AXIS BANK

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

AXIS BANK CENTRE FOR MATHEMATICS AND COMPUTING

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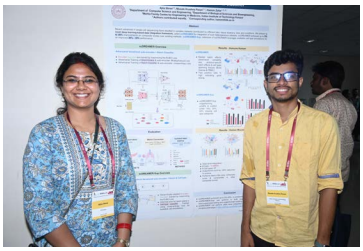

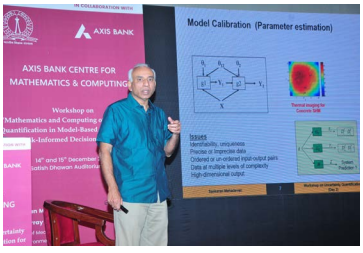

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Chapter 1

Introduction

On January 9, 2023, a momentous collaboration unfolded as the Indian Institute of Science and Axis Bank formalized their commitment to advance the realms of Applied Mathematics and Computation. This groundbreaking partnership culminated in the establishment of the Axis Bank Centre for Mathematics and Computing, a dynamic hub dedicated to fostering cutting-edge research and innovation in the intersection of mathematics and computing.

In the span of just one year, the centre has made remarkable strides, orchestrating workshops, bestowing fellowships, and hosting outreach programs to propel its mission forward. Rooted in a set of well-defined objectives, the Axis Bank Centre for Mathematics and Computing has emerged as a crucible for nurturing talent, driving pioneering research, and cultivating global collaborations.

Objectives of the Centre

1. **Nurturing Future Leaders:** The primary objective of the centre is to cultivate a cadre of rigorously trained individuals poised to become the torchbearers of mathematics and computing in India, charting a course towards leadership in these domains.

2. **Cutting-Edge Research:** A cornerstone of the centre's mission is to conduct cutting-edge research that not only garners international acclaim but also elevates the visibility of India on the global stage.

3. **Innovative Solutions:** Addressing the contemporary and future needs of both the nation and the world, the centre is dedicated to developing innovative, deep tech solutions through its convergence of mathematics and computing expertise.

4. **Global Collaborations:** The centre aims to establish partnerships with leading universities worldwide, fostering international collaborations in the expansive fields of Mathematics and Computing.

5. **World-Renowned Interactions:** By inviting distinguished researchers from around the world, the centre seeks to create a vibrant platform for international interactions, enriching the academic landscape and fostering cross-cultural exchanges.

6. **Educational Outreach:** In a bid to disseminate knowledge and cultivate interest, the centre actively conducts workshops and outreach programs, targeting engineering and science student communities.

Activities of the Centre:

The Axis Bank Centre for Mathematics and Computing, in accordance with its Memorandum of Understanding, has successfully executed a comprehensive array of activities. These include the discerning selection and awarding of fellowships, internships, and grants, as well as the facilitation of workshops to facilitate the exchange of ideas and knowledge.

In all 12 M Tech, 10 PhD, 5 Postdoctoral fellowships, 21 B Tech internships were awarded. The details are given in chapter 2. Under project grants, two projects, one from science and other from engineering discipline were awarded. A detailed report is given in chapter 5. The centre organised two workshops and two outreach programmes. The details are provided in chapter 4 and 5. We had two eminent scholars visiting IISc under the Visiting professor programme. Report of the work done during their visit is given in chapter 3. The centre awarded travel grants to

8 faculties of Institute to participate in international conference and workshops. Refer to chapter 7 for details. The report of the construction of Axis Bank centre for mathematics and Computing is given in chapter 6.

The foundation stone ceremony was held on March 22nd, 2024. The report on the ceremony is given by chapter 8. The details of utilization of the funds are provided in chapter 9.

Governance Structure

Two distinguished boards oversee the centre's operations. The Scientific Advisory Board plays a pivotal role in the selection process for fellowships and grants, ensuring academic rigor and excellence. Simultaneously, the Governing Board provides the necessary approvals and mandates, steering the centre towards its overarching objectives.

Axis Bank Centre Governing Board Members

Prof. Govindan Rangarajan

Director, IISc and Chair

Prof. Srikanth Iyer

Associate Dean,
UG (B.Tech),
IISc

Prof. Navakanta Bhat

Dean, Interdisciplinary Sciences, IISc

Mr. Neeraj Gambir

Group Executive, Treasury, Markets and Wholesale Banking Products, Axis Bank

Prof. Kaushal Verma

Dean, Physical and Mathematical Sciences, IISc

Mr. Subrat Mohanty

Executive Director, Axis Bank

Prof. S. Gopalakrishnan

Convenor,
Axis Bank Centre for Mathematics and Computing, IISc

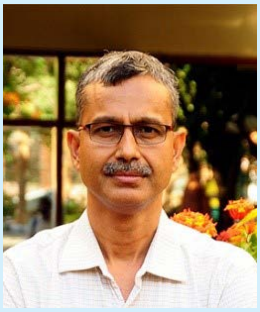
Axis Bank Centre Scientific Board Members

Prof. S. Gopalakrishnan

Chair SB,
Professor, Department of Aerospace Engineering, IISc

Prof. Prabal Kumar Maiti

Chair of Department of Physics, IISc



Prof. Aravind Ayyer

Co-Convener,
Professor, Department of Mathematics, IISc

Prof. Abhishek Singh

Professor, Materials Research Centre, IISc

Prof T. A. Abinandan

Professor, Materials and Engineering, IISc

Mr. N. Balaji

Business Intelligence Unit, Axis Bank

In the synergy of academia and banking, the Axis Bank Centre for Mathematics and Computing stands as a testament to the transformative power of collaboration, propelling India into new frontiers of excellence in Applied Mathematics and Computation.

We express our gratitude for suggestions and guidance received from all the members of GB and SAB. We thank the Chair, Prof K J Vinoy and the staff of ODAA for support and cooperation in all the activities of the centre. We are grateful for the CSR funds received from Axis Bank.

Chapter 2
Axis Bank Fellowships and Internships

2.1 Axis Bank Postdoctoral Fellowships

A total of seventeen applications were received from all over the country. Five candidates were selected based on their CVs, publication history, and reference letters. The fellowship amount is ₹1,00,000 per month. The five candidates selected have reported and started work in their respective departments. Contingency grants of ₹4,00,000 have been provided to each candidate. Two candidates are from engineering, two from mathematics and one from science stream.

Axis Bank Post Doctoral Fellowship - 2023-24

Sl No.	Name Post-doc	Proposed Department / Supervisor	Gender	Category	No. of Publica-tions	Confer-ences attended
Selected Students						
1	Priyam Chakraborty	Prof Shubhadeep Mandal. Mech Eng	Male	General	nil	1
2	Swati Rani Hait	Prof Debnath Pal, CDS	Female	General	1	nil
3	Scindhiya Laxmi	Prof Prathosh A P, EECS	Female	OBC	3	nil
4	Gaurav Kumar	Prof Anand Srivastava, MBU	Male	General	nil	1
5	Shalini Saha	Prof Roy Mahapatra, Aerospace Engg.	Female	OBC	nil	2

The report of work done the post-doctoral scholars are provided in Annexure 2.

2.2 Axis Bank PhD Fellowships

SAB and GB in their last meeting approve 12 PhD students from Institute Mathematics Initiative (IMI) to be awarded a top-up fellowship of Rs 35,000/= per month. Out of this, 5 students have joined from the continuing batch of PhD students and 5 new students from the fresh batch (August 2023) of IMI programme.

The students are from different engineering and science disciplines working on applied mathematics and computation. The fellowship is awarded to women and other underprivileged categories. The students are in different stages of research. The continuation of their fellowship from Axis Bank Centre for Mathematics and Computation will depend on their performance and recommendation of the research guide. The report of work done the PhD scholars are provided in Annexure 2

List of IMI Students Eligible for Axis Bank Fellowship 2023

Sl No.	Student Name	Research Guides	Gender	Category	No. of publications	Conferences attended
1	Soundharya R	Mohit Kumar Jolly (BSSE) Annapoorni Rangarajan (MRDG)	Female	GN	3	2
2	Vishali S	Tejas Murthy (Civil) Vijay Natarajan (CSA)	Female	OBC(NCL)	nil	1
3	Subham Patel	Ratikanta Behera (CDS) Thirupathi Gudi (Math)	Male	OBC(NCL)	nil	2
4	Adarsh Jain	Pawan Bharadwaj (CEaS) Chandra Sekhar Seelamantula (EE)	Male	EWS	nil	1
5	Raghunandan S	G K Ananthasuresh (ME) Kaushal Verma (Math)	Male	OBC(NCL)	nil	1
6	Ankan Biswas	Prof. Supratim Ray (CNS) Prof. Govindan Rangarajan (Mathematics)	Male	SC		
7	Chigicherla Venkata Sai Prasanna	Prof. Mohit Kumar Jolly (BSSE) and Prof. Ramray Bhat (MRDG)	Male	OBC-NCL	1	3
8	Sneha V	Prof. Nagasuma Chandra (BC) Prof. Annapoorni Rangarajan (MRDG)	Female	GN	1	1
9	Heeba Anjum	Prof. Usha Vijayraghavan (MCB) and Prof. Mohit Kumar Jolly (BSSE)	Female	OBC-NCL	nil	2
10	Aswini V.J	Prof. Pawan Bharadwaj (CEAS) and Prof. Chandra Shekar Seelamantula (EE)	Female	OBC-NCL	nil	nil

2.3 Axis Bank M Tech Fellowships

M tech Fellowship was increased from 3 to 12. 5 students are from continuing batch and will get fellowship from April 1st, 2023, to march 31st 2024. 7 students will get fellowship from August 2023 to March 2024. Students were selected by the Scientific advisory board after receiving the nominations from the chair of different departments. The fellowship is awarded to women and other underprivileged categories. The students are in different stages of research The report of the research work done during this period is given in Annexure 2.

Axis Bank M Tech Fellowship - 2023-24

Sl No.	Name	Gender	Category	Department	No of Publication	No of Conference attended
1	Sanjana AR	Female	GN	Electronics and Communication Engineering		
2	Gayathri Venkat	Female	GN	Electronics and Communication Engineering	1	nil
3	Tushar Dilip Kurne	Male	SC converts to Buddhism	Robert Bosch Centre		
4	Swapnil Sanjay Mane	Male	SC	Robert Bosc Centre		
5	Khushit Shaileshbhai Shah	Male	EWS	Computer Science and Engineering		
6	Anil Kumar Dhakad	Male	OBC(NCL)	Computer Science and Engineering		
7	Suvendu Kar	Male	EWS	Computational and Data Science		
8	Abhishek Sharma	Male	EWS	Artificial Intelligence		
9	Shreyashri Sarkar	Female	GN	Aerospace Engineering		1
10	Dolly Sahoo	Female	GN	Civil Engineering		
11	S Pavithirah	Female	OBC(NCL)	Aerospace Engineering		
12	Pawar Rushikesh Gajanansa	Male	OBC(NCL)	Computational and Data Science		

2.4 Axis Bank B Tech Fellowships

The Axis bank centre has been signed an MOU with The Academy Trust under the aegis of Indian Academic of Sciences to support the summer Internship programme for B Tech students. The summary of the MOU to be valid for three years is provided below.

- The Academy Trust will select about 15 to 20 students as Axis Bank Interns with a monthly stipend of Rs 12,500/= each for 2.7 months.
- The selected students getting Axis Bank Centre internship must work in IISc with IISc faculty as their mentors. The allotment of students to professors at IISc will be done by the Academy trust.
- A total sum of Rs 6.75 lakhs per year will be transferred to the Academy trust for providing internship, accommodation, and travel expenses to students. This can also include the administration expenses.
- The Axis Bank Centre should get enough visibility during the time of announcement of application, selection, awarding of internship and in certificate. The academy trust should send list of students selected under the Axis Bank internship.
- The Academy trust should send the detailed report of the project undertaken by the students.

21 students from all over India have participated in the programme and they all worked under the supervision of faculty of IISc.

Axis Bank B Tech Internship - 2023-24

Sl No.	Name and address	Name of the supervisor
1	Ajay Teja, Mr Minnikanti (III BTech), National Institute of Technology, Tiruchirappalli	Ghosh, Dr Debraj (FL4504) IISc, Bengaluru
2	Krishan, Mr J Nitish (III BTech) National Institute of Technology, Tiruchirappalli	Balakrishnan, Prof. N. (FL1015) IISc, Bengaluru
3	Pophale, Mr Anish (III BTech) Indian Institute of Technology, Chennai	Nott, Prof. Prabhu R. (FL811) IISc, Bengaluru
4	Das, Ms Ankita (II BTech) University of Calcutta, Kolkata	Simmhan, Prof. Yogesh (FL3821) IISc, Bengaluru
5	Vijaykrishnan, Mr Vedant (II BTech) Manipal Institute of Technology, Manipal	Chaunsali, Prof. Rajesh (FL4243) IISc, Bengaluru
6	Varadaraj, Ms Rajashri (II BTech) National Institute of Technology, Surathkal	Ghosh, Prof. Prasanta Kumar (FL2521) IISc, Bengaluru
7	Parashar, Ms Gaurangee (II BTech) National Institute of Technology, Surathkal	Ghosh, Prof. Prasanta Kumar (FL2521) IISc, Bengaluru
8	Sarvesan, Mr Srivatsan (II BTech) National Institute of Technology, Tiruchirappalli	Murthy, Prof. Aditya (FL1697) IISc, Bengaluru
9	Kusuma, Ms Bezawada (III BTech) Lakireddy Bali Reddy College of Engineering, Mylavaram	Rao, Prof. Srisha M.V. (FL3899) IISc, Bengaluru
10	Surana, Ms Monisha (III BTech) Jaypee University of Information Technology	Rao, Prof. Srisha M.V. (FL3899) IISc, Bengaluru
11	Sinha, Ms Swastika (II BTech) PES University, Bengaluru	Natarajan, Prof. Vijay (FL2063) IISc, Bengaluru
12	Ravula, Mr Varshith Reddy (III BE) Chaitanya Bharathi Institute of Technology, Gandipet	Viswanadham, Prof. Nukala (FL2812) IISc, Bengaluru
13	Chaparla, Ms Sadhvika (III BTech) National Institute of Technology, Raipur	Murthy, Prof. Aditya (FL1697) IISc, Bengaluru
14	Sharma, Mr Himkant (II BTech) Indian Institute of Technology, Kharagpur Work Preference: Academic	Parag, Dr Parimal (FL3398) IISc, Bengaluru
15	Patel, Mr Harshal (II BTech) Sardar Vallabhbhai National Institute of Technology, Surat	Shrivastava, Prof. Mayank (FL3972) IISc, Bengaluru
16	Anand, Mr Sarthak (II BTech) Indian Institute of Technology - Banaras Hindu University, Varanasi	Gupta, Dr Souradeep (FL4503) IISc, Bengaluru
17	Chatterjee, Mr Shubhranil (II BTech) Indian Institute of Technology, Mumbai	Tomar, Prof. Gaurav (FL2037) IISc, Bengaluru
18	Biju, Ms Sneha Mary (III BTech) National Institute of Technology, Kozhikode	Shrivastava, Prof. Mayank (FL3972) IISc, Bengaluru
19	Choudhary, Mr Manas (III BTech) Indian Institute of Technology, New Delhi	Sinha, Prof. Aninda (FL2177) IISc, Bengaluru
20	Varghese, Ms B Reeya (III BTech) Sathyabama Institute of Science & Technology, Chennai	Viswanadham, Prof. Nukala (FL2812) IISc, Bengaluru
21	Srinivasan, Mr Arvind (II BTech) Indian Institute of Technology, Yerpedu	Vadhiyar, Dr Sathish (FL2069) IISc, Bengaluru

Chapter 3 Axis Bank Visiting Professor / Instructors / Research staff

3.1 International Visiting Professor

The Axis Bank Centre for Mathematics and Computing at IISc is dedicated to fostering international collaboration and excellence in the dynamic fields of mathematics and computing. As a pivotal step in advancing this mission, the Centre endeavors to establish a prestigious visiting chair, inviting eminent international professors to contribute to the academic vibrancy of the institute.

Nomination Process: Faculty members at IISc are encouraged to actively participate by nominating distinguished candidates for the visiting chair. The meticulous evaluation of these nominations falls under the purview of the esteemed Scientific Advisory Board at the Axis Bank Centre. Final approval, ensuring alignment with the centre's vision, rests with the Governing Board.

Selection Criteria: Nominees, sought globally, should exemplify seniority in academia or research, with a proven track record of substantial contributions to the realms of applied mathematics and computing. Their eminence must be beyond dispute, endorsed by peers in the field. Active and contemporary engagement in research, coupled with a genuine desire to contribute to the intellectual milieu at IISc, forms the cornerstone of the selection process.

Honorarium and Logistics: The selected visiting chair will receive an honorarium of Rs 3.0 lakh per visit. Institute accommodation is available on a payment basis, with an additional travel grant of up to Rs 5.0 lakhs provided. The hosting department ensures a seamless and productive visit by offering private office space and all requisite resources.

Expectations from the Visiting Chair: The visiting chair is entrusted with several key responsibilities, including:

- Conducting cutting-edge collaborative research in mathematics and computing, with an emphasis on high-impact outcomes.
- Delivering seminars or compact courses accessible to the entire IISc community and local institutions.
- Presenting an institute lecture on a pioneering topic.
- Mentoring one or more IISc faculty members to contribute to their professional development.
- Submitting a comprehensive written report on the visit's activities and outcomes.
- Providing a courteous acknowledgment of the Axis Bank professorship in any ensuing published materials.
- Ensuring visibility for the professorship by including it in their CV and website.

The centre received the following three nominations for the Internation visiting Chair.

1. Prof N Swaminathan from University of Cambridge, nominated by Prof Sourabh Suhas Diwan, Department of Aerospace Engineering.
2. Prof Dr. Nagendra Somanath, Independent Consultant & Researcher and formerly with Pratt & Whitney Engines, nominated by Prof Pramod Kumar, Department of Mechanical Engineering.
3. Prof. Siv SivLoganathan (Chair, Applied Maths, Department, Univ. Waterloo), nominated by Prof Mohit Kumar Jolly, Centre for Biosystems Science and Engineering.

Based on the proposal, publication record and CV, SAB members recommended Prof Siv SivLoganathan to the Axis Bank International Visiting Professor position.

Dr. Siv Sivaloganathan is a distinguished Full Professor in the Mathematics Faculty at the University of Waterloo, where he also serves as the Head of the Biomedical Research Group within the Department of Applied Mathematics. His academic journey began as a senior scholar and postdoctoral research fellow at Oxford University, showcasing his commitment to excellence from the outset. Following this, Dr. Sivaloganathan assumed a faculty position as an Assistant Professor in the Department of Mathematics at the University of Alberta. Demonstrating his passion for academic leadership, he later transitioned to the University of Waterloo, where he held the position of Associate Chair of the Department of Applied Mathematics from 1994 to 2002.

Dr. Sivaloganathan's expertise lies in the captivating field of biomechanics, where he specializes in crafting mathematical models of clinical conditions and diseases using the principles of continuum mechanics. His research not only exemplifies his profound understanding of mathematical intricacies but also underscores his dedication to addressing real-world challenges in the realm of healthcare.

As a testament to his scholarly contributions, Dr. Sivaloganathan has played a pivotal role as the Principal Investigator on several grants. Notable among these are grants from NSERC Collaborative Health, Hospital for Sick Children Foundation, and CITO, reflecting the diverse and impactful nature of his research endeavors.

Dr. Sivaloganathan's multifaceted career underscores his commitment to advancing mathematical understanding in the context of biomedical research, making him a prominent figure in the academic landscape and a valuable asset to the University of Waterloo.

A report on the collaborations and courses conducted during the visit is given below.

3.2 National Visiting Professor

The centre also supports National visiting Chair dedicated to researchers in the field of mathematics and Computing in the same line of Internation visiting chair. The only change is the honorarium is Rs 2.0 lakhs and travel support up to 2.5 lakhs. Only one nomination was received, and the nominated professor could accept it due to medical exigencies. The Scientific Advisory Board decided to Nominate Dr Nagendra Somanath who was one of the nominees for the International visiting Chair professorship.

Dr Nagendra Somanath works in the field of Composite Mechanics, Computational Mechanics/ Methods, Multidisciplinary Optimization, Theory of Machines, Turbomachinery, Aerodynamics, Learning Systems (Deep / Machine Learning), Applied Mathematics, Structural Reliability, System Validation and Verification, Control System Design, Optimal Control.

He has an extraordinary contribution, to multidisciplinary design and optimization of complex integrated aerospace systems enabling successful application of computational methods, machine-learning, composite mechanics and multidisciplinary optimization to design/test and validate innovative products like medical imaging systems, turbomachinery, and ensure efficient reliable products like MRI Machines, Commercial Engines and Satellites.

3.3 B Tech Instructors

IISc has started a four-year B Tech course in Mathematics and Computing. The Axis Bank centre for mathematics and Computing supports the appointment of B Tech instructors. In the present financial year, four Instructors have been appointed.

1) **Dr. Manpreet Singh:** Dr Manpreeth Singh is a PhD from Indian Institute of Technology Delhi. He works in Topological Dynamics. Earlier Manpreeth Singh worked in National Programme on Technology Enhanced Learning (NPTEL), IIT Madras as Online Teaching Assistant, Chaotic Dynamical Systems. He has worked as Teaching Assistant in IIT Delhi, Assistant Professor (Guest Faculty) - Zakir Hussain Delhi college, University of Delhi.

