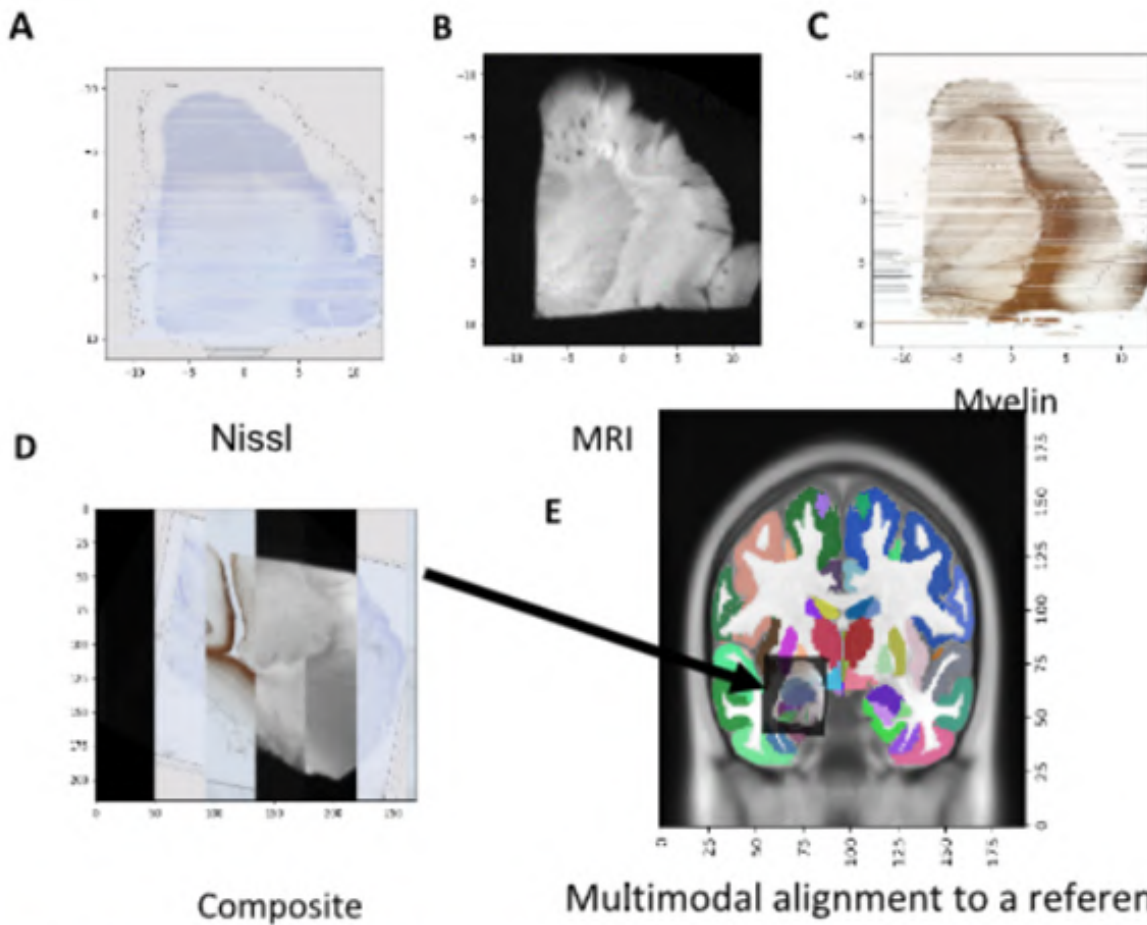


Figure 2 shows the multimodal alignment of a tissue sample from the Human Amygdala. The panels show the 3D aligned sections for (A) Nissl staining (B) is also shown in D demonstrating the close multimodal Alignment and how this sample is aligned to a reference brain



N.R. Narayanamurthy Distinguished Chair in Computational Brain Research

Ongoing Research

1) **A low-cost 3D printed microfluidic bioreactor and imaging chamber for live-organoid imaging:**

Prof. Mriganka Sur and his team have developed a microfluidic chip and bioreactor that enables brain organoids in situ tracking and imaging. These brain organoids are biological systems grown in vitro that self-organize into 3D cellular tissues resembling specific organs. The low-cost and 3D-printed nature of the microfluidic bioreactor provides an optimal imaging chamber for live-organoid imaging, allowing for better understanding and observation of brain development and function.

2) **Signal-to-signal neural networks for improved spike estimation from calcium imaging data:**

Calcium fluorescence signals recorded from large-scale imaging techniques, such as two-photon microscopy, are widely used in neuroscience. However, accurately estimating the neuronal action potentials from these signals poses a challenge due to their low temporal resolution. Prof. Mriganka Sur's team has developed a neural network-based approach that takes raw fluorescence signals as input and learns to estimate spike information in an end-to-end fashion. This approach demonstrates low complexity, interpretability, and the capability to generalise across different calcium imaging datasets, thus enhancing spike estimation accuracy.