2) **Dr. Devnath Shah:** Dr Devnath Shah is PhD Ph.D in Electrical Engineering from North Eastern Regional Institute of Science and Technology, Nirjuli, Arunachal Pradesh in August 2021. His research interest in online power trading through electric power exchange, Application of Evolutionary Optimization Algorithm in Power System and Fractional order PID control system design. He has Worked as Assistant Professor in Department of EEE, MITS Madanapalle from 23 February 2022 to 23 November 2022, Guest Faculty in Tezpur University, Assam from 09 February 2021 to 22 February 2022 and Worked as Teaching Assistant in Department of Electrical Engineering from July 2018 to May 2019 (During PhD).

3) **Mr. Sesha Kumar Nalluri:** Mr Sesha Kumar Nalluri has a M Tech degree and also in qualified NTA-UGC-NET-JRF. He has worked as Asst. Professor(contract) in the Department of Computer Science and Engineering at IIIT Srikakulam, Worked as Adhoc faculty in the Department of Computer Science and Engineering at National Institute of Technology-Warangal, Worked as Adhoc faculty in the Department of Engineering sciences at National Institute of Technology-Andhra Pradesh and worked as a Asst. Professor in the Department of Computer Science and Engineering at Gudlavalleru Engineering College.

4) **Dr. Srikanth Pai:** Dr Srikanth Pai is a PhD from International Centre for Theoretical Sciences. His area of research interest lie at the intersection of higher category theory, algebraic topology, and quantum field theories. In my thesis work with Professor Pranav Pandit, we have studied various aspects of a higher categorical gauge theory (called Dijkgraaf-Witten theory) for finite homotopy 2-types. He also works on theory of error-correcting codes and information theory. He was invited for Indian Maths Olympiad Training Camp, HBCSE-TIFR, Mumbai (in April 2018, April 2023) and Indian National Maths Olympiad Training Camp (in December 2023, December 2022). He has worked as a Teaching Assistant for Professor Manjunath Krishnapur's course "Probability and Statistics", at IISc, Bengaluru in Aug-Dec 2023 and Aug-Dec 2013. Teaching Assistant to Professor Aninda Sinha's "Mathematical Methods of Physics" course at IISc, Bengaluru in Aug-Dec 2023. The course emphasised the use of the software Mathematica to solve physics problems.

3.4 Administrator Staff

1) **Programme Manager:** Dr M K Raghavendra is appointed as Programme Manager. He has 22 years of experience in teaching and research in Physics. Raghavendra has worked in the undergraduate programme and teachers training programme of IISc. His recent assignment was chief consultant in Technical Secretariat Group for National Steering Committee setup for preparation of National Curriculum Framework.

2) **Senior Project Associate:** Mr Vivek Gnana Pandian is appointed for the post. He has degree in statistics, mathematics and computer science. He has14 years of experience in e - publishing company. And has proficiency in computer languages and coding. Vivek is familiar with internet tools such as HTML, XML, JavaScript, Java and CSS. He has also worked on interfaces like DB-library & ODBC. He can also work with software packages MS-Office, Acrobat Distiller, Photoshop.

3) **Office Executive:** Ms Abhinandana C is appointed for the post. She has engineering degree with MBA. She is an organized and energetic team player, with a confirmed ability to prioritize and manage a high volume of tasks with independence. Abhinandana is known for the attention to detail, perseverance to meet deadlines, and excellent written and verbal communication skills. She has worked as project assistant and administrative assistant in IFCAM project and IISc Mathematics Initiative in IISc for five years.

Chapter 4 Courses, Training, and Workshops

The pivotal objective of the Axis Bank Centre for Mathematics and Computing lies in nurturing a cohort of meticulously trained individuals poised to emerge as the torchbearers of mathematics and computing in India. Throughout the year, the centre spearheaded two impactful workshops and a comprehensive communication course, strategically designed to enrich the skills of both students and faculty at IISc.

These initiatives extended beyond the confines of IISc, drawing enthusiastic participation from individuals hailing from diverse academic and research institutions across the nation. Orchestrated by esteemed professors from IISc, these training workshops and courses aimed to fortify the mathematical and computing acumen of the participants.

The response to these endeavors was nothing short of overwhelming, underscoring the thirst for knowledge and the eagerness to delve deeper into these disciplines. Over the course of the financial year, the centre successfully conducted two workshops and a communication course, each leaving an indelible mark on the intellectual landscape. The following report delves into the specifics of these activities, highlighting their impact and contribution to the academic community.

4.1 The Art of Communication for Leaders for students @Indian Institute of Science

The Art of Communication will be 1:1 credit course to be offered in both the semester for students of IISc. 68 students registered for the course and successfully completed with various grades. The first course was conducted during April and second one in the month of November 2023.

Focus of the Course

Students work very hard to enter their dream institutes like IISc. They work even harder to absorb the rich technical courses that the institute offers. They are now ready to enter the corporate world or an academic institute to continue their research career and they soon realize that the 21st century is not just about technical skills. It is also about human skills like the ability to communicate with confidence, collaborate with others and demonstrate one's competence through their spoken words and actions. Many students are very uncomfortable with speaking in front of others. Or if they are comfortable, they are unsure of what to say and how to say it. This is exactly where this course focuses on.

The Art of Communication for Leaders is an online blended course that focuses on a simple framework of the Six Cs of Leadership namely – Confidence, Communication, Curiosity, Creativity, Collaboration and Competence. The course prepares the students to apply these Six Cs to a variety of situations that they will face as they transition from a role of a student to a working professional or an academic.

Using the Six Cs as the foundation, the course further explores concepts like dealing with fear, public speaking, uncertainty, low self-esteem, and mental hygiene. It also encourages critical thinking and facing audiences fearlessly, especially in Job Interviews.

Applications of the Course

This subject is like an ocean. So, to make it most impactful for students, it has been designed to help them with these common but important applications of communication and leadership:

- Overcome fears and inhibitions of speaking in front of audiences and make impactful speeches or presentations. They can use this skill in front

of their professors or an external audience while presenting their research papers or projects.

- Handling Job interviews better to get the dream job. They can use this skill for the placement process within or outside IISc.
- Be able to collaborate with others and build professional relationships. They can use this skill to be a lot more comfortable in meeting and working with people and in teams who are from diverse backgrounds.
- A detailed written feedback per student will be given by Dr. Godhwani. This may help the student identify their own strengths of communication and areas of improvement as they chart their own journeys forward.

4.2 Symposium on Big Data Algorithms for Biology 2023 - 2nd and 3rd of June 2023

Organisers: Prof Chirag Jain, IISc , Prof Debnath Pal, IISc and Dr. Sanchit Misra, Intel

Venue: CDS Seminar Auditorium (102), Indian Institute of Science Bangalore https://www.bdbio2023.in/

BDBio symposium was held in Indian Institute of Science Bangalore on June 2 and 3, 2023 at the CDS Seminar auditorium. This event featured research presentations in bioinformatics, computational biology, and systems biology. The symposium program, spanning two days, included 14 invited talks from eminent scientists in academia and industry. The event also served as a platform for 30 selected students from all over India to showcase their ongoing research during the poster and networking session. The topics include novel computational, statistical and machine learning methods in applications related to:

- Molecular sequence analysis
- RNA sequencing analysis, including single-cell
- Comparative and population genomics
- Cancer and infectious disease
- Computational systems biology
- Biological networks
- Metagenomics
- Computational proteomics, metabolomics and pharmacogenomics - Multi-omics data integration

YouTube link to all talks: https://www.youtube.com/playlist?list=PLAU4YrLp-kU8zJMm6HA-cbY-c6I-op2Tbd

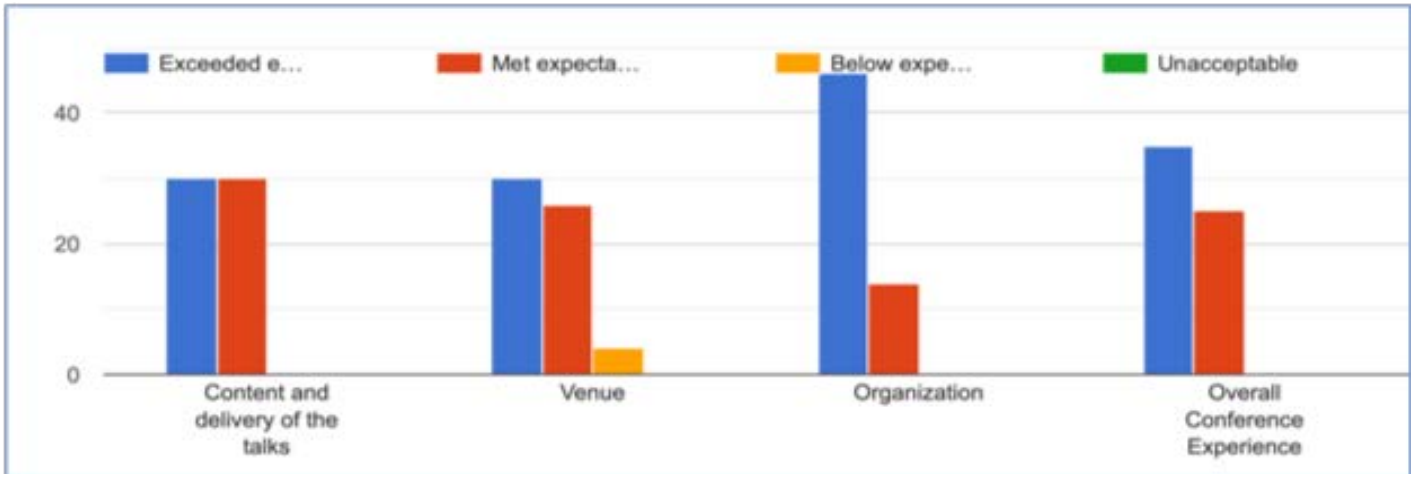
Photographs: https://photos.app.goo.gl/XFiwd5B-SCWnAR4R89

Link to program: https://drive.google.com/file/u/2/d/1p1Offll6D26GEXva4frIpja4BhljNhP5/view

Link to poster session: https://drive.google.com/file/d/1bS7gG8UNojyoAfuLftsy_ND2nU0mFT0M/view

Overall this event was very well received by the Indian computational biology community. The event was attended by more than 120 students + speakers, the auditorium was 100% occupied, and the organisers had to bring additional chairs to accommodate participants in a few sessions. The best component of the symposium were the engaging questions asked by graduate students after each talk.

We collected the **online feedback** using a google form from the attendees on June 4th to identify the strengths of the event, and understand the scope for further improvement. The summary of the feedback received from 60 participants is below.



Looking at the positive impact from this symposium, we are interested in conducting the BDBio symposium again next year at a bigger scale with international plenary speakers and a larger group of students.

4.3 Mathematics and Computing of Uncertainty Quantification In Model-Based Simulation For Risk-Informed Decision Making" - December 14th and 15th 2023

Overview: A tow-day short course on Uncertainty quantification during 14th and 15th December 2023 was organised by the Axis Bank Centre for the benefit of students of IISc and people working in the Industry, Research laboratories and faculty of the Engineering institutions. The announcement received an overwhelming response and about 180 registered for the workshop. The workshop was attended by 130 participants. The Instructor Dr Sankaran Mahadevan enthralled the participants with his lectures and answering the questions of the participants. The workshop covered a very wide variety of topics from basic mathematical concepts to risk-information decision making involving uncertainty. The Satish Dhawan Auditorium in the IISc campus provided the venue for the event. The feedback from the participants was excellent and gave some useful input for the organizers.

The workshop was inaugurated by Prof G K Ananthasuresh, Chair, Mechanical Engineering, IISc. He delivered the keynote address highlighting the importance of computation of uncertainty in the model-based simulation and advised to be ready to absorb the topics covered over the two days. Prof S Gopalakrishnan, the convenor of the Axis Bank Centre for mathematics and Computing, IISc welcomed the chief guest, instructor and all the participants.

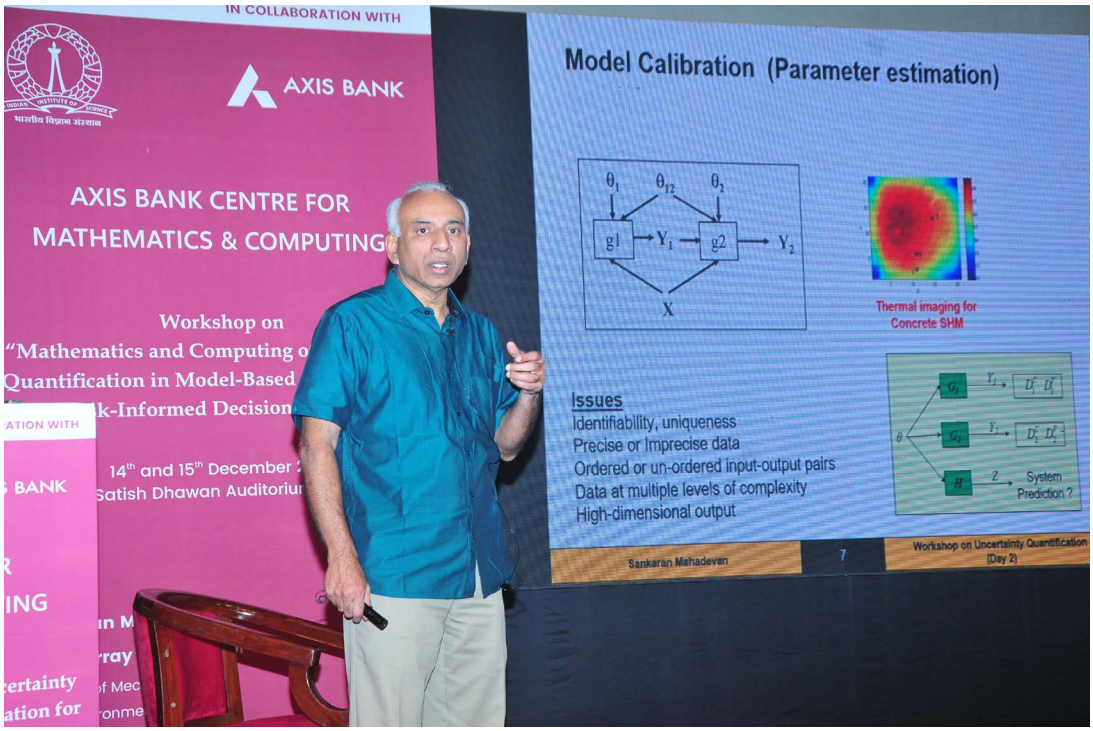
About the Course instructor:

Dr. Sankaran Mahadevan

John R. Murray Sr. Professor of Engineering
Dept. of Civil & Environmental Engineering,
And Dept. of Mechanical Engineering
Vanderbilt University, Nashville, TN 37235

Professor Sankaran Mahadevan has thirty years of research and teaching experience in reliability and risk methods, uncertainty quantification, model validation, system health and risk management, and optimization under uncertainty. His research has been extensively funded by NSF, NASA, FAA, DOE, DOD, DOT, NIST, General Motors, Chrysler, Union Pacific, American Railroad Association, and Sandia, Idaho, Los Alamos and Oak Ridge national laboratories. His research contributions are documented in more than 700 publications, including two textbooks on reliability methods and 350 journal papers. He is one of the world's highest cited researchers in the field of uncertainty and risk analysis (Google Scholar h-index 85). He has directed 53 Ph.D. dissertations and 24 M. S. theses and has taught many industry and university short courses on the mathematics and computing of uncertainty and reliability analysis.

Professor Mahadevan is a Fellow of AIAA, Fellow of the Engineering Mechanics Institute (ASCE), Fellow of Prognostics and Health Management Society (PHM), and winner of several awards including the NASA Next Generation Design Tools award (NASA), SAE Distinguished Probabilistic Methods Educator Award, IASSAR Senior Distinguished Research Award (International Association of Structural Safety and Reliability), and best paper awards in the MORS Journal and the EMI, AIAA SciTech and IMAC conferences. He is currently President of the ASCE Engineering Mechanics Institute and Managing Editor of ASCE-ASME Journal of Risk and Uncertainty (Part B: Mechanical Engineering).



Description of the workshop: Model-based simulation is attractive for the performance prediction and risk analysis of complex engineering and socio-technological systems under extreme conditions since full-scale testing is often unaffordable. However, model-based simulation involves many approximations and assumptions, and thus confidence in the simulation result is an important consideration in risk-informed decision-making. Sources of uncertainty are both aleatory and epistemic, stemming from natural variability, information uncertainty, and modeling approximations at multiple levels. Information uncertainty arises from sparse and imprecise data, measurement and data processing errors, and qualitative information. Model uncertainty arises due to unknown model parameters, model form assumptions, and solution approximation errors. This short course will present recent methods for the quantification of uncertainty from multiple sources, and their aggregation towards the behavior prediction of systems that often have multiple interacting physical phenomena at multiple spatial and temporal scales. Multiple activities such as calibration, verification and validation are conducted as part of the model development at multiple levels, and methods to integrate the results of these activities will be presented. Often the information available is heterogeneous, from multiple sources (models, tests, experts) and in multiple formats. The use of Bayesian networks to integrate heterogeneous information will be presented. An important objective of uncertainty quantification is uncertainty reduction. Different analyses and tests at different levels of fidelity could be performed, offering trade-offs between accuracy and cost; related uncertainty reduction strategies will be discussed. The linking of uncertainty quantification results to risk-informed decision-making will be discussed, covering several types of decisions, such as system design, manufacturing, operations, and sustainment.

The felicitation of the instructor of the workshop, Dr Sankaran Mahadevan was done in a typical Mysore style. A Mysore Petta and Shawal was presented by Prof G Jagadeesh, Professor, Department of Aerospace Engineering on behave of Shock-Wave Society of India. Prof S Gopalakrishnan, convenor of the Axis Bank centre proposed the vote of thanks. The workshop ended after taking a group photo. A copy of the certificate was issued to the participants.

4.4 Axis Bank Travel Grant

An announcement for Axis Bank International Travel Grant was sent to all the faculty members of IISc. A total of 10 applications were received. Based on the requested budget by the faculty and the total available travel budget, SAB recommended the travel grant for the following 8 faculty members. The funds were utilized for the air travel and registration fees for the conference.

Axis Bank Centre Travel Grant - 2023-24						
Sl No	Name of Applicant	Date of International Conference / workshop	Type of Presentation	Estimation of Travel expenses	Name of Conference attended	Department
1	Sai Gautam Gopalakrishnan	October 8-12, 2023	Oral	₹ 80,000.00	244th Meeting of the Electrochemical Society	Materials Engineering
2	Punit Rathore	October 3, 2023	Oral	₹ 120,000.00	IEEE/CVF International Conference on Computer Vision Workshop (ICCVW), VI Priors	Robert Bosch Centre for Cyber-Physical systems
3	Rajeev Kumar Jain	September 11-15, 2023	Oral	₹ 150,000.00	COSMO 2023	Physics
4	Sridharan Devarajan	August 19-25, 2023	Oral	₹ 225,000.00	IJCAI - International Joint Conference on Artificial Intelligence	Centre for Neuroscience
5	Mohit Kumar Jolly	September 18-19, 2023	Oral	₹ 250,000.00	London Mathematical Biology Conference	Centre for Bio-Systems Science and Engineering
6	Arvind Ayyer	July 17-21, 2023	Oral	₹ 250,000.00	Formal Power Series and Algebraic Combinatorics 2023	Mathematics
7	Chirag Jain	September 3-6, 2023	Oral	₹ 250,000.00	Workshop on Algorithms in Bioinformatics (WABI) 2023	Computational and Data Sciences
8	Omkar SN	October 27-29, 2023	Oral	₹ 100,000.00	International conference on Alternative Medicine and Integrative Health	Aerospace Engineering
		Total Amount		**₹ 1,425,000.00**		

Chapter 5 Research Project grant, Purchase of software and Outreach Programme

The Axis Bank Centre for Mathematics and Computing has judiciously allocated approximately 10% of its budget towards advancing research initiatives, acquiring cutting-edge software, and facilitating outreach programs. This strategic allocation underscores the centre's commitment to fostering a dynamic and inclusive environment for the pursuit of excellence in mathematics and computing.

In pursuit of this mission, the centre has sanctioned two research project grants to esteemed faculty members, empowering them to delve into innovative and impactful areas of study. These grants not only signify a financial endorsement but also reflect the centre's dedication to pushing the boundaries of knowledge and contributing to the academic community.

Furthermore, the acquisition of two state-of-the-art software packages stands as a testament to the centre's commitment to staying at the forefront of technological advancements. These software installations on our servers are poised to catalyse breakthroughs in research and significantly benefit the entire research community within the Indian Institute of Science (IISc).

In parallel, the centre has undertaken two outreach programs focused on mathematical computation. These initiatives were meticulously designed to cater to both undergraduate and graduate students, as well as educators venturing into the realms of mathematics and computation. The outreach programs, tailored for beginners in these fields, sought to bridge knowledge gaps, spark interest, and cultivate a foundational understanding among participants.

This chapter provides a comprehensive report detailing the outcomes and impact of these activities. It serves not only as a documentation of the centre's endeavours but also as a testament to its commitment to nurturing a vibrant and collaborative ecosystem for mathematics and computing at IISc.

5.1 Axis Bank Project grant

Two research project grant will be provided to faculties of the institute working in the field of mathematics and computation. Each Project will be provided with a grant amount of Rs 10 lakhs to be spent in one year. The announcement for the proposal was sent to all the faculties on 14th February through the Office of the Research Grant (ORG). It was also sent to all the chairs with a request to circulate with the faculties. Twenty-four research proposals were received. Since the large number of proposals were received, the Scientific Advisory Board decided the following criteria for selection of the proposal.