3) **Functional parcellation of mouse visual cortex using statistical techniques:**

The mouse visual cortex consists of multiple areas, each containing retinotopic visual field maps. Prof. Mriganka Sur and his collaborators employed machine learning techniques to analyse the activity patterns of six core visual areas. By applying supervised classifiers to responses elicited by various stimuli, they successfully distinguished the functional differences among these areas. The classifiers' predictions were highly consistent with labels obtained through retinotopy, and they could model the boundaries of visual areas using resting-state cortical responses. This research sheds light on the functional organisation of the visual cortex.

4) **Modelling neuronal responses using machine learning:**

Prof. Mriganka Sur's team aims to analyse and model neuronal responses in the primary visual cortex (V1) using machine learning techniques, specifically convolutional neural networks (CNNs). By training a CNN on V1 recordings in response to natural movies, they seek to understand the visual processing capabilities of V1. The trained models show promising performance for simple datasets, but ongoing refinement is required to improve scalability for complex datasets.

Development

1) **Electroencephalography (EEG) Lab:**

Under the leadership of Professor Hema A. Murthy, an EEG lab has been established. The lab is equipped with a 128-channel EEG system and focuses on studying EEG as a biometric marker for individuals and the organisation of speech and music into phrases. Ongoing research involves collecting EEG and speech/music data in parallel to investigate the relationship between prosody and EEG. The lab also aims to develop quantitative measures for prosody, explore correlations between acoustics and EEG, and develop new models for automatic speech recognition, text-to-speech synthesis, and music information retrieval. Additionally, the lab aims to build brain-computer interfaces for individuals with speech or motor disabilities.

Impact

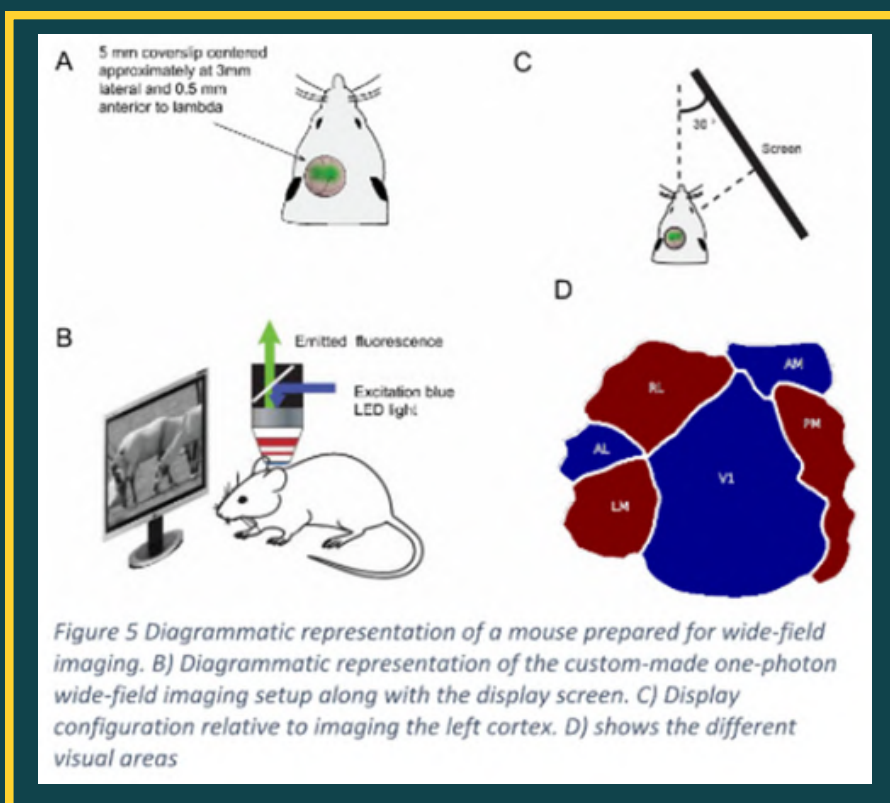
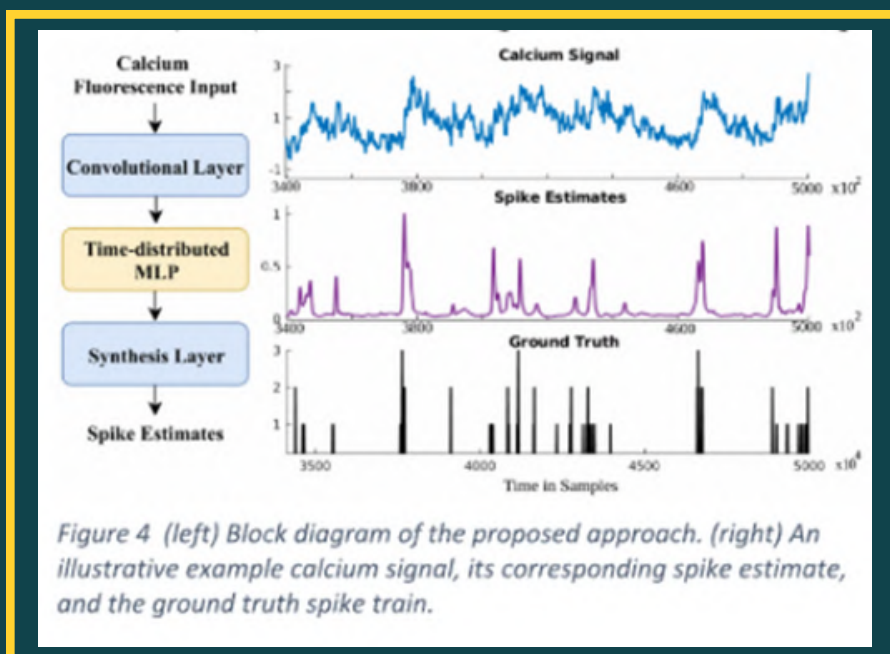
The ongoing research projects led by Prof. Mriganka Sur and Prof. Hema A. Murthy at IIT Madras have the potential to make significant impacts:

Advancements in brain organoid imaging

Developing a low-cost 3D printed microfluidic bioreactor and imaging chamber for live-organoid imaging enables a better understanding of brain development and function. This technology provides researchers with a cost-effective tool to study brain organoids and could contribute to regenerative medicine and drug discovery advancements.

Improved spike estimation from calcium imaging data

The signal-to-signal neural network approach developed by Prof. Mriganka Sur's team



C R Muthukrishnan Distinguished Chair in Computational Brain Research



Ongoing Research

1) Layer wise Disaggregated Evaluation of Spiking Neural Networks:

Goal: Improve the computational efficiency of Spiking Neural Networks (SNNs) by optimizing the number of timesteps evaluated for each layer independently.

Approach: Introduce layer wise disaggregated SNNs (LD-SNNs) to allocate computational effort across layers, balancing accuracy and efficiency.

2) Probabilistic spike propagation for efficient hardware implementation of spiking neural networks:

Goal: Optimize the computational efficiency of rate-coded SNNs by utilizing probabilities to regulate spike propagation.

Approach: Introduce probabilistic spike propagation, resulting in reduced spikes propagated, time, and energy consumption. Develop the Probabilistic Spiking Neural Network Application Processor (P-SNNAP) as a specialized SNN accelerator.

3) Generalizable cost models and their application to mobile devices:

Goal: Address the challenge of varying performance characteristics of Deep Neural Networks (DNNs) and the proliferation of network models in Neural Architecture Search (NAS).

Approach: Build a cost model of DNNs on mobile devices based on latency measurements. Introduce a signature set and machine learning model to predict DNN latency on target hardware.

4) A Novel approach to prevent adversarial attacks on DNNs:

Goal: Increase the robustness of Deep Neural Networks against adversarial attacks.

Approach: Propose ensembles of quantized DNN models with different numerical precisions (EMPIR) as a new approach to enhance robustness.

5) Novel Approaches to Approximate Computing:

Goal: Improve computing system efficiency through Approximate Computing (AxC).

Approach: Shift the focus of approximations from computations to data and propose a data-centric approach (data subsetting) to AxC, reducing off-chip memory traffic.

6) Improving the efficiency of neural networks through dynamic variable effort deep networks:

Goal: Reduce the computational requirements of DNNs during inference while maintaining classification accuracy.

Approach: Introduce Dynamic Variable Effort Deep Neural Networks (DyVEDeep) that dynamically focus compute effort on critical computations, leveraging heterogeneity in input data.

7) Fovea-inspired and pack and detect object detection in video:

Goal: Reduce computational requirements for object detection in videos.

Approach: Introduce Pack and Detect (PaD) approach, processing only anchor frames at full size and reducing computational requirements in inter-anchor frames. Develop an algorithm to pack regions of interest (ROIs) into reduced-size frames while maintaining detection accuracy.



Development

The research team led by Prof. Anand Raghunathan is actively developing the following projects:

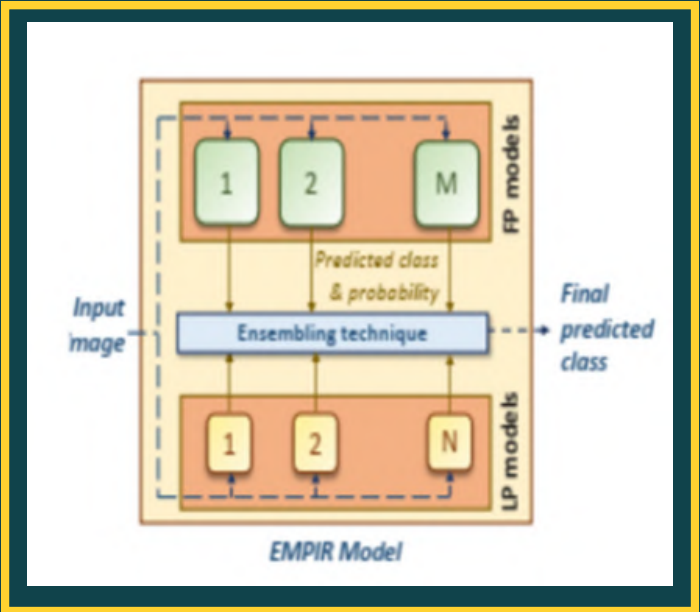
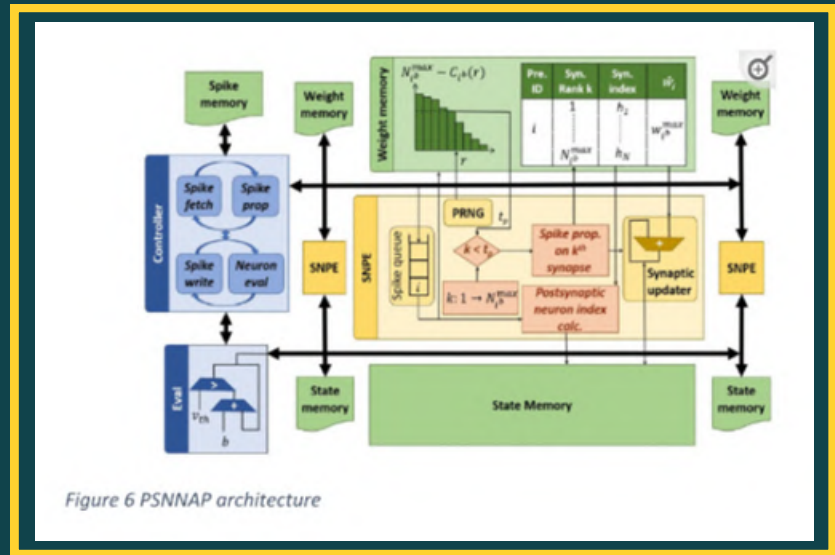
- Layer wise disaggregated evaluation of SNNs for improved efficiency.
- Probabilistic spike propagation and the development of the Probabilistic Spiking Neural Network Application Processor (P-SNNAP).
- Generalizable cost models for mobile devices and machine learning model prediction of DNN latency.
- EMPIR, an ensemble-based approach to increase robustness against adversarial attacks.
- Data-centric approach to Approximate Computing (AxC) using data subsetting.
- Dynamic Variable Effort Deep Neural Networks (DyVEDeep) for reducing computational requirements.
- Pack and Detect (PaD) approach for efficient video object detection



Impact

The ongoing research conducted by Prof. Anand Raghunathan, and the team has a significant potential impact in several areas:

- Improving the computational efficiency of Spiking Neural Networks (SNNs) for processing temporal input streams.
- Enhancing the efficiency of hardware implementations of SNNs through probabilistic spike propagation.
- Providing cost models for DNNs on mobile devices, enabling better resource allocation and optimisation