1. The PI must be an Assistant Professor. Preference must be given to the newly joined faculty. This should be the basic criteria for selection going forward.

2. To have diversity, one proposal each from science departments and engineering departments will be selected for award of grant.

Based on this criteria, 11 proposals were shortlisted. The board members went through these proposals and evaluated them on a scale of 10. The average score formed the basis for selection of the proposal of the grant. The following two selected proposals were selected.

Name of the faculty	Department	Proposal	Utilization of funds in Rs lakhs	Number of Publications
Prof Bhagwati Prasad (Engineering stream)	Material Engineering	All-in-one solution for the development of high-speed and energy-efficient memory systems	9,99,798	Submitted 5 conference papers and 3 articles in Journals Advanced material, APL materials and Nature
Prof Sumantra Sarkar (Science stream)	Physics Department	Molecular Communication in Crowded Environments	9,74,285	Two manuscripts for publication under preparation.

The detailed report on the work done is given in Annexure 5.

5.2 Purchase of software: As per the mandate of the centre, two software were purchased

1) **SCAD-DIC-MFEM Software Module:** Digital Image Correlation is an effective non-contact displacement and strain measurement technique which utilizes scientific grade camera and a speckled pattern on the experimental model under study to determine the displacements. The technique is critically dependent on image processing and post-processing software to determine the measurements. Further, the measured field data can be analysed to gain a deeper understanding of structural dynamics via interface modules to Finite Element Solvers and MATLAB. These software use specialized matrix manipulation techniques to provide three dimensional field information of structural deformation and strains.

Structural samples are subjected to shock loading in shock tubes, and aeroelastic deformation in hypersonic flow is observed using high-speed cameras in LHSR, Department of Aerospace Engineering, IISc. DIC is an excellent tool to study structures under these challenging experimental conditions. SCAD-DIC software has been installed at LHSR to evaluate 3D-DIC deformations from high-speed imaging.

This particular module will enable interfacing the 3D-DIC information with well established FEM solvers and MATLAB for computational modelling and validation purposes. The module is specifically designed for interacting with SCAD-DIC Software installed in LHSR. Establishment of this facility will enable the development of mathematical models for hypersonic aeroelasticity and shock loading studies on structures.

The Laboratory for Hypersonic and Shock Wave Research, Department of Aerospace Engineering, Indian Institute of Science is an academic laboratory housing specialized shock tunnel and shock tube equipment for academic scientific research in the domain of hypersonic and shock waves. The Indian Institute of Science is primarily a graduate research institute and the DIC interfacing software module will used for graduate student training and research purposes.

2) **Maple Software:** Maple, developed by Mapel Soft and exclusively distributed in India by Binary Semantics Ltd, seamlessly integrates a robust math engine with a user-friendly interface designed for effortless analysis, exploration, visualization, and problem-solving. It offers a range of functionalities tailored for educational, research, and commercial purposes, making it a versatile solution for various disciplines.

Key features that make Maple an indispensable asset include:

1. Comprehensive Problem Resolution

Maple facilitates the resolution of mathematical problems from virtually any branch, making it a comprehensive solution for a wide range of disciplines.

2. Visual Intuitiveness

With an extensive collection of customizable 2-D and 3-D plots and animations, Maple provides a visually intuitive way to represent mathematical concepts and data.

3. Sophisticated Programming Language

Equipped with a sophisticated programming language specifically designed for mathematical applications, Maple offers flexibility and efficiency in coding for mathematical operations.

As part of our commitment to providing quality education, the Maple software will be utilized for training students at IISc, with a special focus on empowering students from underprivileged categories. Specifically, it will benefit students in the B.Tech (Mathematics and Computing) program.

The decision to acquire Maple is in accordance with the Memorandum of Understanding (MOU) signed with Axis Bank, further demonstrating the strategic alignment of this purchase with our institutional goals.

To ensure widespread accessibility, the software will be installed on the Supercomputer Education and Research Centre (SERC) server. We are pleased to inform you that the Chair of SERC has expressed keen interest in installing Maple on their server, underscoring the software's relevance and utility within our academic and research community.

Considering the robust features of Maple and its potential impact on our educational and research endeavours, we strongly believe that the purchase of Maple with a single quotation is not only justified but also essential for the continued growth and excellence of our institution.

5.3 Outreach programme

Two outreach programmes were conducted. Brief reports of both the programme are given below.

2-day workshop on programming in C++ for beginners

Purpose of the Workshop: The two-day "Programming in C++ for Beginners" workshop was organised based on valuable feedback from M.Tech. (Res) and PhD students in the Mechanical Sciences division at the Axis Bank Centre. These students expressed the need for formal avenues to learn programming languages like C/C++ and Python, which are essential for their research in scientific computing and utilizing open-source libraries.

Existing academic courses mainly focus on MATLAB, leaving a gap in students' proficiency in other programming languages necessary for their research work. This workshop aimed to address this gap by providing introductory hands-on programming lessons in C/C++, enabling students to become comfortable with programming and utilise online resources for skill development.

The first-of-its-kind workshop aimed to empower participants to leverage open-source tools in their research, enhancing their ability to work on scientific applications requiring languages like Fortran, C/C++, and Python. By the end of the workshop, participants were expected to have gained fundamental programming knowledge, setting them on a path towards incorporating programming skills into their academic pursuits and research.

Chapter 6 Construction of Axis Bank Centre for Mathematics and Computing

IISc Approved Drawings has been received through Tata Consultancy Engineer. A Preliminary Estimate was submitted by SE & PD, CPWD, Bangalore through letter no. 23(2)/SE and PD/2021/330(H) dated 09.11.2023 for Rs.109.678 Crore. Administrative Approval & Expenditure Sanction (A/A & E/S) of Preliminary Estimate by IISc, Bangalore has been received through letter no. DPI/CPWD/01-01/2023 dated 20.01.2023 &modified dated 10.11.2023 for Rs.109.678 Crore.

Based on this Tenders are called on EPC Mode – III, on 16.11.2024. After one month the tenders were opened. The details of project awarded to the construction company is given below.

Timeline for Construction of Building

Sl No	Activity	Tentative period (As per MOU between Axis Bank and IISc)	Present Status	Date
1	Tender preparation, award of work and execution of demolition and barricading works of the building	January 2023 to March 2023	a) Existing buildings including GATE/JAM offices, Center for Campus Management and Development (CCMD) got vacated.	Feb 2023
			b) Tender invited for Demolition and barricading.	27th March 2023
			c) Tender awarded for Demolition and barricading.	25th April 2023
			d) Agency: M/s M.I Agencies	
			e) Completion of demolition and barricading	June 2023
2	Preparation of comprehensive architectural and engineering, planning, designing and estimation reports and issue details for calling tender	January 2023 to June 2023	Agency: TATA Consultancy Engineers	October 2023
3	Finalization and approval of drawings	Last week of June 2023	Drawings are finished and approved by TATA Consultancy Engineers	October 2023
4	E-tendering process for engagement of agency for execution and award of work to the agency	July 2023 to October 2023	a) Tender Invited	17th November 2023
			b) Tender Awarded and commencement of work	16th January 2024
			c) Agency: M/s Chaudhary Construction Company Private Limited	
5	Construction of the building	November 2023 to April 2025	Date of start:	19th January 2024
			Expected date of completion	May 2025
6	Furnishing of the building	May 2025 to September 2025	Expected duration	June to October 2025
7	Inauguration of building	January 2026	Expected date	January 2026

Buildings Covered Under Project

S. No.	Name of Building	No. of Floors	Type of Construction	Plinth Area	
				Sqm	Sqft
1	Construction of Building (Ground + 5 floors) including Internaland External services of Civil, Electrical & Mechanical	G+5	RCC Frame Structure	15459	166400
Total				**15459**	**166400**

Status as on January'24

Sl. No	Name of the Structure	Current Status
1	Construction of Building (Ground + 5 floors) including Internal and External services of Civil, Electrical & Mechanical	• Architectural Drawings and Structural drawings for foundation Received from M/s TCE submitted to the Construction agency • 100% Demolition of existing Building Completed. • Site clearance Completed by the agency. • Preliminary work such as site office etc completed by the Agency. • Excavation expected to start now.

Schedule of deposit of Funds to CPWD as per the MOU between IISc and CPWD.

Sl No.	Deposit of Funds as per schedule of construction	Status
1	05% as the initial deposit at the time of communicating the administrative and financial approval for the project.	Completed
2	10% - second instalment – just after the award	Completed
3	10% - third instalment – after physical commencement of the work at site	Completed
4	20% - fourth instalment – after achieving physical progress of 15%	To be done later
5	20% - fourth instalment – after achieving physical progress of 35%	To be done later
6	20% - fourth instalment – after achieving physical progress of 55%	To be done later
7	10% - fourth instalment – after achieving physical progress of 75%	To be done later
8	5% - fourth instalment – after achieving physical progress of 90%	To be done later

Site photograph showing the cleared site and office barricaded by all the sides.

Chapter 7

Axis Bank Centre Award Ceremony

At the heart of our centre's commitment to fostering inclusivity and academic excellence lies a robust fellowship program. This initiative is designed to support the educational journey of deserving students, particularly those from underrepresented backgrounds. The centre takes pride in contributing to the educational aspirations of the Institute's students through various fellowship opportunities.

The M Tech and PhD fellowships serve as pillars of support for students, particularly women and those from underprivileged categories. PhD students benefit from a monthly top-up grant of Rs 35,000/=, accompanied by an annual contingency grant of Rs 2,00,000/=. Meanwhile, M Tech students receive a monthly grant of Rs 21,000/=, along with a one-time grant of Rs 1,20,000/= for the purchase of a laptop.

For scholars outside the institute, the Post-doctoral fellowships offer a monthly grant of Rs 1,00,000/=, coupled with an annual contingency grant of Rs 4,00,000/=. This initiative not only supports external scholars but also enriches the academic diversity within our community.

Beyond individual fellowships, the centre extends its support to faculty members. An annual grant of Rs 10,00,000/= is allocated for projects proposed by faculties working in the field of Mathematics and Computing. Additionally, travel grants are provided to facilitate faculty attendance at international conferences in the same domain.

This commitment to academic support culminated in the 2023 Award Ceremony, coinciding with the second Governing Board Meeting. The ceremony was graced by distinguished guests, Mr. Subrat Mohanty and Mr. Neeraj Gambir, Executive Director and Group Director of Axis Bank, respectively, along with Prof. K J Vinoy, Chair of ODAA. Prof. S Gopalakrishnan, the Convenor of the centre, presided over the event.

In this ceremony, certificates were awarded to 12 M Tech students, 10 PhD students, and 5 Post-doctoral applicants. A total of 45 attendees, including esteemed guests, faculty, and awardees, witnessed this celebration of academic achievement.

The event concluded with a high tea, symbolizing not just the end of the ceremony but also the beginning of a new chapter for the awardees and the continued commitment of the centre to academic excellence and inclusivity.

Chapter 8 Foundation Stone Ceremony for Axis Bank Centre for Mathematics and Computing

Date: 22nd March 2024

Time: 9:30 am to 10:00 am

Venue: Foyer of Faculty Hall, Main Building

Introduction

On the 22nd of March 2024, a significant milestone was achieved in the journey of the Axis Bank Centre for Mathematics and Computing at the Indian Institute of Science (IISc). The foundation stone ceremony for the centre's building was held with grandeur in the Foyer of the Faculty Hall within the main building of IISc. This event marked a momentous occasion, celebrating the collaboration between academia and industry for the advancement of science and technology.

Attendees

The ceremony witnessed an impressive gathering of distinguished individuals, including eminent scientists from IISc, high-ranking officials from Axis Bank, and representatives from the Central Public Works Department (CPWD). Their presence underscored the importance of the occasion and reflected the collective commitment towards fostering innovation and academic excellence.

Proceedings

The ceremony commenced with a warm welcome address delivered by Prof. Srikanth K Iyer, Associate Dean, UG (B Tech), IISc. In his remarks, he highlighted the achievements and initiatives of the Axis Bank Centre over the past year, while also outlining the future programs planned for the upcoming building. Prof. Iyer extended a heartfelt welcome to the Director of IISc, Prof. Govindan Rangarajan, Ms. Baishakhi Banerjee, Executive Vice President - Regional Branch Banking Head - South I, Axis Bank Limited, as well as other dignitaries present.

Following the welcome address, **Prof. Govindan Rangarajan** unveiled the meticulously prepared foundation stone, accompanied by Ms. Baishakhi Banerjee. In his speech, Prof. Rangarajan underscored the significance of the Axis Bank Centre for Mathematics and Computing as the first of its kind in India, dedicated to advancing the fields of mathematics and computing. He emphasized the transformative impact the centre would have on various disciplines of science and engineering. Prof. Rangarajan expressed sincere gratitude to Axis Bank for their generous support through corporate social responsibility grants and expressed hope for continued collaboration in the future.

Ms. Baishakhi Banerjee from Axis Bank Limited reiterated the importance of collaboration between Axis Bank and IISc, highlighting the pivotal role such partnerships play in driving scientific and technological innovation for the betterment of society. She expressed pride in the association with a premier institution like IISc and reaffirmed Axis Bank's commitment to supporting initiatives that contribute to societal progress.

Prof. K J Vinoy, Chair, ODAA, IISc, concluded the proceedings with a vote of thanks, expressing profound gratitude to Prof. Rangarajan and Ms. Banerjee for their presence and support. He acknowledged the invaluable financial assistance provided by Axis Bank Limited and extended appreciation to the CPWD officials for their meticulous preparation of the foundation stone and decorations. Prof. Vinoy also expressed delight at the presence of the Deans during the ceremony, highlighting their collective dedication to the success of the Axis Bank Centre.

The ceremony concluded on a convivial note with the serving of high tea, providing an opportunity for further networking and camaraderie among the attendees.

Pictures Taken During the Foundation Stone Ceremony.

Chapter 9

Utilization of funds for the Financial year 2023-24

9.1 Capital Expenditure

Particulars	Budget (Rs)	Amount spent (Rs)	Unspent balance (Rs)
Capital Cost	31,67,00,000	25,84,19,850	5,82,80,150

9.2 Operational Expenditure

A: Fellowships and Internships					
Sl No	**Particulars**	**Initial Budget (Rs)**	**Revised Budget (Rs)**	**Amount spent (Rs)**	**Unspent balance (Rs)**
A1	Axis Bank Postdoctoral Fellowship	48,00,000	60,00,000	54,51,578	5,48,422
A2	Axis Bank PhD Fellowships	66,00,000	55,00,000	53,25,433	1,74,567
A3	Axis Bank M Tech Fellowships	39,60,000	37,92,000	36,74,904	1,17,096
A4	Axis Bank Internships	6,75,000	6,75,000	6,75,000	0
Sub Total		**1,60,35,000**	**1,59,67,000**	**1,51,26,915**	**8,40,085**

B: Professors, Instructors and Research Staff					
Sl No	**Particulars**	**Initial Budget (Rs)**	**Revised Budget (Rs)**	**Amount spent (Rs)**	**Unspent balance (Rs)**
B1	International Chair Visiting Professors	8,00,000	8,00,000	2,29,884	5,70,116
B2	Visiting Professors	4,50,000	6,00,000	5,13,378	86,622
B3	B Tech Instructors and Teaching Assistants	40,19,680	40,19,680	35,70,350	4,49,330
B4	Administration & Staff Expenses	12,80,000	12,80,000	12,79,658	342
Sub Total		**65,49,680**	**66,99,680**	**55,93,270**	**11,06,410**

C: Courses, Trainings and Workshops					
Sl No	**Particulars**	**Initial Budget (Rs)**	**Revised Budget (Rs)**	**Amount spent (Rs)**	**Unspent balance (Rs)**
C1	Prework Shop Training Schools	10,00,000	5,95,873	5,95,873	0
C2	Communication Skill Courses	10,00,000	10,00,000	10,00,000	0
C3	Workshops and Travel Expenses for Presenting Papers	22,50,000	22,75,000	22,23,962	51,038
Sub Total		**42,50,000**	**38,70,873**	**38,19,835**	**51,038**

D: Other Operational Expenses					
Sl No	**Particulars**	**Initial Budget (Rs)**	**Revised Budget (Rs)**	**Amount spent (Rs)**	**Unspent balance (Rs)**
D1	Research Project Grant for Operational Costs	10,00,000	10,00,000	9,99,798	202
D2		10,00,000	10,00,000	9,74,285	25,715
D3	Others Consumables, Software, Tools etc,.	28,90,320	31,87,447	29,33,037	2,54,410
Sub Total		**48,90,320**	**51,87,447**	**49,07,120**	**2,80,327**

E: Project Management Cost					
Sl No	**Particulars**	**Initial Budget (Rs)**	**Revised Budget (Rs)**	**Amount spent (Rs)**	**Unspent balance (Rs)**
E	Project Management Cost	15,75,000	15,75,000	15,68,779	6,221
Sub Total		**15,75,000**	**15,75,000**	**15,68,779**	**6,221**
Grand Total		**3,33,00,000**	**3,33,00,000**	**3,10,15,918**	**22,84,082**

Funds Utlization Summary			
Particulars	**Building Project (A)**	**Operational Support (B)**	**Totals (A+B)**
Funds Received in the FY 2022-23	2,85,00,000	35,05,500	3,20,05,500
Funds Received in the FY 2023-24	31,67,00,000	3,33,00,000	35,00,00,000
Total Funds Received for Respective Projects	**34,52,00,000**	**3,68,05,500**	**38,20,05,500**
Amount Spent in FY 2022-23	2,85,00,000	35,05,500	3,20,05,500
Amount Spent in FY 2023-24**	25,84,19,850	3,10,15,918	28,94,35,768
Total Amount of Expenditure till Date	**28,69,19,850**	**3,45,21,418**	**32,14,41,268**
Balance Funds Availble for FY 2023-24	**5,82,80,150**	**22,84,082**	**6,05,64,232**
** An excess expenditure of Rs. 2,23,39,000/- spent by IISc on building for FY 2022-23 is adjusted against CSR contribution for FY 2023-24.			

Annexure 1 Governing Board and Scientific Advisory Board Meetings

The Scientific Advisory Board met twice during the current financial year 2023-24. One of them was a joint meeting with the Governing Board. The Governing board met three times.

- The Second Scientific Advisory Board meeting held on June 23rd 2023.
- The Second Governing Board meeting held on August 21st 2023 (Jointly with Scientific Advisory Board).
- The Third Governing Board meeting to be held on February 21st 2024.

The minutes of the meeting (MOM) of the above three meeting is given below. The annexures have been left out. The decision taken and action points are included in the MOM.

Second Scientific Board Meeting – June 23rd, 2023 Minutes of Meeting

The Second Scientific Board Meeting was held on 23rd June at the Axis Bank Centre's office, A216, Department of Aerospace Engineering, IISc, Bangalore. The minutes of the meeting are reported below.

1) Members Present

i) Prof. Gopalakrishnan - Convenor
ii) Prof. Arvind Ayyer - Co- Convenor
iii) Prof. Prabal Kumar Maiti, Chair, Physics Department, IISc - Member
iv) Prof. N Balaji, Business Intelligent Unit, Axis Bank- Member (attended online)
(Prof Abhinandanan T and Prof Abhishek Kumar Singh expressed their inability to attend the meeting)

2) The members were welcomed by Prof S Gopalakrishnan, Chair, Scientific Advisory Board, Axis Bank Centre for mathematics and Computing (ABCMC).

3) The MOM of the first SAB meeting held on March 7th, 2023, was approved.

4) Presentation Highlights: Prof S Gopalakrishnan presented an overview of the activities taken up by the centre between April and June. Summary is as given below.

- The annual report for the period of January to March 31st, 2023, has been prepared and submitted to Axis bank.
- Five continuing M. Tech and five continuing PhD students (from IMI Program) selected in the previous meeting has been informed and will be getting fellowship from July 2023. The fellowship amount will be given from April 1st, 2023.
- MOU to be signed with Indian Academy of Science for B.Tech internships with Academy trust have been approved by IISc Legal and is currently with Academy Trust for their approval
- Debit head has been created for PIs for the two project grants approved for IISc Faculty
- The advertisement for Axis Bank Post doctoral fellowships was sent to all IITs and some IISERs. 17 applications have been received. The details of the applicants are shared with Scientific Advisory Board members.
- The request for nomination of National and International visiting Professor. Three nominations for International and one for National visiting professor are received.
- First workshop for the financial year, Big data algorithm in biology was conducted on June 2nd and 3rd, 2023. About 112 students and 17 speakers participated in the workshop.
- Two more workshop proposal has been received for conducting workshops to be conducted in this financial year.

5) Discussion of the Agenda items

1. M Tech fellowships: The SAB was informed that the Institute has set up a committee under the Chairmanship of Prof K J Vinoy to recommend M.Tech Fellowship coming under CSR Grant and he was requested to select M.Tech candidates for Axis Bank Centre as well. Since the grant arrived two months late and based on the available budget and projected expenditure on other budget heads, the total number of fellowships has been increased to 12 for M Tech fellowship. Out of 6 continuing students selected for M.Tech fellowship, two students has discontinued the course. Hence, Prof. Vinoy's Committee have recommended 8 fresh M.Tech students for the fellowship. For this financial year. These students will get fellowship from August 2023 to March 2024. The list of students selected from the new batch is given below. The total amount allotted for the M Tech fellowship is Rupees thirty-nine lakhs and sixty thousand (Rs 37,92,000/=).

Axis Bank Centre For Mathematics And Computing
Recommended Students - Axis Bank M Tech Fellowship - 2023-24

Sl no	Name	Gender	Category	Programme	Department
1	Sanjana A R	Female	GN	M Tech	Electronics and Communication Engineering
2	Gayathri Venkat	Female	GN	M Tech	Electronics and Communicati on Engineering
3	Tushar Dilip Kurne	Male	SC converts to Buddhism	M Tech	Robert Bosch Centre
4	Swapnil Sanjay Mane	Male	SC	M Tech	Robert Bosc Centre
5	Khushit Shaileshbhai Shah	Male	EWS	M Tech	Computer Science and Engineering
6	Anil Kumar Dhakad	Male	OBC(NCL)	M Tech	Computer Science and Engineering
7	Suvendu Kar	Male	EWS	M Tech	Computational and Data Science
8	Abhishek Sharma	Male	EWS	M Tech	Artificial Intelligence
9	Shreyashri Sarkar	Female	GN	M Tech	Aerospace Engineering
10	Dolly Sahoo	Female	GN	M Tech	Civil Engineering
11	S Pavithirah	Female	OBC(NCL)	M Tech	Aerospace Engineering
12	Pawar Rushikesh Gajanansa	Male	OBC(NCL)	M Tech	Computational and Data Science

2. PhD fellowships: Based on the projected budget and expenditure, SAB in its last meeting approved 12 PhD students from IMI to be awarded a top-up fellowship of Rs 35,000/= per month. Out of this, 6 students will be from the continuing batch of PhD students. It was reported that one of them will be getting a PMRF grant. Hence only 5 of the continuing batch of students will be eligible for the fellowship. 5 more students from the fresh batch (August 2023) of IMI programme will be selected. Prof Arvind Ayyer has provided the list of students. The list is provided below. The total amount budgeted for the Ph D fellowship is Rupees fifty-nine lakhs and eighty thousand only (Rs 59,80,000).

List of IMI Students eligible for Axis Bank Phd Fellowship 2023, BATCH 2023

Sl no	Application No.	Student Name	Research Guides	Gender	Category
1	230102427	Soundharya R	Mohit Kumar Jolly (BSSE) Annapoorni Rangarajan (MRDG)	Female	GN
2	230105979	Vishali S	Tejas Murthy (Civil) Vijay Natarajan (CSA)	Female	OBC(NCL)
3	230100173	Subham Patel	Ratikanta Behera (CDS) Thirupathi Gudi (Math)	Male	OBC(NCL)
4	230104295	Adarsh Jain	Pawan Bharadwaj (CEaS) Chandra Sekhar Seelamantula (EE)	Male	EWS
5	230104724	Raghunandan S	G K Ananthasuresh (ME) Kaushal Verma (Math)	Male	OBC(NCL)

Axis Bank Post Doctoral Fellowship - 2023-24					
Sl No.	**Name of the Applicant**	**Stream**	**Proposed department / Supervisor**	**Gender**	**Category**
Selected students					
1	Priyam Chakraborty	Engineering	Prof Shubhadeep Mandal. Mech Eng	Male	General
2	Swati Rani Hait	Engineering	Prof Debnath Pal, CDS	Female	General
3	Scindhiya Laxmi	Mathematics	Prof Prathosh A P, EECS	Female	OBC
4	Gaurav Kumar	Science	Prof Anand Srivastava, MBU	Male	General
5	Shalini Saha	Mathematics	Prof Roy Mahapatra, Aerospace Engg.	Female	OBC
Wait list					
6	Shushma Rani	Mathematics	Prof R. Venkatesh, Maths	Female	General

3 Selection of students for post-doc fellowships. The advertisement was sent to all the relevant departments at IITs and some IISERs. Facility to apply online was provided through our website. Seventeen applications from students spread all over India were received. The details of the applicants along with their CVs, reference letter, proposal etc were sent to all the SAB members in advance. It has been decided to shortlist 8 candidates based on their CVs and publications. It is also decided to increase the number of fellowships be increased to 5 from the existing 3.

d) Selection of International Visiting fellowship: An announcement was sent to all the chairs of departments and centres of IISc to nominate the names for the position of International Visiting Professor. Three nominations were received, and these are as given below.

Prof N Swaminathan from University of Cambridge, nominated by Prof Sourabh Suhas Diwan, Department of Aerospace Engineering.

Prof Dr. Nagendra Somnath, Independent Consultant & Researcher and formerly with Pratt & Whitney Engines, nominated by Prof Pramod Kumar, Department of Mechanical Engineering.

Prof. Siv Loganathan (Chair, Applied Maths, Department, Univ. Waterloo), nominated by Prof Mohit Kumar Jolly, Centre for Biosystems Science and Engineering.

The members after going through the CVs of the three nominations, decided that Prof Siv Loganathan be recommended for selection to the Axis Bank International Visiting Professor position. The board also decided that in case Prof Siv Loganathan cannot accept the professorship then this position can be offered to Prof Nagendra nominated by Prof Pramod Kumar.

e) Selection of National Visiting fellowship: An announcement was sent to all the chairs of departments and centres of IISc to nominate the names for the position of National Visiting Professor. Received only one nomination from Prof Gautam Bharali for Prof Srihari Sridharan, IISER, Thiruvanathapuram. Prof Srihari Sridharan wants to spend one year in IISc rather than one month as mentioned in the announcement. The members of the SAB have selected Prof Srihari Sridharan and agreed to extend the duration to one year with condition that total funds available will be restricted to Rs four lakhs and fifty thousand only (Rs 4,50,000/=), which is the fund allocated to National Visiting Professor.

f) International travel grant for faculty: The guidelines for the Axis Bank Travel grant have been prepared and approved by the members of SAB. A copy of the same is given in annexure 1. An announcement will be sent to all the faculty for applying online for the travel grant.

g) Appointment of One B Tech instructor: Associate Dean for Mathematics and Computing requested an additional B.Tech Instructor for the B.Tech Program. This request was approved by SAB. One more Instructor, Dr Devnath Shah, will be appointed from the Axis Bank Centre budget. A letter has been written to H R section for internal transfer. The salary and other conditions remain the same.

h) Workshops: SAB was informed that two workshop proposals were received to be conducted in this financial year. The details of the proposals are as follows:

- A Short course in mathematics and computing of uncertainty quantification in model-based simulation for risk-informed decision making has been proposed by Dr Sankaran Mahadev, John R Murray, Senior Professor of Engineering, Department of Civil and

Environmental engineering, Vanderbilt University, Nashville. The workshop will cover Basic mathematical concepts and computing methods, Data uncertainty, Model uncertainty and Uncertainty Aggregation and Risk-informed. The members of SAB have Approved for 2-day workshop and allow about six lakhs to be utilized for travel and remuneration of the resource person. The total budget allocated is Rupees ten lakhs (Rs 10,000/=). The proposal is attached as annexure 2.

- 2-day workshop on programming in C++ for beginners has been proposed by Prof Ramsharan Rangarajan, Department of Mechanical Engineering. The workshop will be conducted in Skill Development Centre, IISc, Challakere Campus. This will be for IISc students. The convenor of Skill Development Centre, Prof D N Rao, has agreed to provide the facilities of the centre to be utilised for the workshop. The estimated budget is Rupees one lakh and eight-four thousand (Rs 1,84,000/=).

Both these proposals were approved by SAB

6) Action Points

1	Approval of List of Axis Bank list of 7 students from M.Tech fellowship	Approved by the SB. Sent to GB
2	Provide list of 7 students from fresh batch for Axis Bank PhD fellowship	Prof Aravind Ayyer will be providing the list from IMI programme.
3	Preparation of Short List of 6 candidates	Members of SAB to share the list of 6 candidates from 17 applicants by one week.
4	Approval of two workshops	Information can be shared with the organizers.
5	Selection of International and National Visiting Fellowship	Inform the selected professor and take the acceptance through the faculty who nominated them.
6	Guidelines for Axis Bank Travel Grant approved.	Announcement to be sent to all the faculty of IISc.

This minute is released with the approval of the Chair.

S. Gopalakrishnan

Prof S Gopalakrishnan,
Convenor,
Axis Bank For Mathematics and Computing
Indian Institute of Science
Bangalore 560012

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Second Governing Board Meeting–August 21st, 2023
Minutes of the Meeting

Members Present

1. Prof G Rangarajan, Director, IISc and Chair
2. Prof Navakanta Bhat, Dean, Interdisciplinary sciences, Member
3. Mr Subrat Mohanty, Executive Director, Axis Bank, Member
4. Mr Neeraj Gambir, Group Executive, Treasury, Markets and Wholesale banking Products, Axis Bank, Member (online participation)
5. Prof S Gopalakrishnan, Professor, Department of Aerospace, IISc, Convener
6. Prof Arvind Ayyer, Professor, Department of Mathematics, IISc, Member of SAB

(GB Members not present: Prof Kaushal Verma and Prof Srikanth Iyer)

Introductory remarks:

- The members were welcomed by the Chair, Prof G Rangarajan and the Convener, Prof S Gopalakrishnan.
- A copy of the Annual Report (January–March 2023) was shared with all the members.
- The minute of meeting of the first Governing Board held on February 17th meeting was placed and accepted.
- The following agenda items were presented by Prof S Gopalakrishnan.

Discussion of Agenda items:

1) M Tech fellowships: M tech Fellowship was increased from 3 to 12. This increase was possible due to 1) late arrival of the CSR grants and 2) initial specified fellowship amount of Rs 36,000/= was not admissible as per Institute norms. Out of these 12, 6 fellowships were recommended for continuing M. Tech students and the rest 6 for incoming students. Out of 6 continuing students selected for M.Tech fellowship, two students discontinued the course, hence, 8 incoming M.Tech students were recommended for the fellowship for this financial year. These students will get fellowship from August 2023 to March 2024. The list of students selected is given below. The total reappropriated budget allotted for the M Tech fellowship is **Rupees thirty-seven lakhs and ninety-two thousand only (Rs 37,92,000/=). The Governing Board (GB) has approved both the recommendation and the reappropriated budget.**

Axis Bank Centre For Mathematics And Computing
Recommended Students - Axis Bank M Tech Fellowship - 2023-24

Sl no	Name	Gender	Category	Programme	Department
1	Sanjana A R	Female	GN	M Tech	Electronics and Communication Engineering
2	Gayathri Venkat	Female	GN	M Tech	Electronics and Communication Engineering
3	Tushar Dilip Kurne	Male	SC converts to Buddhism	M Tech	Robert Bosch Centre
4	Swapnil Sanjay Mane	Male	SC	M Tech	Robert Bosc Centre
5	Khushit Shaileshbhai Shah	Male	EWS	M Tech	Computer Science and Engineering
6	Anil Kumar Dhakad	Male	OBC(NCL)	M Tech	Computer Science and Engineering
7	Suvendu Kar	Male	EWS	M Tech	Computational and Data Science
8	Abhishek Sharma	Male	EWS	M Tech	Artificial Intelligence
9	Shreyashri Sarkar	Female	GN	M Tech	Aerospace Engineering
10	Dolly Sahoo	Female	GN	M Tech	Civil Engineering
11	S Pavithirah	Female	OBC(NCL)	M Tech	Aerospace Engineering
12	Pawar Rushikesh Gajanansa	Male	OBC(NCL)	M Tech	Cp Computational and Data Science

2) PhD fellowships: Based on the projected budget and expenditure, SAB and GB in their last meeting approved 12 PhD students from IMI to be awarded a top-up fellowship of Rs 35,000/= per month. Out of this, 5 students will be from the continuing batch of PhD students. It was reported that one of them will be getting a PMRF grant. Hence only 5 of the continuing batch of students will be eligible for the fellowship. 5 new students from the fresh batch (August 2023) of IMI programme have been recommended. The list of students is given below. The total reappropriate budget for the Ph D fellowship is Rupees fifty-five lakhs only (Rs 55,00,000). **The Governing Board (GB) has approved both the recommendation and the reappro**

3) Recommendation of students for post-doc fellowships: SAB recommended, based on the available budget the number of post-doc fellowship be increased from the existing 3 to 5. A total of 17 applications were received from all over the country and SAB recommended 5 candidates based on their CVs, publications, and reference letters. The list of recommended candidates is given below. The total amount budgeted for the Post-doc fellowship is Rupees Sixty lakhs only (Rs 60,00,000). The Governing Board (GB) has approved both the recommendations and the reappropriated budget.

List of IMI Students eligible for Axis Bank Fellowship 2023				
Sl no	**Student Name**	**Research Guides**	**Gender**	**Category**
1	Soundharya R	Mohit Kumar Jolly (BSSE) Annapoorni Rangarajan (MRDG)	F	GN
2	Vishali S	Tejas Murthy (Civil) Vijay Natarajan (CSA)	F	OBC(NCL)
3	Subham Patel	Ratikanta Behera (CDS) Thirupathi Gudi (Math)	M	OBC(NCL)
4	Adarsh Jain	Pawan Bharadwaj (CEaS) Chandra Sekhar Seelamantula (EE)	M	EWS
5	Raghunandan S	G K Ananthasuresh (ME) Kaushal Verma (Math)	M	OBC(NCL)
6	Ankan Biswas	Prof. Supratim Ray (CNS) Prof. Govindan Rangarajan (Mathematics)	M	SC
7	Chigicherla Venkata Sai Prasanna	Prof. Mohit Kumar Jolly (BSSE) and Prof. Ramray Bhat (MRDG)	M	OBC-NCL
8	Sneha V	Prof. Nagasuma Chandra (BC) Prof. Annapoorni Rangarajan (MRDG)	F	GN
9	Heeba Anjum	Prof. Usha Vijayraghavan (MCB) and Prof. Mohit Kumar Jolly (BSSE)	F	OBC-NCL
10	Aswini.V.J	Prof. Pawan Bharadwaj (CEAS) and Prof. Chandra Shekar Seelamantula (EE)	F	OBC-NCL

4) Recommendation of International Visiting fellowship: Based on the announcement, the following three nominations were received.

- **Prof N Swaminathan from University of Cambridge,** nominated by Prof Sourabh Suhas Diwan, Department of Aerospace Engineering.
- **Prof Dr. Nagendra Somanath, Independent Consultant & Researcher and formerly with Pratt & Whitney Engines**, nominated by Prof Pramod Kumar, Department of Mechanical Engineering.
- **Prof. Siv SivLoganathan (Chair, Applied Maths, Department, Univ. Waterloo)**, nominated by Prof Mohit Kumar Jolly, Centre for Biosystems Science and Engineering.

Axis Bank Post Doctoral Fellowship - 2023-24					
Sl no	**Name of the Applicant**	**Stream**	**Proposed department / Supervisor**	**Gender**	**Category**
1	Priyam Chakraborty	Engineering	Prof Shubhadeep Mandal. Mech Eng	Male	General
2	Swati Rani Hait	Engineering	Prof Debnath Pal, CDS	Female	General
3	Sudarshan Santra	Mathematics	Prof Ratikanta Behera, CDS	Male	General
4	Gaurav Kumar	Science	Prof Anand Srivastava, MBU	Male	General
5	Shalini Saha	Mathematics	Prof Roy Mahapatra, Aerospace Engineering.	Female	OBC

Based on the proposal, publication record and CV, SAB members recommended Prof Siv SivLoganathan to the Axis Bank International Visiting Professor position. The CV is enclosed as Annexure (1). The Governing Board (GB) has approved the recommendation.

5) Recommendation of National Visiting Professor: Based on the announcement only one nomination was received. Prof Gautam Bharali from the Department of Mathematics has nominated **Prof Srihari Sridharan**, IISER, Thiruvananthapuram. After going through Prof Sridharan credentials, the SAB has recommended him for National Visiting Professor. The CV of the nominee is enclosed as Annexure (2) **The Governing Board (GB) approved the recommendation.**

Prof Srihari Sridharan has communicated his inability to accept the offer for the visiting professorship. The SAB has recommended **Prof Nagendra Somanath** for the same position. The additional funds required for international air travel can be reappropriated from other budget heads. The GB members were contacted by email and their approval has been taken.

6) International travel grant for faculty: Based on the announcement for Axis Bank International Travel Grant, a total of 10 applications were received. Based on the requested budget by the faculty and the total available travel budget, SAB recommended the travel grant for the following **8 faculty** members has been selected for the award. The total amount budgeted for the Travel grant is **Rupees Fourteen lakhs, twenty-five thousand only (Rs 14,25,000). The Governing Board (GB) has approved both the recommendation and the re-appropriated budget.**

7) Appointment of One B Tech instructor: Based on the request for additional B. Tech Instructor from the Associate Dean for Mathematics and Computing, SAB has recommended Dr Devnath Shah for the position. **The Governing Board (GB) has approved the recommendation.**

8) Workshops: The following workshop proposal to be conducted in this financial year was received.

• A Short course in mathematics and computing of uncertainty quantification in model-based simulation for risk-informed decision making has been proposed by Dr Sankaran Mahadev, John R Murray, Senior Professor of Engineering, Department of Civil and Environmental engineering, Vanderbilt University, Nashville. The workshop will cover Basic mathematical concepts and computing methods, Data uncertainty, Model uncertainty and Uncertainty Aggregation and Risk-informed. The members of SAB have Approved for 2-day workshop and allow

Sl No	Name of Applicant	Date of International Conference / workshop	Type of Presentation	Estimation of Travel expenses	Conference Name
1	Sai Gautam Gopalakrishnan	8-12 October, 2023	Oral	₹ 80,000.00	244th Meeting of the Electrochemical Society
2	Punit Rathore	03/10/2023	Oral	₹ 1,20,000.00	IEEE/CVF International Conference on Computer Vision Workshop (ICCVW), VI Priors
3	Rajeev Kumar Jain	September 11-15, 2023	Oral	₹ 1,50,000.00	COSMO 2023
4	Sridharan Devarajan	August 19-25, 2023	Oral	₹ 2,25,000.00	IJCAI - International Joint Conference on Artificial Intelligence
5	Mohit Kumar Jolly	September 18-19,2023	Oral	₹ 2,50,000.00	London Mathematical Biology Conference
6	Arvind Ayyer	July 17-21, 2023	Oral	₹ 2,50,000.00	Formal Power Series and Algebraic Combinatorics 2023
7	Chirag Jain	September 3-6 2023	Oral	₹ 2,50,000.00	Workshop on Algorithms in Bioinformatics (WABI) 2023
8	Omkar SN	27/10/2023 to 29/10/2023	Oral	₹ 1,00,000.00	International conference on Alternative Medicine and Integrative Health

about six lakhs to be utilized for travel and remuneration of the resource person. The total budget allocated is Rupees ten lakhs (Rs 10,00,000/=). The proposal is attached as Annexure (3). Aeronautical Society of India will be collaborating in organizing the workshop.

The Governing Board (GB) has approved the workshop and the budget.

9) Prof Gopalakrishnan presented to the GB, the activities undertaken by the centre since the last GB meeting in February 2023.

• **Axis Bank B Tech internship:** GB was informed about the signing of MOU with The Academy Trust under the aegis of the Indian Academy of Science for the supporting their successful annual Summer Internship Programme. 21 students from all over India have participated in the programme and they all worked under the supervision of faculty of IISc. The MOU is enclosed as Annexure (4).

• **Symposium on Big Data Algorithms for Biology 2023** was successfully organised during June 2nd and 3rd. The workshop had 112 participants and 14 speakers. It had one poster and one panel discussion. The report is attached as Annexure (5).

• **Communication Workshop:** The first edition of communication workshop was conducted by Office of the Communication during Jan-April 2023. The course Instructor was Rakesh Godhwani, Adjunct faculty of communication at IIM(B) and Udaipur. This is a 1:1 credit course elective course in the Institute. 82 students enrolled for the course and has given excellent feedback. The second edition is scheduled for August – December semester. About 100 students are expected to attend.

• **Axis Bank Project Grant:** The sanctioned grant money has been transferred to the debit head of the faculty members selected by SAB and approved by GB.

10) Out-reach programmes: Prof Gopalakrishnan requested an opinion of the GB on the Outreach programme in general and in particular the proposal sent by The Academy Trust and Talent Development Centre, Challakere, since the Axis Bank MOU doesn't mandate any such programmes. The GB in principle agreed that such outreach programmes are necessary to increase the visibility of the centre. They requested the convenor to take this outreach programme based on the available budget after December 2023. In addition, the following opinions were expressed by the GB.

• The outreach programme must be restricted to math and computing.

• Thes programmes should have a smaller budget.

• The Axis Bank Centre at IISc can utilize Axis Bank marketing team to enhance the Branding of the centre.

11) Measuring the outcome of the cutting-edge research and projects coming under the Axis Bank Centre. GB expressed that a mechanism be designed to objectively evaluate the outcome of the research work coming out of fellowships and project grants. It was suggested that paper publications and patents resulting during the tenure of the project and fellowship should be documented. However, the projects are short term (maximum of one year) and hence care must be taken while setting the expectation.

12) Emphasis on the areas of quantum computing, AI/ML, and computation in finance: GB members felt that some projects and fellowships (PhD and Post-doc) should be dedicated in the areas of quantum computing, AI/MI and computation in finance. In addition, members wanted the Axis Bank centre should explore conducting workshops for B Tech students and for others working in the area on computational finance. Axis Bank executives can also participate in the workshop both as participant and Instructors. It was suggested that the second year M Tech students could also take up projects on the data analysis using AI/ML tools with the participation of Axis Bank executives. In this regard, GB suggested involving Mr N Balaji, Axis Bank, Head of the Business Intelligence Unit (also a member of SAB).