Kris Gopalakrishnan Institute Chair

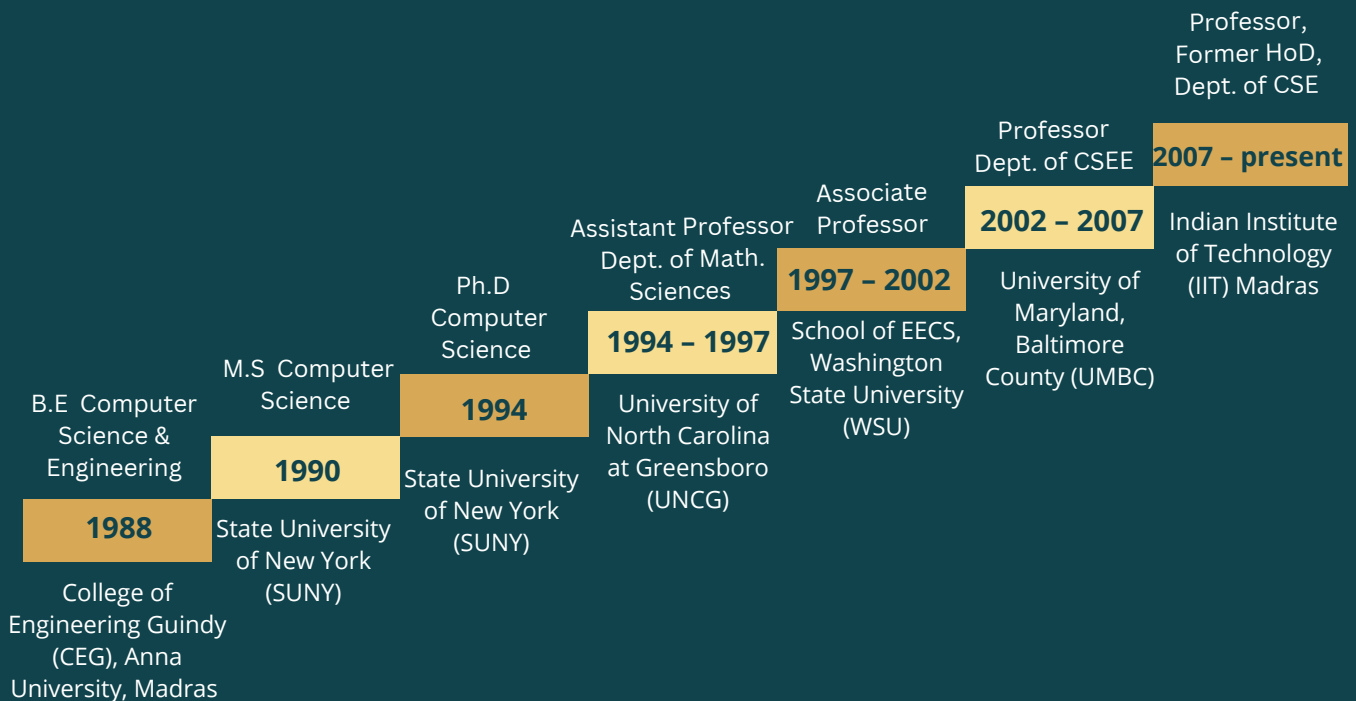


Prof. Krishna Sivalingam

Kris Gopalakrishnan Institute Chair Professor - 2019

Department of Computer Science & Engineering

Stellar Journey :



Patents and Publications:

- No. of Journal articles and Conference Proceedings from 2019 to present: 29
- No. of Patents from 2018 to present: 6

Broad Area of Research:

Computer Networks, in general, with specific interests in:

- AI/ML Techniques for Networking Systems
- Programmable Data Plane Networking, using NetFPGA / Tofino/ other hardware
- Cellular (5G, 6G) Networks
- Wireless (WiFi) Networks

Current Research:

5G/6G Networks (Funded by VMWare): Machine learning techniques (Prediction, RL, etc.) for resource allocation and resource optimization problems in 5G-and-beyond networks for Network Slicing, Orchestration and Run-time System Optimization; Data collection from 5G Testbed in CEWIT, data processing and dataset creation for future studies.

Programmable Data Plane Switches/Routers (Funded by Ciena): Implementation of Machine Learning techniques in Tofino/P4 hardware and emulated environments, for network applications including network security. This requires implementation of techniques in hardware switches such as those based on NetFPGA / Intel Tofino2 and other similar switches.

5G/6G Core Networks: Problems Studied:

Slice Admission Control for 5G-and-Beyond Network Slicing

- Deep Reinforcement Learning-based and Priority-based admission
- Overbooking; ML-based Forecasting
- Multi-agents

Virtual Network Embedding for 5G-and-Beyond Network Slicing

- Shareable Substrate Nodes across VNFs
- Federated Learning-based approach
- Graph Convolutional Neural Networks-based approach

VNF Resource Forecasting for Auto-scaling

- Federated Learning-based approach for Multi-domain systems

VNF Placement Techniques based on Prediction

- Federated Learning-based approach for Multi-domain systems

Prog. Data Plane Networks: Problems Studied:

Packet classification Techniques

- Flow classification for network security using P4-based Programmable Data Plane switches
- Machine Learning based Flow Classification in DCNs using P4 Switches

P4 and NetFPGA based secure in-network computing architecture for AI-enabled Industrial Internet of Things

Enhanced Mechanisms for Routers/Switches

- A Minimal Resource High-speed Routing Lookup Mechanism for Servers with NetFPGAs
- Collaborative packet header parsing in NetFPGA-based high speed switches
- Comparative Evaluation of IP-Address Anti-Spoofing Mechanisms using a P4/NetFPGA-based Switch
- Mitigation of security attacks in the SDN data plane using P4-enabled switches

Active research projects, 2019 – present:

- » Oct. 2021 – Sep. 2024, “Federated Machine Learning for Network Elements using Programmable Data Plane Environments”, Ciena, USA, USD 125,000 (INR 95 Lakhs); PI.
- » April 2020 – April 2025, “Orchestration for Network Slicing in 5G Networks based on SDN/NFV Concepts”, VMWare University Research, USD 105,000 (INR 78 Lakhs); PI.
- » March 2018 – Oct. 2021, “Indigenous 5G Test Bed: Building End to End 5G Test Bed in India”, Department of Telecommunications, Co-PI. PI: Dr. Radhakrishna Ganti, IIT Madras; Multi-institutional (IITs/IISc and National Labs)
- » Sep. 2017 – Mar. 2022, INR 50.6 Lakhs (Networking part) out of INR 9.70 Crores, DRDO, “Development of a Highly Versatile Secure Very Wide-Band Wireless Communication Platform (VERSA- COMM) for Defence and Strategic Applications”, Participating faculty member. PI: Prof. Bhaskar Ramamurthi; Major partner: CeWIT, IITM.