13) Reap propriated Budget: The line items of the reappropriated budget, where the changes have been made are given below. A detailed budget is given in Annexure (6)

Line Item	Previous budget (Rs)	New budget (Rs)	Difference (Rs)
A.3 M tech fellowship	₹ 39,60,000.00	₹ 37,92,000.00	₹ 1,68,000.00
A.2 PhD fellowship	₹ 66,00,000.00	₹ 55,00,000.00	₹ 11,00,000.00
A1 and A5 Post Doc fellowship	₹ 48,00,000.00	₹ 60,00,000.00	-₹ 12,00,000.00
C++ workshop	₹ 0.00	₹ 1,80,000.00	-₹ 1,80,000.00
C. 2 Workshop on Big data	₹ 10,00,000.00	₹ 5,95,873.00	₹ 4,04,127.00
C.4 Travel Grant	₹ 12,50,000.00	₹ 14,25,000.00	-₹ 1,75,000.00
D.2 mathematical software and software tools	₹ 8,00,000.00	₹ 9,17,127.00	-₹ 1,17,127.00
Total	₹ 1,84,10,000	₹ 1,84,10,000	0

The Governing Board (GB) has approved the reappropriated budget.

• Summary of approvals from the GB

1	Approval for previous MOM		Approved
2	Approval for reappropriated Budget in agenda points 1 to 3, 6 and 13	Annexure 6	Approved
3	Recommendation of International Visiting fellowship	Annexure 1	Approved
4	Recommendation of National Visiting fellowship	Annexure 2	Approved
5	International travel grant for faculty		Approved

This minute is released with the approval of the Chair.

S. Gopalakrishnan
(Prof S Gopalakrishnan)

(Convenor, Axis Bank Centre for Mathematics and Computing)

Third Governing Board Meeting - Axis Bank Centre for Mathematics and Computing (operational) – February 21st, 2024

Minutes of the Meeting

- **Members Present:**

1. **Prof G Rangarajan, Director**, IISc and Chair
2. **Prof Navakanta Bhat**, Dean, Interdisciplinary sciences, Member (Online participation)
3. **Mr Subrat Mohanty**, Executive Director, Axis Bank, Member (Online participation)
4. **Mr Neeraj Gambir**, Group Executive, Treasury, Markets and Wholesale banking Products, Axis Bank, Member (online participation)
5. **Prof S Gopalakrishnan**, Professor, Department of Aerospace, IISc, Convener
6. **Prof Kaushal Verma**, Chair, Office of Communication, IISc, Member
7. **Prof Srikanth Iyer, Associate Dean**, UG (B Tech), Member (online participation)

- **Introductory remarks:**

- The members were welcomed by the Chair, Prof G Rangarajan and the Convener, Prof S Gopalakrishnan.
- A copy of the draft Annual Report 2023-24 was shared with all the members.
- The minute of meeting of the second Governing Board held on August 21st 2023 meeting was placed and accepted.
- The following agenda items were presented by Prof S Gopalakrishnan.

- **Discussion of Agenda items:**

1. **Annual report:** A draft of the annual report consisting of activities pertaining to the operational part was shared with all the members. The summary of the report presented in the meeting is listed below.

- **Axis Bank Fellowships and Internships**

1. **Post-Doctoral fellowship:** 16 applications were received as a response to the announcement sent to all IITs, NITs and IISERs. 5 candidates were selected by the SAB and approved by the GB. All the five accepted the offer and reported to duty. The terms and conditions are the same as Raman and IOE fellowship. They are receiving monthly fellowship of Rs 1,00,000/= and annual contingency grant of Rs 4,00,000/=. The reports shared by all the post-docs are included in the annual report. The post-docs have published 4 papers and attended 4 conferences.
2. **Axis Bank PhD fellowship:** The PhD fellowship is provided to women and underprivileged categories of IISc Mathematics Initiative (IMI). The fellowship was awarded to 10 students representing different departments working in the field of mathematics and computing. A monthly top-up fellowship of Rs 35,000/= and annual contingency grant of Rs 2,00,000/= was provided. There are 5 women, 3 men belonging to OBC (NCL), 1 EBC and 1 SC category. The PhDs have published 5 papers and attended 13 conferences.
3. **Axis Bank M Tech fellowship:** The M Tech fellowship is provided to M Tech students belonging to women and underprivileged categories of IISc. The fellowship was awarded to 12 students representing different departments. A monthly fellowship of Rs 21,000/= and a one-time laptop grant of Rs 1,20,000/= was provided. There are 5 women, 2 men belonging to OBC (NCL), 2 SC and 3 EWS category.
4. **Axis Bank B Tech Internships:** The Axis Bank centre has signed an MOU with The Academy Trust under the aegis of Indian Academic of Sciences to support the summer Internship programme for B Tech students.

- The Academy Trust selected 21 students as Axis Bank Interns with a monthly stipend of Rs 12,500/= each for 2 months.
- The interns worked in IISc with IISc faculty as their mentors.
- A total sum of Rs 6.75 lakhs per year has been transferred to the Academy trust for providing internship, accommodation, and travel expenses to students. This also include the administration expenses.

- Axis Bank Visiting Professors / B Tech Instructors and Research staff:

The following two visiting professors were selected from the nominations received from the faculties of IISc.

1. **Prof. Siv SivLoganathan, Chair, Applied Maths, Department, Univ. Waterloo:** Professor is currently on the campus teaching a course on Oncology Computation in the Centre for Biosystems Science and Engineering. He is working with Prof Mohit Kumar Jolly of the same centre. A Colloquium will be held on March 30th 2024 on the topic "A Mathematical Odyssey: From Brain Biomechanics to Cancer Therapeutics.

   The return air ticket was booked from the ABCM and Prof Siv SivLoganathan will be receiving a remuneration of Rs 3 lakhs. He will be provided with an accommodation in the Institute guest house for three months of his stay. The total expenditure will not exceed the amount allotted under International Visiting Professor budget head.

2. **Prof Dr. Nagendra Somnath, Independent Consultant & Researcher and formerly with Pratt & Whitney Engines:** Professor visited the Institute from 26th September to 26th October. He worked in the department of Interdisciplinary Centre of Energy Research, with Prof Pramod Kumar. Ha had engaged with the research group working with Prof Gopalakrishnan, Prof Jagadeesh and Prof S Rao from Department of Aerospace Engineering. He taught a course on Optimization and Computational search strategies with students working with Prof G K Ananthasuresh. He also gave lecture discussions on "Optimization of Engineered Systems". About 120 students registered for the lecture series.

   The professor was paid return air fare and a remuneration of 2.5 lakhs.

➤ **The following four B Tech Instructors** having been appointed during this financial year:

1. Dr. Manpreet Singh
2. Dr. Devnath Shah
3. Mr. Sesha Kumar Nalluri
4. Dr. Srikanth Pai

There are getting salaries from the Axis Bank Centre for Mathematics and Computing as per the budgetary allotment.

- **Courses, Trainings and Workshops:**

➤ **1:1 course on Communication:** This course is an elective course, hosted by the Office of Communication for the students of IISc in both semesters. Mr Rakesh Godhwani, Adjunct Faculty of Communication, IIM(B) and Udaipur is the course instructor. In the first edition 82 students participated and the second edition is going on presently. Axis Bank Center is supporting the course financially with an amount of Rs 5 lakhs per course (total of Rs 10 lakhs).

➤ **Symposium on Big data Algorithms for Biology -2023** was held on June 2nd and 3rd. Prof Chirag Jain and Debnath Pal from IISc and Dr Sanchit Misra from Intel labs organised the event from the financial support of Axis Bank Centre for Mathematics and Computing. The amount spent is Rs 5.96 lakhs. About 112 participants and 14 speakers from all over India participated in the Symposium.

➤ **Training Workshop on "Mathematics and Computing of Uncertainty Quantification In Model-Based Simulation For Risk-Informed Decision making"** was conducted on 14th and 15th December 2023. Dr Sankaran Mahadevan, John R Murray Sr. professor of Engineering from Vanderbilt University, Nashville was the Instructor. The workshop was organised by the Axis Bank Centre for Mathematics and Computing. A total amount of Rs 8.56 lakhs was spent. The workshop saw participation of about 150 students from IISc and about 25 from the research labs such as DRDO, ADE and NAL.

➤ **Travel Grant:** The grant covers the travel and registration expenses for faculty presenting papers at International Conferences. Center received 10 application and Eight faculty members were selected to avail the grants. Rs 14.25 lakhs has been budgeted for this purpose.

- **Research Project Grant, Purchase of Software and Outreach programme:**

➤ **Axis Bank Project Grant:** Two project proposals from the following faculty members were selected from 16 applicants.

- **Prof Sumantra Sarkar**, Assistant professor, Department of Physics, IISc: Work involved two different problems on molecular communication with relays and first passage problems in crowded media. The funds were utilized in buying Computer, iPad and computer accessories such as GPU and storage cards. Part of the fund is also utilized for travel and buying books. The work led to three publications One of which is published and other two under preparation.

- **Prof Bhagwati Prasad**, Department of Material Engineering, IISc: Work involves All in one solution for the development of high-speed energy-efficient memory systems. A detailed report on the work done will be submitted by the end of February.

➤ **Outreach programmes:** There are two outreach programmes.

1. **Two days' workshop on "Let Us C++** conducted by Prof Ramsaran from department of Mechanical Engineering, IISc on July 22nd and 23rd at Skill Development Centre, IISc, Kudhapura, Challakere. It was a programming course for beginners to familiarize themselves with Python, Fortran, C++ and software like MATLAB. 50 students participated in the outreach programme.

2. **Workshop on Applied mathematics and Related Computations** will be conducted from March 11th to March 20th, 2024. This will also be conducted in Talent Development Centre, IISc, Kudhapura, Challakere. The workshop is targeted for students of BSc and MSc to give a head start in mathematics and Computing. About 60 students are expected to participate. Food and accommodation will be provided for participants. The expense for the workshop is estimated to be 7.2 lakhs. It was decided in the 2nd GB meeting that if funds are available one more outreach programme can be organised. This workshop has been planned based on this suggestion. Members of GB approved the proposal.

➤ **Purchase of Software:**

1. **SCAD-DIC-MFEM software module:** Digital Image Correlation is an effective non-contact displacement and strain measurement technique. The measured field data can be analysed to gain a deeper understanding of structural dynamics via interface modules to Finite Element Solvers and MATLAB SCAD-DIC software has been installed at LHSR to evaluate 3D-DIC deformations from high-speed imaging The cost of the software is: Rs 7.96 lakhs.

2. **Maple Software:** It Integrates a robust math engine with a user-friendly interface designed for effortless analysis, exploration, visualization, and problem-solving. Its functionalities tailored for educational, research, and commercial purposes. It has flexibility and efficiency in coding for mathematical operations. It is successfully Installed on the server of Supercomputer Education and Research Centre (SERC). The cost of Campus unlimited license is Rs 10.62 lakhs.

● **Utilization of Funds (Operational expenses):** The expenditure under different items as shown below was presented to the GB.

1. The budget for Postdoc fellowship could not be utilized completely since appointment got delayed by 4 months due to funds being received only in the month of June.

2. The budget for 4 B Tech Instructor and 2 TAs is not utilized completely. One Instructor was appointed only in August. 2 TAs were not appointed.

3. Travel grants were not completely utilized.

4. To utilize the unspent amount of about Rs 26.67 lakhs, talks are going on with the Dean (UG) to utilize for B Tech expenditure. Reappropriation will be necessary as per the requirement. GB has given approval for the reappropriation to utilize the amount to the extent possible.

● **Operational Budget for 2024-25:** The budget 2024-25 was presented to the GB. Some of the changes were made compared to the one given in the MOU. These changes are made in accordance with experience of the previous year's spending.

1. The B Tech Instructor salaries will be moved to Kotak Mahindra AI ML center. This will provide an additional surplus of Rs 48.6 lakhs.

2. There is not much demand for the purchase of software from the B Tech programme and hence removed the allocation completely.

3. Increase the number of Postdocs from 5 to 6 in comparison with previous FY. The actual increase in comparison with MOU is from 3 to 6.

4. Increase the number of PhDs from 10 to 12 in comparison with previous FY. The actual increase in comparison with MOU is from 6 to 12.

5. Overall operational expenses remain same.

The GB has given approval for the budget.

Utilization of Funds 2023-24						
No.	**Items**	**Revised budget FY 2023-24**	**Amount Spent up to 8th Feb**	**To be spent till 31st March**	**Total amount**	**Difference**
A	**Fellowships & Internships**	**₹15,967,000**	**₹12,199,761.00**	**₹2,954,000.00**	**₹15,153,761.00**	**₹813,239.00**
A.1	Axis Bank Postdoctoral fellowships	₹ 4,000,000	₹2,132,258.00	₹1,000,000.00	₹3,132,258.00	₹867,742.00
A.2	Axis Bank PhD fellowships	₹ 5,500,000	₹4,376,327.00	₹1,050,000.00	₹5,426,327.00	₹73,673.00
A.3	Axis Bank M.Tech fellowships	₹ 3,792,000	₹3,141,903.00	₹504,000.00	₹3,645,903.00	₹146,097.00
A.4	Axis Bank Internships	₹ 675,000	₹675,000.00	₹0.00	₹675,000.00	₹0.00
A.5	Contingency amount for Postdoctoral fellowships	₹ 2,000,000	₹1,874,273.00	₹400,000.00	₹2,274,273.00	-₹274,273.00
B	**Professors, Instructors and Research staffs**	**₹6,549,680**	**₹3,759,135.00**	**₹1,170,132.00**	**₹4,929,267.00**	**₹1,620,413.00**
B.1	International Chair Visiting Professors - Honorarium	₹ 300,000		₹300,000.00	₹300,000.00	₹0.00
B.2	International Chair Visiting Professors - Travel	₹ 500,000	₹148,181.00	₹100,000.00	₹248,181.00	₹251,819.00
B.3	Visting Professors - Honorarium	₹ 250,000	₹250,000.00	₹0.00	₹250,000.00	₹0.00
B.4	Visting Professors - Travel	₹ 200,000	₹113,378.00	₹0.00	₹113,378.00	₹86,622.00
B.5	B.Tech Instructors	₹ 3,511,680	₹2,138,250.00	₹556,800.00	₹2,695,050.00	₹816,630.00
	Teaching Assistant	₹ 508,000	₹0.00	₹0.00	₹0.00	₹508,000.00
B.6	Support Staff - Senior Project Associate	₹ 640,000	₹554,663.00	₹106,666.00	₹661,329.00	-₹21,329.00
B.7	Support Staff - Office Executive	₹ 640,000	₹554,663.00	₹106,666.00	₹661,329.00	-₹21,329.00
C	**Courses, trainings and workshops**	**₹4,200,873**	**₹2,993,496.00**	**₹700,000.00**	**₹3,693,496.00**	**₹507,377.00**
C.1	Preworkshop training schools	₹ 1,000,000	₹855,562.00	₹0.00	₹855,562.00	₹144,438.00
C.2	Workshops	₹ 595,873	₹595,873.00	₹0.00	₹595,873.00	₹0.00
C.3	Communication skills courses	₹ 1,000,000	₹448,400.00	₹500,000.00	₹948,400.00	₹51,600.00
C.4	Travel expenses for presenting papers	₹ 1,425,000	₹913,661.00	₹200,000.00	₹1,113,661.00	₹311,339.00
	C++ workshop	₹ 180,000	₹180,000.00	₹0.00	₹180,000.00	0

Utilization of Funds 2023-24						
No.	**Items**	**Revised budget FY 2023-24**	**Amount Spent up to 8th Feb**	**Expenditure for next 2 months**	**Total amount**	**Difference**
D	**Other operational expenses**	**₹5,007,448**	**₹2,469,199.19**	**₹2,829,070.00**	**₹5,298,269.19**	**-₹290,821.19**
D.1	Research project grant for operational costs	₹ 2,000,000	₹1,156,930.00	₹843,070.00	₹2,000,000.00	₹0.00
D.2	Mathematical software and soft-ware tools purchase/ subscription (Mathematica, Maple, etc.)	₹ 917,127	₹1,312,269.19	₹1,986,000.00	₹3,298,269.19	-₹290,821.19
D.3	Consumables, equipment, cloud services, outreach and contingencies	₹ 2,090,321	₹0.00	₹0.00	₹0.00	
	Subtotal (A+B+C+D)	₹ 31,725,001	₹21,421,591.19	₹7,653,202.00	₹29,074,793.19	₹2,650,207.81
E	**Program management expenses (5%)**	**₹1,586,250**	**₹1,568,779**	**₹0**	**₹1,568,779**	**₹0**
	Total (FY wise)	₹33,311,251	₹22,990,370	₹7,653,202	₹30,643,572	₹2,667,679

The complete budget for 2024-25 is given in Annexure 1. The summary of the budget is given below.

Operational Budget 2024-25			
	Items	**Overall budget FY 2024-25 (₹) (MOU)**	**Revised budget FY 2024-25 (₹)**
A	Fellowships & Internships	₹1,38,45,000	₹2,05,39,000
B	Professors, Instructors and Research staffs	₹73,90,000	₹25,29,992
C	Courses, trainings and workshops	₹42,50,000	₹42,50,000
D	Other operational expenses	₹52,90,000	₹34,56,008
	Subtotal (A+B+C+D)	₹3,07,75,000	₹3,07,75,000
E	Program management expenses (5%)	₹15,38,750	₹15,38,750
	Total (FY wise)	₹3,23,13,750	₹3,23,13,750

- **Proposal for workshops :** There are two proposals for conducting the workshops. They were presented to the GB for approval. The detailed proposal is given in Annexure 2 and 3.

➤ **Symposium on Big Data Algorithms for Biology (BDBIO) - 2024 (May 31-June 1, 2024):** This in continuation of the previous year successfully completed symposium. This time the number of participants is increased to 200 with additional International speakers. The topics to be covered are given below.

1. Molecular sequence analysis
2. RNA sequencing analysis, including single-cell
3. Comparative and population genomics
4. Cancer and infectious diseases
5. Computational systems biology
6. Biological networks
7. Metagenomics
8. Computational proteomics, metabolomics and pharmacogenomics
9. Multi-omics data integration

Convenors will be Prof Chirag Jain (IISc) Dr. Debnath Pal (IISc) and Dr. Sanchit Misra (Intel Labs). The Budget requested is Rs 10 lakhs. GB has given the approval.

➤ **Workshop on Mathematical Modelling and Optimization (December 16-18, 2024):** This will be the sequel to the Workshop on Uncertainty Computation conducted last year. This time there be more topics and speakers. The topics and speakers are listed below. About 300 participants are expected to attend and will be organised in J N Tata Auditorium. The budget required is Rs 10 lakhs. **GB has given the approval**.

Themes of the workshop	Speakers
Topology optimization	Prof. Ole Sigmund, Denmark Technical University (Topology optimization)
Uncertainly modelling	Prof. Sankaran Mahadevan, Vanderbilt University (Modelling uncertainty)
Evolutionary computing	Prof. Kalyanmoy Deb, Michigan State University (Evolutional computation)
AI-ML in engineering, and	Prof. Sanghamitra Bandyopadhyay, Indian Statistical Institute (AI-ML, soft evolutionary compting)
Multidisciplinary and Multiphysics computation.	Prof. Prabhat Hajela, Rensselaer Polytechnic Institute (MDAO)

- **Summary of approvals from the GB:**

1	Approval for previous MOM		Approved
2	Utilization of operational funds as given in item 2		Approved
3	Budget for 2024-25	Annexure 1	Approved
4	Proposed Workshops given in item 4	Annexure 2 and 3	Approved
5	Request for advance funds	Annexure 4	Approved

The above minutes of the meeting are sent to all the members by email and their approval taken.

This minute is released with the approval of the Chair.

(Prof S Gopalakrishnan)

(Convenor, Axis Bank Centre for Mathematics and Computing)

Annexure 2

Reports submitted by fellowship awardees

Axis Bank Postdoctoral Fellowships

A total of seventeen applications were received from all over the country. Five candidates were selected based on their CVs, publication history, and reference letters. The fellowship amount is ₹1,00,000 per month. The five candidates selected have reported and started work in their respective departments. Contingency grants of ₹4,00,000 have been provided to each candidate. The report of work done the post-doctoral scholars are provided below.

1) Dr Priyam Chakraborty: Microswimmers propel themselves in the ambient fluid. Background flow, self-propulsion speed, orientation and swimmer-type dictate their paths in the suspending medium. Their study has gained significant interest in recent years due to the relevance in various fields, including biomedicine, microfluidics and soft robotics. The present study evaluates the contribution of certain parameters, such as swimming morphology, fluid rheology and environmental conditions, on microswimmer navigation in pulsatile flows. In particular, the study intends to unravel stable positions and orientations which may inherently guide the swimmers. The study further aims to leverage GPU-accelerated computing to enhance the efficiency and accuracy of simulating the motion of swimmers using multi-particle collision dynamics. The algorithm will be implemented on CUDA-capable GPUs towards an efficient parallel implementation of the computational model.

Conferences/workshops attended: Interfacial Engineering at Multiple Spatio-Temporal Scales, 2024, IISc

2) Dr Swati Rani Hait: The first objective is to propose some framework of relationship handling aggregation operators. Aggregation operators are mathematical functions most widely utilized for information fusion in vivid decision-making systems. The relationship handling aggregation operators are of great importance in the task of information accumulation as it enables to capture the intrinsic relationship among the inputs or features.

The next objective is to focus on the application of those relationship handling aggregation operators in the process of information fusion for vivid decision-making system. One of the decision-making systems where we are working is in the domain of epidemic modelling. More precisely, we are working on the modelling of dengue epidemic for Karnataka state. The aim is to predicts disease spread, informing prevention strategies through mathematical analysis of transmission dynamics and population and climatic factors.

List of publications (In progress): Directed graph based fusion functions to model non-symmetric input interactions.

3) Dr Sudarshan Santra: Fractional calculus is an advanced extension of conventional calculus. It stands as a significant milestone in mathematical analysis, substantially impacting a wide range of scientific and engineering fields. This mathematical field extends the concept of derivatives and integrals to non-integer orders, providing a refined and extensive framework for capturing the essence of complex, non-linear, and memory-influenced behaviours. See more details in [1, 2]. In the past few decades, the analysis of delay integro-partial differential equations (DIPDEs) have become more popular in today's research community due to its immense application in modelling many phenomena in Biology, Medicine, Chemistry, Physics, Engineering, Economics, etc. For instance, see the work reported in [3, 4].

The mathematical expressions in fractional integro-differential equations are often more complicated and less intuitive, making analytical solutions extremely difficult or even impossible to find in most cases. The process will be more complicated if the model contains a delay parameter along with weakly singular kernel. Numerical methods provide a practical way to approximate solutions and understand the

behaviour of these equations. The methods include a several semianalytical methods, finite differences techniques, and finite element methods, etc. However, it's important to note that these methods have their limitations, such as difficulties in handling very irregular domains or extremely fine-scale features without significant computational resources for very large or complex problems. Wavelet-based numerical approximations provide a multi-resolution analysis framework, allowing for local refinement of the solution where needed. This is particularly useful for capturing local phenomena or singularities without the need to refine the mesh globally. Over the past few decades, there has been a significant transformation in the domain of numerical approximations due to the growing utilization of wavelet-based methodologies. These techniques have attracted considerable interest as a result of the remarkable precision with which they approximate values ina wide range of mathematical fields. This encompasses not only differential and integral equations but also integro-differential equations, as highlighted in [5, 6]. Moreover, the research is remarkably adaptable and can rapidly adjust the time domain and frequency domain in order to define the particulars of the problem. The characteristics of time-frequency positioning and multi-resolution [7] enhance the importance and utility of wavelet research. Additionally, wavelet-based numerical methods have the advantage of being able to manage functions that differ from one another by localized areas of abrupt transition [8, 9]. This property lets the local grid be fine-tuned to any size without greatly increasing the number of collocation points. Because of this, high-resolution calculations can only be done in places where the scales change quickly.

List of publications:

1. Santra, S., Mohapatra, J., Das, P., & Choudhuri, D. (2023). Higher order approximations for fractional order integro-parabolic partial differential equations on an adaptive mesh with error analysis. Computers and Mathematics with Applications, 150, 87-101. https://doi.org/10.1016/j.camwa.2023.09.008

Articles Communicated

2. Santra, S., & Behera, R. A novel higher-order numerical method for parabolic integro-fractional differential equations based on wavelets and $L2 - 1_\sigma$ scheme. https://doi.org/10.48550/arXiv.2304.08009
3. Santra, S., & Behera, R. Wavelet-based $L2 - 1_\sigma$ approach for time-fractional option pricing model under jump-diffusion.

Articles Under Preparation

4. Santra, S., & Behera, R. Simultaneous space-time Hermite wavelet framework for time-fractional nonlinear weakly singular integro-partial differential equations.

4) Dr Gaurav Kumar: Eukaryotic cells have evolved a highly organized sorting platform called endosomal networks to perform protein trafficking and their recycling within the cell. At various stages of vesicular transport, proteins are called upon in a highly coordinated manner to perform process. In this project, we are interested in understanding how integral transmembrane cargo proteins such as CI-MPR are sorted and trafficked out of endosomal membrane using sorting-nexin class of proteins.

Sorting Nexins(SNXs) proteins play a crucial role to regulate the intracellular trafficking of cargo proteins. These SNX proteins localize as large scaffolds on the endosomal membrane through the lipid binding interactions and tightly regulated protein-protein interactions. BAR domain of SNXs have hydrophobic and charged interactions and due to these interactions, only a limited number of homo and hetero dimers of SNXs are formed. In this project, we have focused on the SNXs heterodimers SNX1/SNX2 and SNX5/SNX6. Experimentally, it has been found that SNX5 and SNX6 dispersed more amount of CI-MPR than any other SNX proteins. This suggest that SNX5/6 plays a crucial role in endosome to TGN retrograde transport of CI-MPR. SNX5/6 forms a heterodimer with SNX1/2 and binds to transmembrane proteins to perform protein trafficking for endosomal protein recycling. We have developed an nematic-based model for this project and performed the Monte-Carlo simulations.

In this model, we have used an augmented Helfrich-based Hamiltonian. The protein coated membrane is represented as a nematic field adhering to a deformable fluid membrane surface. The local orientation of the nematic field is denoted by the unit vector $\hat{n}(r)$, which lies in the local tangent plane of the membrane and is free to rotate in this plane. Protein-membrane interactions are modelled as anisotropic spontaneous curvatures of the membrane, in the vicinity of the filament. Protein-protein interactions are modelled by the splay and bend terms of the Frank's free energy for nematic liquid crystals.

A key aspect of the nematic membrane model is its ability to induce the curvature even when the directional spontaneous curvatures are set to zero. We have already shown the cell membrane deformation due to one and multiple types of SNXs proteins. Now we have developed the current model to incorporate cargo-sorting features in the model so that we can study the SNX-heterodimer induced recognition, localization and trafficking of CI- MPRs proteins. This work will open doors for providing testable hypothesis for reconstition experiments related to trafficking processes in the endosomal network. We have completed the most of simulations. Currently, we are working on the other calculations and writing the paper.

Workshop/Conference: Mathematics and Computing of Uncertainty Quantification in Model-Based Simulation for Risk-Informed Decision Making.

5) Dr Shalini Saha: The investigation into dynamic-induced contact waves within viscoelastic solids is prompted by the necessity to comprehend the complexity of wave propagation when two bodies interact. The essence of this exploration lies in acknowledging the fundamental significance of dynamic contact-induced wave propagation, particularly in the design and analysis of mechanical components such as gears, bearings, and joints. The crucial factors of reliability and durability emphasize the significance of delving into the intricate complexities linked to the viscoelastic behavior of materials. Within the realm of structural dynamics, a crucial aspect is gaining a profound understanding of response of structures to dynamic loads. There is an essential need to delve into the vibrations and wave dynamics within materials, with a specific emphasis on the distinctive characteristics of viscoelastic solids. These materials, characterized by their simultaneous elasticity and viscosity, introduce complexities that significantly impact dynamic contact-induced wave propagation through it. The implications of this research extend to aerospace engineering, where waves generated during landings or collisions find substantial applications in ensuring structural integrity and safety in aircraft. Thus the present research work focuses on investigating the subtle aspects of contact dynamics, with a specific concentration on the waves and vibrations transmitted during interactions between bodies under dynamic loading conditions. The behavior of wave propagation induced by dynamic loads in microstructure introduces complexities at smaller scales and solving the inverse problems involves different approaches. Through the utilization of numerical simulations and computational methods, the primary goal is to predict and analyze the intricate behavior of structures under dynamic loading and contact conditions, considering the specific challenges posed by viscoelastic solids.

In structural dynamics, an imperative inverse problem revolves around identifying material properties within a structure. Dynamics-induced-contact waves utilize in identifying material properties viz. Young's modulus and damping ratios for cutting-edge high-performance materials.This intricate task involves deducing unknown system parameters through observed responses. Solving inverse problems employs optimization algorithms, iteratively adjusting parameters to minimize disparities between observed and predicted responses. Contact dynamics extends into non-destructive testing, offering insights into material properties without causing structural harm. Structural Health Monitoring (SHM) provides real-time assessments, identifies changes in material properties or emerging damages through dynamic response analysis. For next-generation high-performance materials with complex behaviors, contact dynamics offers an insights into their dynamic response under varying loading conditions. Integrating contact dynamics into multi-physics simulations enhances material property identification accuracy by considering the coupled effects of mechanical, thermal, and other factors. The spectral method is well suited for solving the partial differential equations governing the wave propagation phenomenon with specifically implementing the nature of the contact, the geometry of the solid, and the desired level of accuracy. It is a numerical technique that represents functions as a sum of basis functions with known coefficients in a transformed domain of frequency or wave number. Moreover, the machine learning models, such as neural networks or regression models, can be trained using both simulated data which provides accurate predictions.

Conferences / workshops attended:

(i) Two day short course on “Mathematics and computing of uncertainty quantification In model based simulation for risk informed decision making”, at IISC Bnagalore, 14th-15th December 2023.

(ii) Three-day short course on “Theory and Analysis of Laminated Composite and Functionally Graded Structures,” jointly organized by Ramaiah Institute of Technology & Ramaiah University of Applied Sciences, Bengaluru, Karnataka, 3rd-5th January 2024.

Axis Bank PhD Fellowships

SAB and GB in their last meeting approve 12 PhD students from Institute Mathematics Initiative (IMI) to be awarded a top-up fellowship of Rs 35,000/= per month. Out of this, 5 students have joined from the continuing batch of PhD students and 5 new students from the fresh batch (August 2023) of IMI programme.

1) Ms Soundharya R: Epithelial-Mesenchymal Transition (EMT) is a fundamental biological process that plays a crucial role in embryonic development, tissue repair, and the progression of various diseases, notably cancer. EMT involves a series of orchestrated molecular and cellular changes that transform epithelial cells into mesenchymal cells, imparting them with increased migratory and invasive capabilities. EMT is now seen as a spectrum, not just an epithelial or mesenchymal state, as previously described. This implies that tumor cells can show variability in their extent of undergoing EMT, giving rise to heterogeneity within a tumor. The phenotypic switching by cancer cells also helps it acquire other properties such as migration, immune evasion, resistance to therapy, etc.

To unravel the associations between EMT and other pathways driving cancer progression, a thorough meta-analysis of publicly available transcriptomic data was conducted. This exploration encompassed characterisation of deregulated metabolic pathways, immune evasion mechanisms, and lineage of cancer and their EMT status. Similar analysis was also carried out in single cell RNA sequencing data to accurately identify and study tumor cells, without stromal or immune cells affecting these trends. Their clinical benefits were also ascertained using survival analysis to check how simultaneously occurrence of some pathways are correlated with survival outcomes.

Publications:

• Characterizing heterogeneity along EMT and metabolic axes in colorectal cancer reveals underlying consensus molecular subtype-specific trends

Soundharya R#, Manas Sehgal#..., Mohit Kumar Jolly

• A systems-level analysis of the mutually antagonistic roles of RKIP and BACH1 in dynamics of cancer cell plasticity

Sai Shyam, Soundharya Ramu#, Manas Sehgal# and Mohit Kumar Jolly

• Multi-modal transcriptomic analysis unravels enrichment of hybrid epithelial/mesenchymal state and enhanced phenotypic heterogeneity in basal breast cancer.

Sarthak Sahoo, Soundharya Ramu… , Mohit Kumar Jolly

Conference / workshop attended:

• Poster presentation at IACR (The Indian Assocition for Cancer Research) 2024

• 10th Annual Symposium, BE 2024

2) Ms Vishali S: The diverse properties of Granular materials, or particulate materials rely heavily on how the particles are arranged (interparticle arrangement) and how they interact with each other. The pervasiveness of these particulate materials in construction, mining, pharmaceutical, manufacturing and food industries, underscores the importance of examining and analyzing them for the efficiency of these industrial processes.

My research initiative is to investigate a framework for understanding the intricate structure and packing dynamics of particulate matter of various shapes, forms and biochemical structures (different morphologies) using image analysis. This can be achieved by harnessing high-resolution tomography data and appropriately adopting principles of networks to comprehend the packing of these systems. Also, the recent advancements in imaging and image analysis have become invaluable assets to researchers seeking to understand the physical properties and the mechanical behaviour of these granular materials.

Topological Data Analysis (TDA) methods, built on solid mathematical foundations in Morse theory and algebraic topology, are crucial for analyzing and visualizing structural data in various fields. Additionally, it is noteworthy that the framework rooted in Morse theory yields a higher quality segmentation of a granular ensemble compared to previous methods. Furthermore, the framework supports efficient computation of various distribution statistics on the segmentation and the connectivity network between individual particles. Hence, our primary aim is to explore the development of TDA techniques for examining granular ensembles.

In the previous semester (Aug – Dec 2023), I have been dedicating myself to completing my course work, taking active part in my lab meetings and seminars and also learning about the ongoing work on this research topic.

Conferences/Workshops attended: Bangalore Vis Workshop 2023

3) Mr Subham Patel: In addition to the coursework, I have gone through a literature review on wavelet methods [1,2]. Wavelets are a class of functions used to localize a given function in both space and scaling. Wavelets play a crucial role in solving partial differential equations (PDEs) due to their efficient decomposition, localization, and compression capabilities. Unlike traditional sine and cosine functions used in Fourier analysis, which extend infinitely, wavelets are localized in both time and frequency. This localization property makes wavelets effective in capturing intricate details of PDE solutions. By providing sparse representations of functions and operators, wavelets facilitate efficient numerical solutions through nonlinear thresholding of coefficients. Moreover, wavelet analysis allows for estimating the local regularity of solutions, enhancing the understanding and accuracy of PDE solving processes, making them a versatile tool in computational mathematics.

The main objective of the research work is to develop efficient and computationally effective numerical techniques using wavelet and physics-informed neural networks to address the solution of the fractional order PDEs. I have implemented Haar and Hermite wavelets as computational tools for discretizing ordinary differential equation (ODE) (see Example 1) and 1-dimensional partial differential equation (PDE) (see Example 2). The solution process included decomposing the PDE solution into wavelet coefficients, creating a system of equations, and iteratively solving for accurate numerical results. The methods demonstrated computational effectiveness, especially in capturing intricate details and solution variations. The numerical solutions were validated against known analytical solutions and compared favorably with existing numerical methods. I've explored two examples: firstly, solving a second-order ordinary differential equation using the Haar wavelet method; and secondly, solving a time-fractional 1-dimesional partial differential equation using both Haar and Hermite wavelet methods. In both cases, I've calculated and noted the absolute error.

Conference /workshops attended:

• Workshop on Mathematics and Computing of Uncertainty Quantification in Model-Based Simulation for Risk-Informed Decision Making: Participated in the workshop on "Mathematics and Computing of Uncertainty Quantification in Model-Based Simulation for Risk-Informed Decision Making". Organized by the Axis Bank Centre for Mathematics and Computing, Indian Institute of Science, Bangalore on December 14-15, 2023.

• Workshop on Tensor Computation and Machine Learning (TCML): Participated in the workshop on "Tensor Computation and Machine Learning (TCML)". Organized by the Dept. of Computational and Data Sciences, Indian Institute of Science, Bangalore on November 17-18, 2023.

4) Mr Adarsh Jain: Uncertainty can arise in seismic exploration due to various factors, including model errors, numerical errors, and acquisition errors. In the realm of seismic exploration, specifically seismic imaging, quantifying these uncertainties is essential since numerous significant tasks, including selection of a site for exploration in the oil and gas industry, depend heavily on the results obtained from seismic imaging. If the uncertainty quantification (UQ) study is performed on seismic imaging techniques, it will enable the industry to make informed decisions. Full Waveform Inversion (FWI) is one of the prominent seismic imaging methods capable of providing high-resolution subsurface images and is extensively used within the oil and gas industry. FWI involves solving numerous wave equations, making it a computationally expensive process. Consequently, very little development in Uncertainty Quantification (UQ) has been done in the context of FWI.

Uncertainty Quantification is widely done using Ensemble learning and Bayesian approximation techniques. We plan to employ the method based on the Bayesian framework, specifically the Markov Chain Monte Carlo (MCMC) method, to investigate UQ in the context of full waveform inversion. Additionally, we are also exploring other UQ techniques to ensure a more robust assessment of uncertainties in full waveform inversion.

Conferences/Workshops attended:

National e-Conference on Recent Advances in Engineering, Technology & Applied Sciences–2023 (RAETAS-2023)

5) Mr Raghunandan S: The driving force behind the project is the concept of minimal surfaces, the surfaces with least surface area, particularly TPMS, triply periodic minimal surfaces which are the minimal surfaces periodic in three independent directions (need not always be in cartesian). The first objective is to parametrize a transition from two TPMS primitives that belong to the same class. In a computational point of view the resulting surfaces should be meshable so that we can perform CFD simulations

as well as for tessellations. Further Optimizing heat exchangers by using TPMS, while the optimal solution has multiple primitives that is where the process in first part of the project comes in (a smooth transition) to make the solution viable in some sense.

Conferences/Workshops attended:

National e-Conference on Recent Advances in Engineering, Technology & Applied Sciences–2023 (RAETAS-2023)

6) Mr Chigicherla Venkata Sai Prasanna: Using Cellular Potts model-based multiscale computational framework (Compucell3D) we studied a tumor core of two subsets of cells that were arranged to varying extents of spatial intermingling, which we quantified by a simple metric called Heterogeneity Index (HI). Our simulations show that for a given two intra-subset cell-cell adhesions for two subsets of cells, low and high inter-subset cell adhesion favors migration of high HI and low HI intermingled populations, respectively. In addition, for the most explored values of cell-ECM adhesion strengths, populations with high HI values collectively migrate better than those with lower HI values. We then studied how spatial migration is regulated by progressively intermingled cellular subsets that were epithelial, i.e., showed high cell-cell but poor cell-ECM adhesion, and mesenchymal, i.e., with reversed adhesion strengths to the former. Here too, inter-subset adhesion plays an important role in contextualizing the proportionate relationship between HI and migration. We also observe an exception to this relationship for cases of heterogeneous cell-ECM adhesion where sub-maximal HI patterns with higher outer localization of cell with stronger ECM adhesion collectively migrate better than their relatively higher HI counterparts. Our simulations also reveal how adhesion heterogeneity qualifies migrative dynamics through collective cellular unjamming, when either cell-cell or -ECM adhesion type is varied but incorporates dispersion when both adhesion types are simultaneously altered.

Publication:

Spatial heterogeneity in tumor adhesion qualifies collective cell migration.

[Submitted and under review in The Biophysical Journal, expecting to be published in February 2024.]

Conferences/Workshops attended:

Some part of annual contingency fund has been utilized to attend the conference 'Simulating tissue dynamics with Cellular Potts models' at Lorentz centre, Oort of Leiden University in The Netherlands from 18 – 22 December 2023. Below are the details of other conferences that I have attended in 2023.

• Big Data Algorithms for Biology (BDBIO) at Computational and Data Sciences department in IISc.(poster presentation) – June 2 and 3 2023

• Modelling and Tackling Complex Biological Systems at IMSc, Chennai (Poster presentation) – October 13th and 14th 2023

• Simulating tissue dynamics with Cellular Potts models at Lorentz centre in The Netherlands (Flash talk and poster presentation)

7) Ms Sneha V: The immune mechanisms that provide the first line of defence in the body come under the broad term innate immunity. The primary manifestation of innate immunity is inflammation, which at the molecular level involves multiple cell signalling pathways comprising various types of reactions among biomolecules, especially proteins. In many pathways, the activity of these innate immune proteins is regulated by small molecules (ATP, cAMP, SAM etc.). These molecules do not just show a one-to-one association in binding the proteins, but one-to-many associations. To understand the small molecule regulation of innate immune response, a multi-level view encompassing the systems-level breadth and the structural-level depth is necessary, as there is a tight regulation of events by the same small molecule across different pathways or along the same pathway at different points of time. This work uses a structural-systems approach to identify proteins of innate immune function in humans that can potentially bind and get regulated by these small molecules. To start with, we used the dataset of proteins binding to the small molecule cAMP to derive a structural cAMP binding motif, utilising bioinformatic and computational tools and use it to screen for the cAMP binding activity in a repertoire of innate immune proteins.

Publication:

1. Sankar, S., Vasudevan, S., & Chandra, N. (2024). CRD: A de novo design algorithm for the prediction of cognate protein receptors for small molecule ligands. Structure (London, England : 1993), S0969-2126(23)00450-1. Advance online publication. https://doi.org/10.1016/j.str.2023.12.009

Conferences/Workshops attended:

Conference on "Macromolecular Assemblies: Structure, Function, and Evolution" and Workshop on "Integrative Modelling Platform" at IISER Pune from 2nd to 4th August 2023

8) Ms Heeba Anjum: The grass family (Poaceae) is a diverse group of flowering stem/inflorescence architectures, including major cereal crops like rice, wheat, maize, and barley. Inflorescences in grass species, including cereals, vary in the number of branches and florets in a spikelet. The combinatorial action of ABCDE group of transcription regulators model is widely accepted to determine the identity of floral organs and their whorled arrangement in meristems.

Our laboratory aims to unravel the genetic regulators that govern developmental transitions and their specificity to particular developmental pools. This work aims to understand the splicing patterns of genes associated with multiple isoforms and identify specific genes involved in the developmental transition. Integrating these studies with nucleoproteome data will provide valuable insights into the regulatory landscape governing developmental transitions at the protein level.

Hence by using rice as a model organism, this multi-omics approach will improve our understanding of genes undergoing alternative splicing playing a critical role in complex gene regulation, genes driving the developmental transition, genes unique to particular developmental pools, transcript-protein relation of those genes and genes which are under post transcriptional and post-translational regulation etc.