Software Developed and Technology Transfer:

Our research group at IIT Madras was part of the team that developed the 5G Core software, installed in the India 5G Testbed

- Jointly developed with CeWIT (IITM Research Park) and IIT Bombay

The 5G Core software has been licensed to

- TCS
- Department of Telecommunications
- IITM Pravartak Technologies (Technology Innovation Hub)
- Military College Of Telecommunication Engineering (MCTE)

Plans ahead:

Research: Continue investigation on topics related to:

- AI/ML Techniques for Networking Systems
- Programmable Data Plane Networking, using Tofino/ SmartNICs/ other hardware
- Cellular (5G, 6G) Networks
- Wireless (WiFi) Networks

"The generous and continuous support of Shri Kris Gopalakrishnan, for various IITM activities including this Institute Chair position, is greatly and sincerely appreciated.

Personally, the Institute Chair recognition has paved way for several project funding opportunities and helped me consider research problems from a more practical perspective."

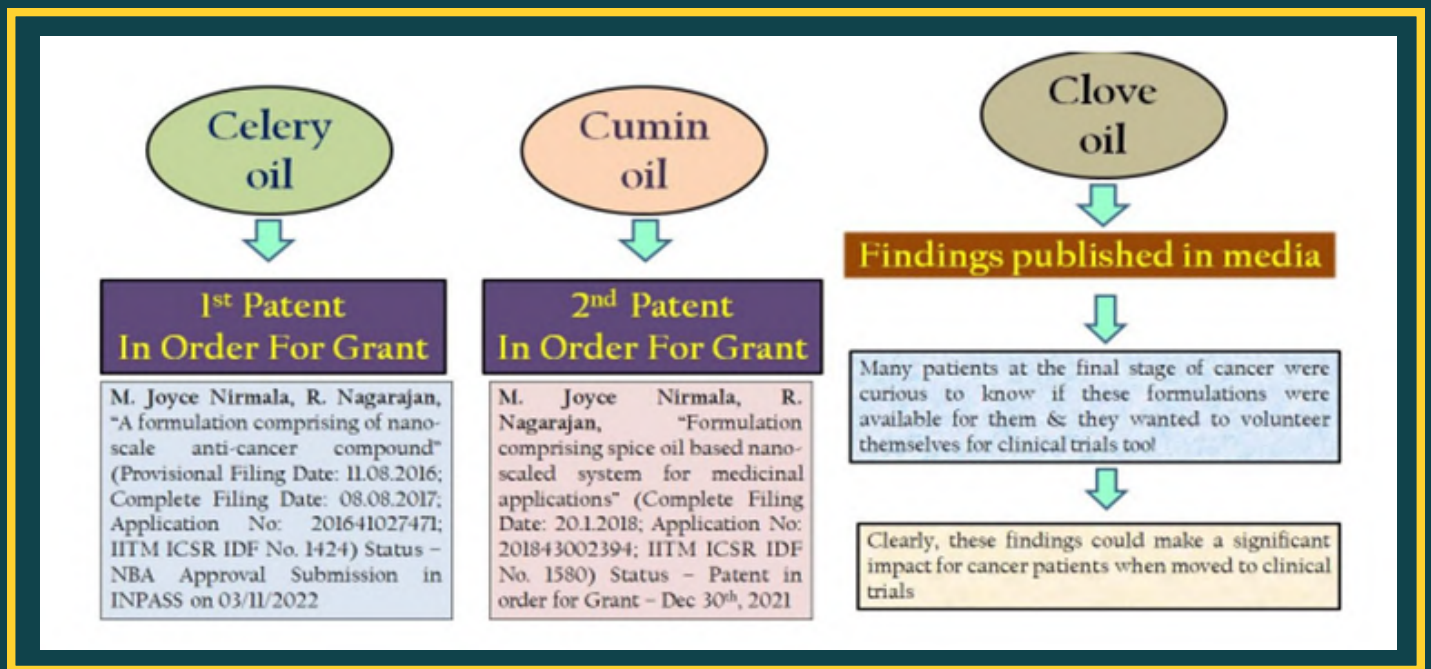


Indian Spice-derived Cancer Nanomedicine

Introduction and Background :

This research proposal focuses on discovering Indian spice-based cancer nanomedicines, aiming to combat cancer with no toxic side effects and at a low cost. Three Indian spice oils, namely celery seed, cumin seed, and clove bud oil, have been formulated into nano-scale emulsion systems. These formulations have shown potential anti-cancer effects in cervical, colon, thyroid, lung, and breast carcinoma cell lines through lab-scale studies. Nano-scale formulations can deliver therapeutic or diagnostic effects, target cancer cells, and overcome biological barriers in the body.

Outcome of the Prior Research :



Objective :

The objective of this research is to discover Indian spice-based cancer nanomedicines that effectively combat cancer without toxic side effects and at a low cost.