Conferences/Workshops attended:

- Attended an international conference titled "Biological Transactions: From Molecules to Organisms" from the 17th to the 20th of January, 2023.
- Attended the 20th International Symposium on Rice Functional Genomics (ISRFG 2023), which was held on 03 - 05 November 2023.

9) Ms Aswini.V.J: The Symmetric Autoencoder (SymAE), is a recently developed deep-learning approach that extracts earthquake information from far-field seismic waves in an unsupervised manner. SymAE exploits the concept of approximate symmetry, where the source information is invariant with respect to receiver permutations within a group of closely spaced receivers due to the scale separation principle. It also uses stochastic regularization, a key component that prevents overfitting and helps enhance the accuracy and dependability of analysis, to disentangle source and path information to construct virtual seismograms from the measured displacement field. The training of SymAE enables the generation of virtual seismograms by the method of redatuming to incorporate subsurface scattering effects from other seismograms.

We have performed time reversal of SymAE-generated virtual seismograms and it outperforms the traditional back-projection by producing consistent images across different receiver arrays despite the uncertainties in travel times. The approach is observed to be effective in producing reliable source images through time reversal, demonstrating the effectiveness of using these virtual seismograms with uniform path effects. The key advantage is that it eliminates the requirement of empirical time calibration, and has the potential to provide good extraction of rupture directivity information, particularly for deep and intermediate-depth earthquakes with limited near-field observations. Additionally, this method of time reversal using virtual seismograms has enhanced the understanding of complex earthquake sources, including their stopping phases, and offers a means for conducting uncertainty analysis when extracting source information.

We are aiming to improve the precision of the source image by avoiding outliers using the Least Absolute Shrinkage and Selection Operator in time reversal of the SymAE-generated virtual Seismograms.

10) Mr Ankan Biswas: The electrophysiological signal recorded from the brain shows rhythmic activity (oscillations) at different frequencies. One such rhythm, called gamma (~30-80 Hz), is modulated by high-level cognitive processes such as attention memory, and meditation and therefore could provide clues about mechanisms underlying high-level cognition. Interestingly, gamma oscillations can also be "induced" in the brain by presenting certain stimuli such as bars, gratings, and color patches (especially red hues), and the gamma power and frequency depend on stimulus features such as size, contrast, orientation, and spatial frequency. Moreover, these stimulus-induced gamma oscillations weaken with age and the onset of Alzheimer's Disease. While many meditation studies have observed changes in endogenous (stimulus-free") gamma with meditation, no study to date has tested if stimulus-induced gamma oscillations are also modulated by meditation. The main aim of my thesis is therefore to (i) find suitable "gamma-inducing" stimuli in humans and (ii) study the effect of meditation on these stimulus-induced gamma oscillations. Our preliminary analysis shows that meditators have more stimulus-induced gamma than the age and gender-matched controls.

Axis Bank M Tech Fellowships

M tech Fellowship was increased from 3 to 12. 5 students are from continuing batch and will get fellowship from April 1st 2023 to march 31st 2024. 7 students will get fellowship from August 2023 to March 2024.

The report of the research work done during this period is given below.

1) Gayathri Venkat: Optical Coherence Tomography (OCT) is a non- invasive imaging technique that is used to image tissues such as retina. An OCT image is produced by capturing the dim red reflected light from the retina and optic nerve of the eye. These OCT images can be used for identifying IRF, SRF and PED pathologies.

In India, there is a dire shortage of medical professionals, with only 0.08 doctors per 1000 people. This shortage has been exacerbated during the COVID-19 pandemic, as patients have died due to lack of timely diagnosis. To mitigate the problem, there is a need for the development of automatic screening tools for medical images such as CT scans, X-rays, and electronic health records, which can aid in prompt and accurate treatment of patients.

Hence segmentation models and classification models are required to accurately identify the region of diseases and classify the images to the corresponding disease. Segmentation with three different models were experimented mainly, Recurrent Residual Convolutional Neural Network based on U-Net (R2U-Net), Attention Residual Recurrent Convolutional Neural Network based on U-Net (R2AU-Net) and Shifted Window Transformer based Unet (Swin-Unet). With Swin-Unet, very good Intersection Over Union (IoU) and Dice scores were obtained for all the three diseases.

Apart from segmentation, Segmentation guided Classification of the three diseases was also performed. The first one being the segmented model output being fed to the Small-Inception Resnet V2 classification model. In the second method, segmented model output was used to enhance the features in the classification model in only the lesion areas. In the third method, new loss was added to the existing loss of the model. All these are explained in detail in the subsequent sections. Very good accuracy, precision, recall and f1-scores for all the three diseases was obtained using the second method.

Publications:

1. Submitted to IEEE International conference on Image Processing (ICIP) 2024.

2) Tushar Dilip Kurne: My research is focused on developing a sophisticated approach for satisfying spatio-temporal and logic-based specifications in cyber-physical systems, with a particular emphasis on path planning for robotic systems exhibiting unknown dynamics in generalized environments. This approach is methodically structured into three primary stages:

Learning Motion Primitives: In this initial stage, the objective is to learn fundamental motion primitives for robots with unknown dynamics using reinforcement learning, specifically Proximal Policy Optimization (PPO). The goal is to develop environment-independent policies that can construct complex paths from these primitives.

Reachability Estimation: Building upon the learned motion primitives, this phase involves generalizing the motion capabilities like moving forward a certain distance at a specific speed. Gaussian Process-based regression is employed to develop a supervised learning model that maps variables such as distance and time, providing a continuous and adaptable reachability estimation.

Sampling-Based Path Planning: The final step integrates the policies for motion primitive execution with the reachability estimates to construct a comprehensive path planning strategy. We formulate a cost function that considers the robustness of Signal Temporal Logic (STL) expressions. This function is then applied to guide and prune a Rapidly-exploring Random Tree (RRT), resulting in an optimized path that adheres to all specified spatio-temporal and logical constraints.

This layered approach, encompassing both machine learning and algorithmic path planning techniques, represents a novel contribution to the field of autonomous robotics, particularly in the realm of cyber-physical systems with intricate operational requirements."

3) Suvendu Kar: PDEs such as the 1D heat equation can be solved by Physics-Informed Neural Nets (PINNs). PINNs combine physics-based constraints (the PDE itself) with data-driven machine learning to approximate the solution to the PDE.Our aim is to solve PDEs smoothly and effectively using Dynamic

Activation Functions. DY-ReLU is one such dynamic activation function. Dynamic ReLU (DY-ReLU), a dynamic rectifier of which parameters are generated by a hyper function over all input elements. The key insight is that DY-ReLU encodes the global context into the hyper function, and adapts the piecewise linear activation function accordingly. Compared to its static counterpart, DY-ReLU has negligible extra computational cost, but significantly more representation capability, especially for light-weight neural networks. To give an example, simply using DY-ReLU for MobileNetV2, the top-1 accuracy on ImageNet classification is boosted from 72.0% to 76.2% with only 5% additional FLOPs.

I am a first-year MTech student and started a literature review on the above research topic. I attended few departmental seminar, workshops and to name a few "Solving PDEs with Neural Operators" by Dr. Siddhartha Mishra(ETH Zurich), Workshop on Tensor Computation and Machine Learning, Nov. 17-18,2023.

4) Shreyashri Sarkar: Turbulence constitutes a non-linear, high- dimensional non-conservative complex dynamical system that exhibits intermittent fluctuations at different scales of motion. Intermittency in turbulence has been characterized by higher order moments of velocity gradients (small scale intermittency) and velocity increments (large scale intermittency). In this research work, data driven tools rooted in information theory is used as an improved measure of intermittency in direct numerical simulation data of homogenous isotropic turbulent flow and turbulent channel flows. Specifically, measures such as Shannon entropy and Kullback-Leibler (KL) divergence, which are functions of the complete probability distribution rather than a few selected moments, are used to quantify turbulence intermittency. Overall, this study will derive an improved understanding of turbulence intermittency and its accurate scaling properties.

Conferences/ Workshops attended: ANSYS Workshop by AERES' 24

5) Pawar Rushikesh Gajanansa: Material modelling and discovery often involves finding molecular spatial structure with lowest energy, for crystal structure prediction. Traditional approaches use principles like Density Functional Theory (DFT). Such physics-based method requires solving complex optimization problems through iterative processes, each iteration involving computation of eigenvalue-eigenfunction pairs, and hence these calculations are notoriously resource-intensive and often lead to bottlenecks in computational power and memory usage.

To address these challenges, researchers have turned to Machine Learning and particularly Graph Neural Networks (GNNs). These innovative approaches have demonstrated potential of offering accuracy comparable to traditional DFT methods while significantly accelerating the inference process post-training. Two key ingredients needed for this analysis are energy and force components at each atom. However, GNNs which predict forces with high accuracy, also have the downside of being extremely expensive in training. The aim of this project is to explore techniques to make these models lightweight, without compromising on the prediction accuracy.

4.4 Axis Bank B Tech Internships:

Axis Bank B. Tech internship: It was decided in the SAB meeting that the B. Tech internship should be awarded to students from Institutions outside IISc. Prof Prabal Maiti suggested that B. Tech students can be selected from the pool of Indian Academic summer fellowships. We have discussed with Executive Secretary of Indian Academy of Sciences, and they have in principle agreed to have a tie up our centre in allotting about 20 internships to work in IISc. The MOU is signed based on the following conditions.

- The Academy Trust will select about 15 to 20 students as Axis Bank Interns with a monthly stipend of Rs 12,500/= each for 2.7 months.
- The selected students getting Axis Bank Centre internship must work in IISc with IISc faculty as their mentors. The allotment of students to professors at IISc will be done by the Academy trust.
- A total sum of Rs 6.75 lakhs per year will be transferred to the Academy trust for providing internship, accommodation, and travel expenses to students. This can also include the administration expenses.
- The Axis Bank Centre should get enough visibility during the time of announcement of application, selection, awarding of internship and in certificate. The academy trust should send list of students selected under the Axis Bank internship.
- The Academy trust should send the detailed report of the project undertaken by the students.

21 students from all over India have participated in the programme and they all worked under the supervision of faculty of IISc.

Annexure 3 Reports submitted by Prof Nagendra Somanath

SEPT 26 – OCT 27 2023

The visiting professor position at the Axis Bank Centre for Mathematics and Computing was a very fruitful experience that enabled several key activities identified as under:

1. Engagement with active researchers at the Indian Institute of Science.
2. Engagement and active discussions with Professors at Aerospace and Mechanical Engineering.
3. Teaching with optimization and computational search strategies for students of ME260.
4. Lecture Discussions on "Optimization of Engineered Systems" with students.

The month-long visiting professorship with the Centre of Mathematics and Computing was an excellent opportunity to understand and contribute to the excellent work being done at the Indian Institute of Science.

Engagement with IISc Researchers:

- Working with Prof Gopalakrishnan, Aerospace Department, IISc, and his students, excellent work in spectral elements and its applications to acoustic waves, constitutive material modelling of advanced texture control and design of materials for noise and shock absorption were discussed. Opportunities for applying design optimization for tailored material and structural design was identified as portions for future work.
- Discussions on application of optimization and design approaches for hypersonic vehicles at the Centre of Hypersonic at the Aerospace Department was fruitful in identifying collaborative areas of work with Prof G. Jagadeesh and Prof. S. Rao and their team. Excellent potential for weight reduction by structural tailoring and applying optimization techniques for shock management, external shape as well as internal layout were identified. Excellent potential for applications of machine learning and deep learning approaches exist to enable future hypersonic vehicle design.
- Working with Prof Pramod Kumar, at the Interdisciplinary Centre, of Energy Research, IISc has been very good. His team of research associates and students are developing core technology for next generation sCO2 thermal systems. Students are extremely motivated and are well trained in developing computational models and validate the simulations with hardware designed to specifications. Students are engaged in developing high speed computational turbomachinery technology, bearing technology and simulation of sCO2 machines from first principles. Translating heat exchanger technology into critical applications and ensuring technology to mature to achieve key performance metrics of heat exchangers using optimization and validating using test (eg diffusion bonding panels, leak testing bonded panels etc) is an avenue that is being explored. Excellent fundamental approach to design, analyze, build, test and validate has been the foundation of well-trained students, who have both developed testing and simulation expertise during their learning phase. Fundamental challenges have been wrestled with as well as Dr Nagendra Somanath Visiting Professor Axis Bank Centre of Mathematics and Computing Indian Institute of Science Bangalore 560003 solved by collaboration with intent to resolve issues and test where necessary, thus building a reservoir of in-house expertise and know-how.

Engagement and Active Discussions with Professors:

It has been a pleasure to work with and engage with faculty at IISc. Advanced science and technology work done at IISc has been an engaging effort and excellent work in both Aerospace and Mechanical Sciences had been at the forefront of activities in developing hypersonic as well as heat exchanger technologies using sCO2. The works of Prof Gopalakrishnan, Prof Jagadeesha and Prof Pramod Kumar and their students are at the forefront of applications needed for future technology needs of high-performance aerospace and mechanical systems. Two particularly interesting opportunities for collaborative work currently in progress contributing towards

1. The optimal design of heat transfer devices for sCO2 with Shubam, V., resulting in a paper submitted to the forthcoming ASME Gas Turbine Conference in 2024 entitled "Topological shape and performance optimisation of Microchannel Diffusion-Bonded Heat Exchangers used in s-CO2 Brayton cycle." Shubham, V., Adhip, S., Pramod, K. Pradip, D., Nagendra, S. ASME Turbo Expo 2024 Conference.

2. Working with Prof Pramod's student Ashutosh on bearing technology on optimal design and testing of gas bearings. Gas bearing testing is a difficult problem. Optimal gas introduction to limit tilt and rub of adjacent bearing surfaces is an important portion of the design and needs to be calibrated within realistic tolerances to maintain a thin boundary layer of gas under pressure to ensure smooth bearing performance.

3. Working with Prof Pramod's student Vyas, and project engineer Adhip, was interesting in developing curved passages with enhanced heat exchange capability. Excellent progress in areas of introducing smooth path functions and criteria for design optimization was made. Optimization approaches using DOE based approached coupled with a GA and continuous optimization for conversion to practical designs was recommended.

Teaching optimization and computational search strategies for students of ME260

An opportunity to teach ME260 arose when Prof. G.K. Ananthasuresh, (Dean Mechanical Sciences) requested me to teach students of ME260. The mutually agreed topic was Sensitivity Analysis and Applications to Engineered Systems. Two 90 min lectures were planned and students of ME260 attended. It was a very encouraging experience, interacting and engaging with the students, all of whom demonstrated keen motivation and willingness to learn the approach and practical tools of Sensitivity Analyses. The class was held at ME Annex. Students actively responded to queries and guidance regarding optimization used in FEA as well as engaged in class problem solution and discussions.

Lecture Discussions on "Optimization of Engineered Systems". A three lecture series on "Optimization of Engineered Systems" was presented to students and faculty of IISc. The lectures were geared towards optimization tools and applications that have had key impact on development of aerospace systems, primarily aircraft design and aircraft engine applications. The introduction of system complexity and methods developed for deep learning of systems were discussed with applications. The lectures were well attended and discussions with students and faculty were fruitful. The short four-week engagements as the Axis Bank Visiting faculty at the Axis Bank Math and Computing Centre was quite rewarding in terms of engagement with faculty and students working on challenging problems of the future. It was indeed a pleasure to work with the Axis Bank Centre officials – Dr Raghavendra and Mr Vivek. I would like to thank them for the excellent arrangement of facilities as well as enabling a smooth working of all aspects associated with paper work needed with the organization. I would like to particularly thank Prof Pramod Kumar, and the officials at ICER who provided an excellent office space and facilities for day to day working at the Interdisciplinary Centre for Energy Research. In addition, working with students, Ashutosh, Vyas, Shubam and research engineers Adhip and Vijay was an engaging and collaborative learning experience. Last but not least, I would like to thank Prof S. Gopalakrishnan, Convener, Axis Bank Centre of Math and Computing for providing me with an opportunity to work at the Centre and enabled my interaction with faculty and students at IISc. It was indeed a wonderful experience working at IISc and ICER.

Annexure 4

Details of Workshops conducted

Communication workshop

Description of the course

1. Synchronous classroom interaction – 10 hours spread over few weeks. Out of these 10 hours, at least 2 hours will be in the classroom depending on the Covid19 (Omicron) status and guidelines.

2. Asynchronous Blended learning – 10 hours of video lectures, reading materials, quizzes, and reflections for students to absorb at their own pace within the course duration.

3. Two video submissions which are lot of fun. Students may take about 3-4 hours per submission depending on their own creative processes.

4. One project to assess a scientific lecture or a TED talk to understand speaking styles which may take 3-4 hours.

5. There is no written exam. There cannot be. This subject is about communicating not memorizing.

6. This course is not a spoken or written English course. It has no focus on Grammar or pronunciation of the English language. Dr. Godhwani believes that despite having mother tongue influence or a background from a vernacular education system, one can still learn how to communicate with confidence and change audiences for a positive impact.

7. This course also does not focus on resume building or any other written mediums of communication like proposals, papers, thesis, emails etc.

Instructor of the course

Dr. Rakesh Godhwani is the founder of ***School of Meaningful Experiences***, an online ed-tech start-up in Bangalore. He is also an Adjunct Faculty of Communication at IIM Bangalore and IIM Udaipur. Dr. Godhwani coaches promising startups and senior managers in the industry, gives seminars and talks in corporate events and colleges, reads a story to his kids every night before they sleep, bicycles, does yoga, writes, earns a fraction of what he used to, but lives a million times better. Rakesh's research and teaching interests focus on how a charismatic leader builds a persuasive message to impact audiences. His fourth book titled "***Public Speaking Kaleidoscope***" was released by Business Expert Press USA in May 2017. His earlier book "What to Say and when to Shut Up!" was published by Penguin Random House in November 2014 and translated in Marathi in 2017. Rakesh launched his online course on EdX and IIMBx called "***Effective Business Communication***" designed for learners around the world. Besides this, Dr. Godhwani also has his own podcast called "Plunnge" which is available on Spotify, Google, Apple Podcast apps or on his ***website***.

Prior to his plunnge into academia, teaching and writing, Dr. Godhwani worked with companies like Wipro, Intel and Qualcomm in various capacities ranging from engineering to business development. He also volunteers with Vishwas Society for Mental Health, an organization that offers free and confidential counselling. 3 Dr. Godhwani practices what he preaches. His speeches are quite popular and have garnered more than a million views on the social media. Some of them relevant for IISc students are below.

Symposium on Big Data Algorithms for Biology 2023 - 2nd and 3rd of June 2023

Organisers: Prof Chirag Jain, IISc , Prof Debnath Pal, IISc and Dr. Sanchit Misra, Intel

Venue: CDS Seminar Auditorium (102), Indian Institute of Science Bangalore https://www.bdbio2023.in/

BDBio symposium was held in Indian Institute of Science Bangalore on June 2 and 3, 2023 at the CDS Seminar auditorium. This event featured research presentations in bioinformatics, computational biology, and systems biology. The symposium program, spanning two days, included 14 invited talks from eminent scientists in academia and industry. The event also served as a platform for 30 selected students from all over India to showcase their ongoing research during the poster and networking session. The topics include novel computational, statistical and machine learning methods in applications related to:

- Molecular sequence analysis
- RNA sequencing analysis, including single-cell
- Comparative and population genomics
- Cancer and infectious disease
- Computational systems biology
- Biological networks
- Metagenomics
- Computational proteomics, metabolomics and pharmacogenomics - Multi-omics data integration

YouTube link to all talks: https://www.youtube.com/playlist?list=PLAU4YrLp-kU8zJMm6HA-cbY-c6I-op2Tbd

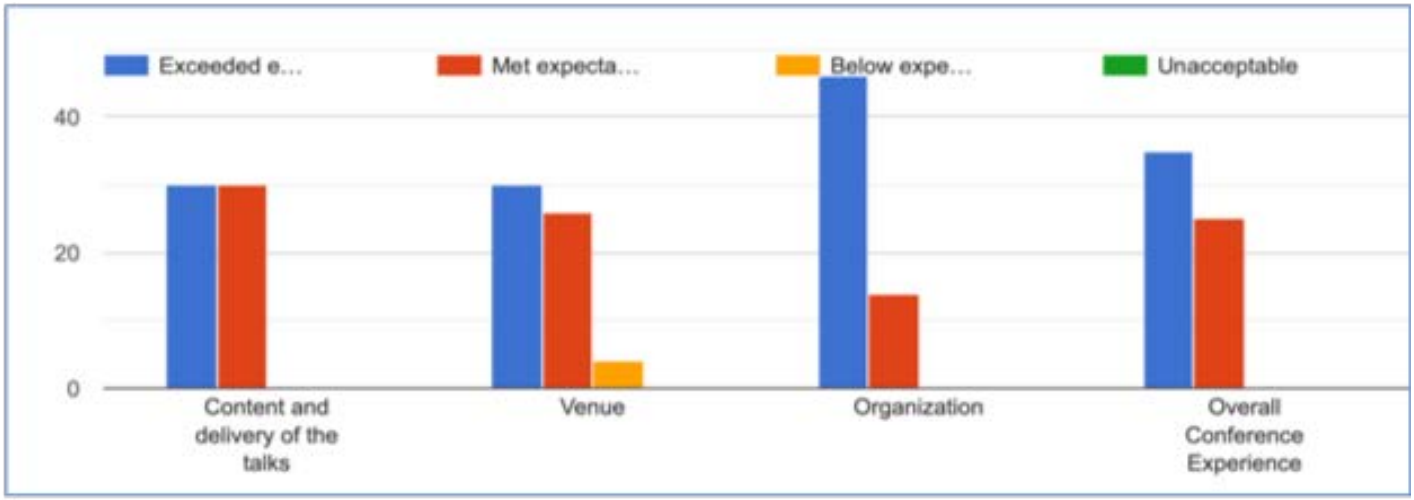
Photographs: https://photos.app.goo.gl/XFiwd5B-SCWnAR4R89

Link to program: https://drive.google.com/file/u/2/d/ 1p1Offll6D26GEXva4frIpja4BhljNhP5/view

Link to poster session: https://drive.google.com/file/d/ 1bS7gG8UNojyoAfuLftsy_ND2nU0mFT0M/view

Overall this event was very well received by the Indian computational biology community. The event was attended by more than 120 students + speakers, the auditorium was 100% occupied, and the organisers had to bring additional chairs to accommodate participants in a few sessions. The best component of the symposium were the engaging questions asked by graduate students after each talk.