Current Progress :

- Formulated Indian spice oil-based cancer drugs induce cancer cell death through apoptosis without affecting normal cells.
- Large-scale production of our Indian spice-based cancer drugs is possible at a low cost, as India contributes to about 75% of the global spice production.
- Our formulations utilise oils and components already approved as safe, ensuring the safety of the cancer nanomedicine.
- Nano-formulations exhibit good stability, improved pharmacokinetics, and efficacy against prevalent and aggressive cancers.
- We have initiated the optimisation of spice-based nano-formulations, characterisation studies, and detailed anti-cancer mechanistic studies using colon carcinoma cell lines.

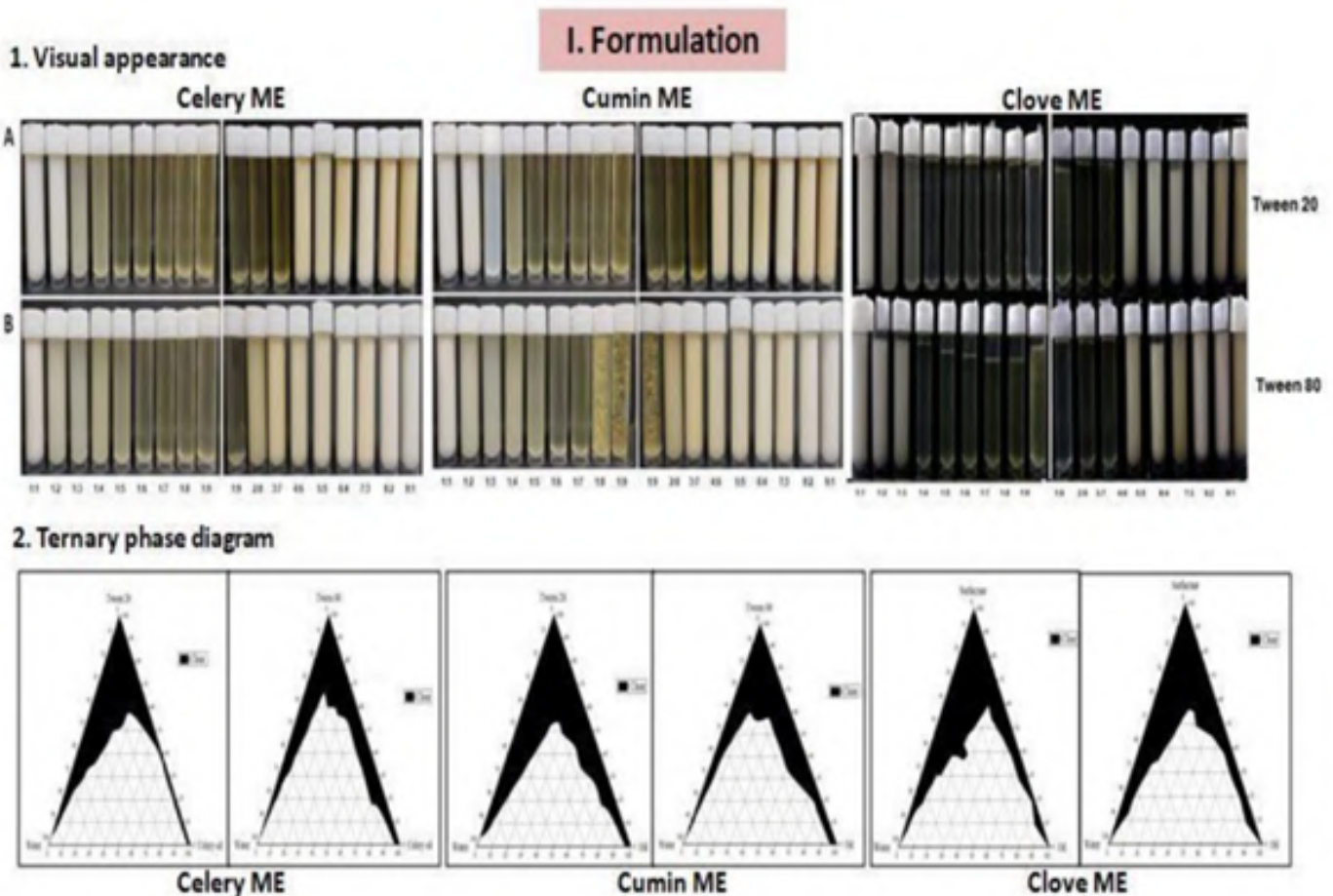
Achievements :

- Formulated Indian spice oil-based cancer drugs induce cancer cell death through apoptosis without affecting normal cells.
- Large-scale production of our Indian spice-based cancer drugs is possible at a low cost due to abundant spice production in India.
- Our formulations utilise safe oils and components, overcoming the toxic side-effects of FDA-approved cancer nanomedicines.
- Nano-formulations demonstrate good stability, improved pharmacokinetics, and effectiveness against prevalent and aggressive cancers.

Future Plans :

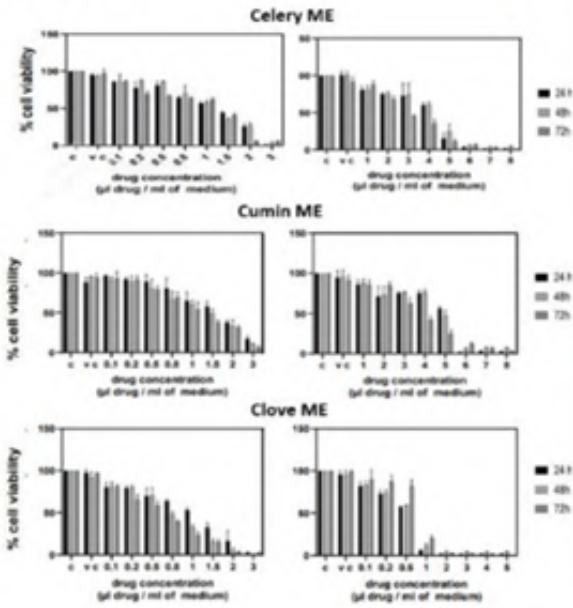
In the upcoming year, our plans include:

- Continuing the optimisation and characterization of spice-based nano-formulations.
- Determining encapsulation efficiency, release studies, and kinetic modelling of the formulations.
- Expanding anti-cancer mechanistic studies to include other cancer cell lines.
- Conducting animal studies to assess toxicity and skin sensitisation.
- Assessing genotoxicity through bacterial reverse mutation, chromosomal aberration, and micronucleus assays.
- Conducting pharmacokinetic studies of the test formulation in rats.
- Evaluating in vitro cytotoxicity using normal and lung cancer cell lines.

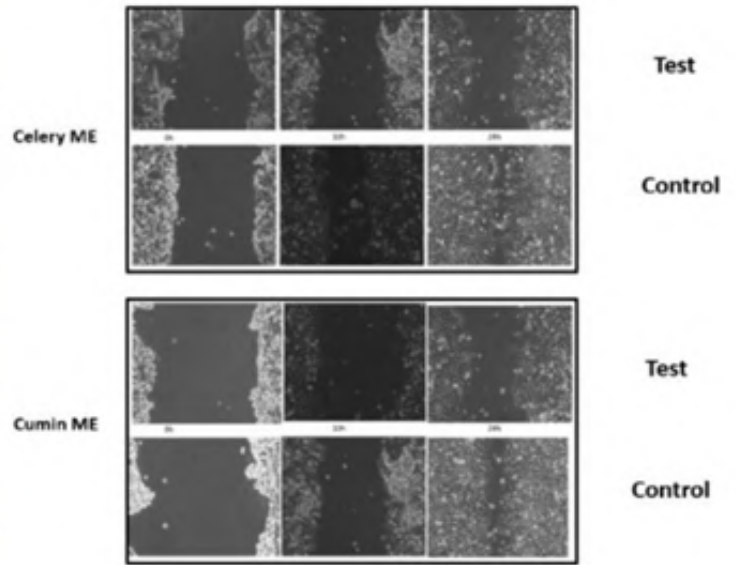


III. Anticancer activity

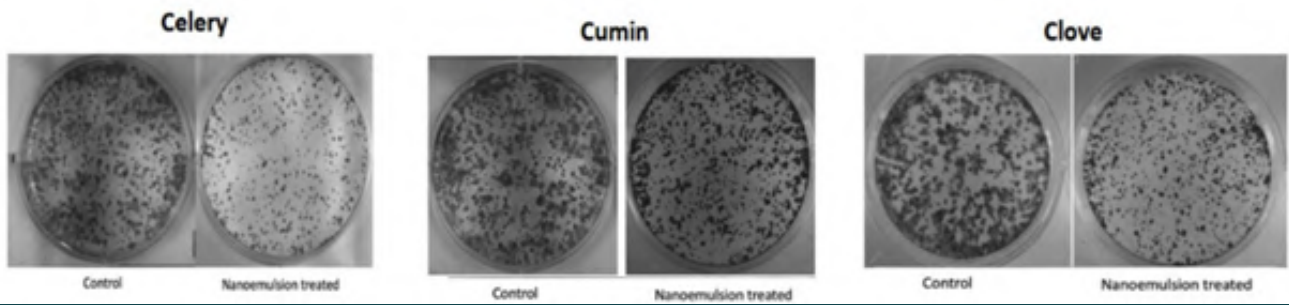
1. MTT assay



2. Scratch assay



3. CLONOGENIC ASSAY



Thank you!



We are grateful to you & your family

Shri Kris Gopalakrishnan



Thank you for your sustained generosity to IIT Madras over the years. Contributors such as yourself enable our students and Professors to dream big and work towards a better and brighter future. We hope you are proud of your Alma mater and how it has remained steadfastly committed to academic and research excellence since your time here. You and your family have been instrumental in facilitating this significant growth.

Our efforts to nurture the culture of academic excellence that is the hallmark of IIT Madras - quality education, cutting-edge research, and unfettered creativity shall continue. We are privileged and humbled to have you and your family walking with us along this trail. We wish you and your family the best always in all walks of life!



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