We collected the **online feedback** using a google form from the attendees on June 4th to identify the strengths of the event, and understand the scope for further improvement. The summary of the feedback received from 60 participants is below.



Looking at the positive impact from this symposium, we are interested in conducting the BDBio symposium again next year at a bigger scale with international plenary speakers and a larger group of students.

List of invited speakers

Dr. Debarka Sengupta

IIIT Delhi

Dr. Hamim Zafar

IIT Kanpur

Dr. Ishaan Gupta

IIT Delhi

Dr. Karthik Raman

IIT Madras

Dr. Leelavati Narlikar

IISER Pune

Dr. Rahul Siddharthan

IMSc Chennai

Dr. Vinod Scaria

CSIR IGIB Delhi

Dr. Ramesh Hariharan

Strand Life Sciences

Dr. Manikandan Narayanan

IIT Madras

Dr. Md Vasimuddin

Intel Labs, Bangalore

Dr. Shweta Ramdas

CBR, IISc Bangalore

Dr. Nagasuma Chandra

IISc Bangalore

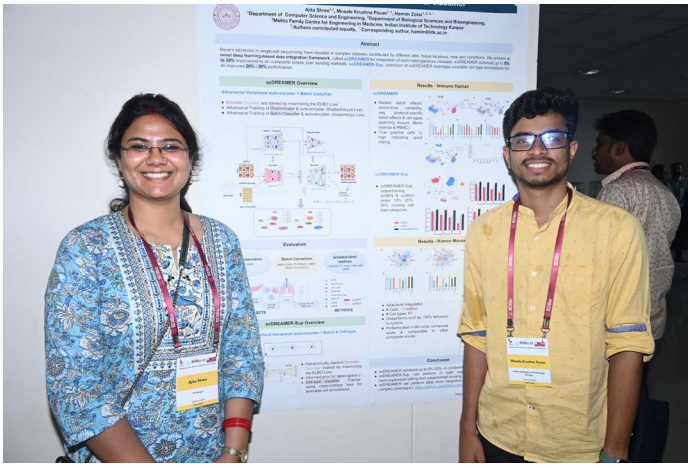
Dr. Sabarinathan Radhakrishnan

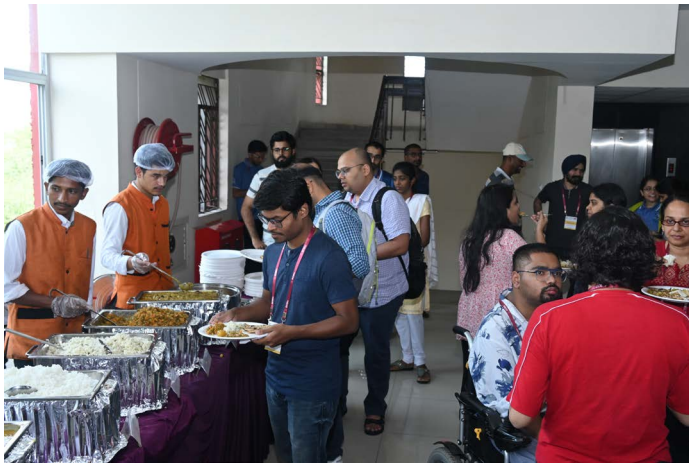
NCBS, Bangalore

Dr. Rukmini Kumar

Vantage Research

Selected Photos from the Event





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SCAN HERE

Symposium on Big Data Algorithms for Biology (BDBIO)

June 2

TIME	EVENT	SPEAKER
08:00	Registration opens (Venue: SERC Auditorium, IISc Campus)	
08:45 – 09:00	Introducing the Axis Bank Centre for Mathematics and Computing	Prof. Gopalakrishnan Convenor of Axis Bank Centre for Mathematics and Computing, IISc
09:00 – 10:00	**Plenary Talk** (Chair: Dr. Debnath Pal) Applying Omics to medical diagnosis and early detection	Dr. Ramesh Hariharan (Strand Life Sciences)
10:00 – 10:30	Coffee Break	
10:30 – 12:30	**Session 1: Population-Scale Genomics** (Chair: Dr. Ramesh Hariharan)	
	Personal genomes to populations and back	Dr. Vinod Scaria (CSIR IGIB, Delhi)
	Statistical algorithms for decoding regulatory information	Dr. Leelavati Narlikar (IISER Pune)
	Where's the causal gene? Moving from genetic association to function in lipid genomics	Dr. Shweta Ramdas (CBR, IISc)
12:30 – 13:30	Lunch	
13:30 – 15:30	**Session 2: Cancer Biology** (Chair: Dr. Rukmini Kumar)	
	Decoding driver genes in cancer genomes: From pan-cancer to personalized predictions	Dr. Karthik Raman (IIT Madras)
	Cis-regulatory effect of Human papillomavirus integration in cervical cancers	Dr. Sabarinathan Radhakrishnan (NCBS Bangalore)
	Developing tools in digital pathology for precision oncology	Dr. Ishaan Gupta (IIT Delhi)
15:30 – 16:00	Coffee Break	
16:00 – 17:20	**Session 3: Single-cell Analysis** (Chair: Dr. Leelavati Narlikar)	
	Single cell data integration: within and across modalities	Dr. Hamim Zafar (IIT Kanpur)
	Single cell biology through the lenses of big genomic data	Dr. Debarka Sengupta (IIIT Delhi)
17:20 – 19:00	Poster Session	
19:00 – 21:00	Banquet Dinner (Main Guest House, IISc)	

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Symposium on Big Data Algorithms for Biology (BDBIO)

June 3

TIME	EVENT	SPEAKER
09:00 – 11:00	**Session 4: Systems Biology** (Chair: Dr. Karthik Raman)	
	Taking two roads to predict mediators of inter-organ communication: the literature and omics (data mining) routes	Dr. Manikandan Narayanan (IIT Madras)
	Multiscale modelling of host response to infectious diseases	Dr. Nagasuma Chandra (IISc)
	Impacting drug development through Bio-Simulation - case studies from a Quantitative Systems Pharmacology team	Dr. Rukmini Kumar (Vantage Research)
11:00 – 11:30	Coffee Break	
11:30 – 12:50	**Session 5: Accelerating Biology** (Chair: Dr. Debarka Sengupta)	
	Evolution of transcription factor binding sites, and a fast algorithm for likelihood calculation using the Felsenstein 1981 model	Dr. Rahul Siddharthan (IMSc Chennai)
	OpenOmics: A framework for accelerating digital biology research	Dr. Vasimuddin Md. (Intel Labs)
12:50 – 14:00	Lunch	
14:00 – 16:00	Special Session on **Grand Challenges in Computational Biology** (Chair: Dr. Sanchit Misra)	Dr. Ishaan Gupta Dr. Debarka Sengupta Dr. Ramesh Hariharan Dr. Manikandan Narayanan Dr. Nagasuma Chandra Dr. Karthik Raman Dr. Rukmini Kumar
16:00 – 16:15	Best Poster Awards	
16:15 – 16:30	Vote of Thanks	
16:30 – 17:00	High Tea and Distribution of Participation Certificates	

Mathematics and Computing of Uncertainty Quantification In Model-Based Simulation For Risk-Informed Decision Making" - December 14th and 15th 2023

The Outline of the workshop: Day 1: December 14, 2023

Session 1: Basic mathematical concepts and computing methods (9:30 am to 1:30 pm)

- Aleatory vs. epistemic uncertainty
- Random variables, random processes and fields
- Uncertainty propagation
- Surrogate models
- Variance-based sensitivity analysis
- Application examples

Session 2: Data uncertainty (2:30 pm to 4:30 pm)

- Sparse and imprecise data, families of distributions
- Separation of aleatory and epistemic contributions
- Non-parametric distributions
- Likelihood concept, Bayes' theorem
- Bayesian computation (Markov chain Monte Carlo, Particle filter)
- Application examples

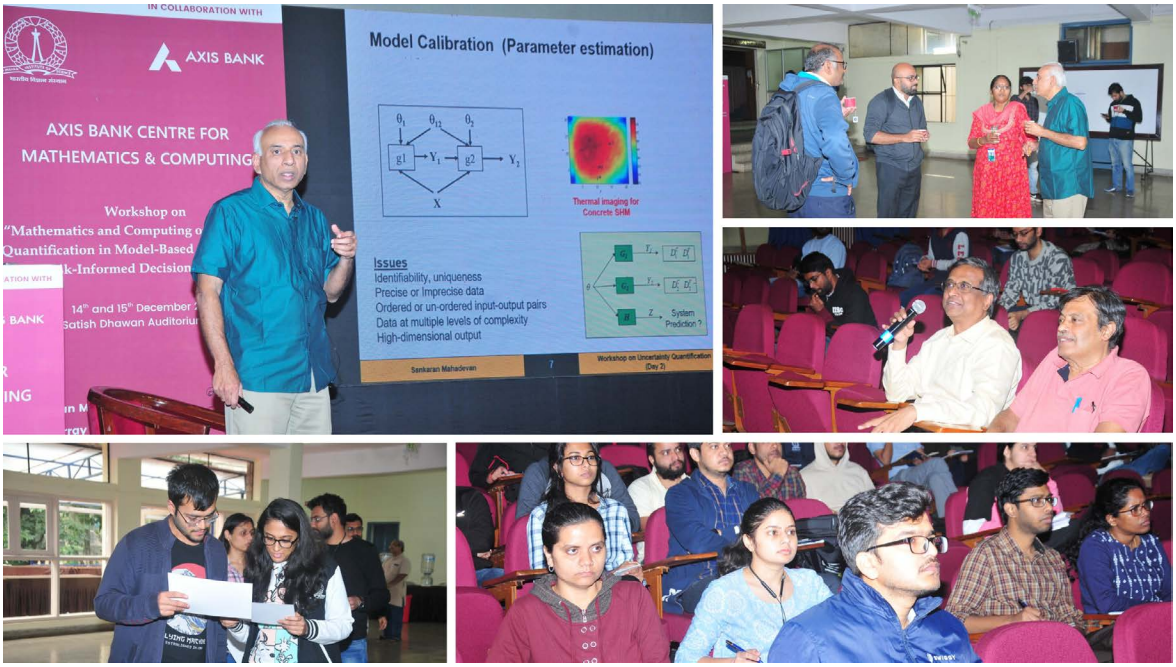
Day 2: December 15, 2023

Session 3: Model uncertainty (9:30 am to 1:30 pm)

- Sources of model uncertainty
- Model calibration
- Model verification
- Error estimation, error aggregation
- Model validation, quantitative metrics
- Model selection and ensemble models
- Application examples

Session 4: Uncertainty Aggregation and Risk-informed Decision-Making (2:30 pm to 4:30 pm)

- Bayesian networks for uncertainty aggregation
- Probabilistic digital twin construction
- Decision-making under uncertainty
- Formulations for design, manufacturing, operations, and life cycle management
- Application examples



Feedback and Felicitation programme

A simple felicitation programme and a feedback session was organised. Written feedback of the workshop was taken from the participants. A brief overview of the feedback is given below. The following three participants also presented their feedback on the programme. Certificates were distributed to all the participants who attended both the days of the workshop.

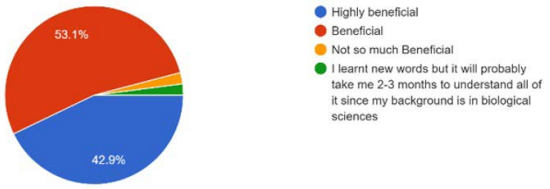
1. **Adwait Sharma**, Department of Civil Engineering, IISc
2. **Kausik Bhattacharya**, CPDM, IISc
3. **Thomas Philip**, Department of Finance and Risk Engineering, NYU

Content and delivery of the speaker in the workshop

49 responses

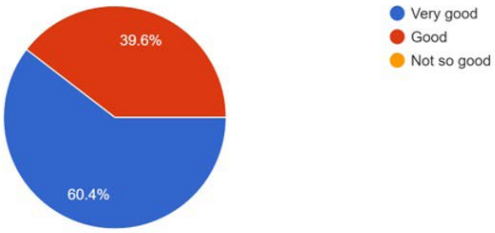
Please comment on the benefit of Workshop on your research work

49 responses



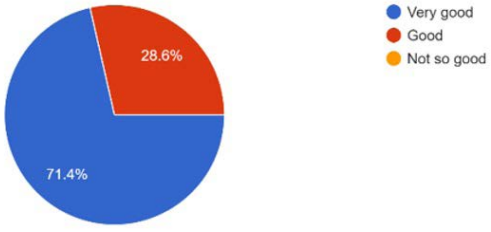
Food arrangement

48 responses



Overall organization of workshop

49 responses



Summary of written feedback

1) Course material can be provided.
2) Some links or problems which can be tried hands-on on our own could be a value addition to those interested without the tedious requirement for the instructor to have to guide us with the hands-on work.
3) Distribution of slides/reading material before the programme so that we can study and prepare beforehand.
4) One more day for problem solving... Examples...
5) Try to include lab lesson if possible related to the content delivered.
6) I appreciate the topic and resource person chosen. I need such type of workshop on bigdata, healthcare domain.
7) A longer duration workshop covering the topics in more detail can be considered. Hybrid mode may also be considered for future workshops.
8) Really it was a good session, gained lot of information, in future try to include hands on session.
9) It was a good experience.
10) Well organized. Excited for such future interesting workshops.
11) Professor Lecture style was very elegant. All the example he gave, was very relatable.
12) The course expected us to have prior knowledge which wasn't made clear in the email. It was helpful as an exposure to these concepts but would have been great if the level was beginner level.

Annexure 5

Report of research project grant

Report All-in-one solution for the development of high-speed and energy-efficient memory systems

INTRODUCTION:

Magnetic devices and sensors play an important role in the modern technological era. They form the backbone for applications ranging from navigation to medical imaging and data storage. It is evident from the applications that magnetic devices and sensors play a major role in multiple different fields. With the current advancements in this technology and relentless research in this field to improve the efficiency, performance, and reduction in size, it is important to have an innovative approach to the design and optimization of such devices and sensors. Optimization of various parameters of the material based on the application is important as it will save a lot of time, energy, and materials for finding the right combination. Optimization of the various parameters of a material can be done through different methods such as density functional theory (DFT), first principal approach, finite elemental method (FEM), finite difference method (FDM), etc.

Optimizations based on DFT and first principles even though they can be accurate there are a lot of limitations to these methods. Starting with DFT, the picture that it provides is overall incomplete since it relies on a single-particle picture which overlooks the small yet important correlations between electrons and thereby the other magnetic domains which leads to inaccuracies in predicting the magnetic ordering and band gaps. It is also well known that the accuracy of the DFT calculations is dependent on the exchange-correlation functional (Xc) [1] for which choosing the right function is not a straightforward task and it is important to find and implement the right Xc for the given system. Another issue that we face in DFT is mapping out the dynamics of magnetization, especially for rapidly changing magnetic fields which hinders the study of high-frequency devices/ systems as DFT works well for finding the ground state or the minimum energy configuration of the system. Now in the case of the first principle, it is a core-intensive process [2] and since it is based on solving the complex equations of fundamental physics often times there must be simplifying assumptions for making the calculations traceable which leads to inaccuracy. Moreover, this method is mainly used for studying the materials at an atomistic scale (atomistic simulation), thereby scaling up the simulation using the first principal method is computationally very intensive. Along with this, the true essence of the material parameters is not included there contributing to more inaccuracy.

MuMax3 [3] is a finite difference method-based simulation that uses GPU to accelerate the calculations thereby providing a computational framework for understanding and predicting the behavior of the magnetic materials on the microscopic scale. In mumax3, the geometry of the system is divided into cells of the same dimensions, this method of discretization is called as the finite difference method (FDM), and the Landau-Lifshitz-Gilbert (LLG) equation is solved for each of these cells. LLG equations describe the behavior of magnetization response to external magnetic fields in a material and it is given as

$$\frac{d\vec{m}}{dt} = -\gamma\, \vec{m} \times \vec{B}_{eff} + \alpha\, \vec{m} \times \frac{d\vec{m}}{dt}$$

Where $\vec{B}_{eff}$ is given as,

$$\vec{B}_{eff} = \vec{B}_{ex} + \vec{B}_{anis} + \vec{B}_{demag} + \vec{B}_{DMI} + \vec{B}_{SOT} + \vec{B}_{ex,inter}$$

α is the Gilbert damping parameter, and γ is the gyromagnetic ratio. We solve this equation over entire space for the time and space evolution of $\vec{m} = \vec{m}(x, y, z, t)$. In micromagnetic simulations, the magnetization is normalized with saturation

magnetization $\vec{m}(x,y,z,t) = \frac{\vec{M}(x,y,z,t)}{M_S}$. These energy terms are specified by useful phenomenological parameters such as, exchange stiffness (A_{ex}), DMI constants (D_bulk and D_int) and magneto crystalline anisotropy (K_{ui} (i = 1,2) for uniaxial anisotropy). Further, we can also specify external fields(B_ext) as well. We chose this simulation approach since it is GPU intensive, thereby much faster calculations and lower simulation time, also, complex geometry and interaction in-between various materials can be incorporated into the simulation resulting in more accuracy in simulation and comparable results to the experimental values.

Currently, we are studying the ferromagnetic resonance (FMR) in metallic thin films using MuMax3 micromagnetic simulation software. To understand what we are working on and how it is important let us first understand FMR. FMR [4]is a phenomenon in which the magnetization precession of a ferromagnetic material in the presence of an external static magnetic field matches with the frequency of an externally varying magnetic field (tickle field) and when it happens the energy from the tickle field is absorbed and utilized to sustain the precession for a longer period. Usually, the tickle field will have a strength less than that of the external static field and have microwave frequency. Through FMR we can get a better understanding of the material and also is useful for making magnetic sensors that will have better sensitivity without any additional needs or external conditions (like magnetic isolation, cryogenic temperatures, etc). Currently, to find a material with parameters that align with the application one must go through several research articles and conduct trial-and-error-based experiments to find and then optimize the material, which all in all will take a good amount of time and material. We can overcome this problem by implementing micromagnetic simulations to find the right set of parameters and optimize the material overall to get a good FMR absorption (better absorption better sensitivity better sensors).

Another frontier where we are currently utilizing our computational resources is for simulating new generation MRAM devices. MRAMs are among the most promising memory solutions, where can provide low-power, high-reliability, faster switching, high storage density and low costing methods. Spin transfer Torque [5] MRAM(STT-MRAM) and Spin orbit Torque MRAM(SOT-MRAM) [6] [7] are two most examined schemes for magnetization switching. STT-MRAM provides deterministic switching behavior, while SOT-MRAM works on considerably lesser energy requirements. In our simulation experiments, we optimize the design and material choices in our Magnetic tunnel junction, for maximizing on the desirable properties. Another aspect of experimentation involves developing innovative schemes for switching. We are also working on MRAM based on skyrmionics [8], where we utilize the interesting spin textures for storing and manipulation of the storage bits inside the memory solution.

When micromagnetic simulations are coupled with the optimization algorithms, one can explore the diverse design space of the magnetic devices and sensors. Parameters like geometry, material properties, and external magnetic conditions can be iteratively refined by the optimization algorithms which help in enhancing the performance of the system, reducing the number of prototypes, and unlocking novel designs which is rather difficult if done solely in an experiment.

RESULTS AND CONCLUSIONS:

We are working on modeling a 2D-FMR system where two static external magnetic fields are involved, each placed orthogonal to the other and the tickle field with a microwave frequency (2.2GHz) is applied along the third axis (perpendicular to both the static external field). Through this 2D-FMR method, we will understand the FMR absorption of the material at various angles and various magnetic field strengths. This is important, as by varying the angle we will understand the anisotropic behavior of the magnetic thin film[9]. The simulation is done for a thin film system exhibiting uniaxial anisotropy, a tickle field of 2.2GHz is oriented along the z axis and the static field is varied in 10-degree succession from 0 to 360 degrees. The system is relaxed first to attain its low energy state for a given orientation of the external magnetic field. Then the simulation runs for 15ns with the initial 5ns being the buffer period for the system to stabilize. One of the results obtained is given here for a thin film with uniaxial anisotropy of 1400 J/m^3 for 360 degrees and an external magnetic field varying from 0 to 100 gauss at 2.2GHz of FMR frequency.

In figure 1 (a), we can observe that there is FMR absorption between 135 to 225 degrees with a strong absorption at 180 degrees for an external magnetic field of 20 to 40 gauss. From this, we can interpret that the sample of given parameters will exhibit strong FMR absorption for an FMR frequency of 2.2GHz and at an external magnetic field of 30 gauss. Similar to this we can tailor the system by varying various magnetic parameters to exhibit strong FMR absorption for a

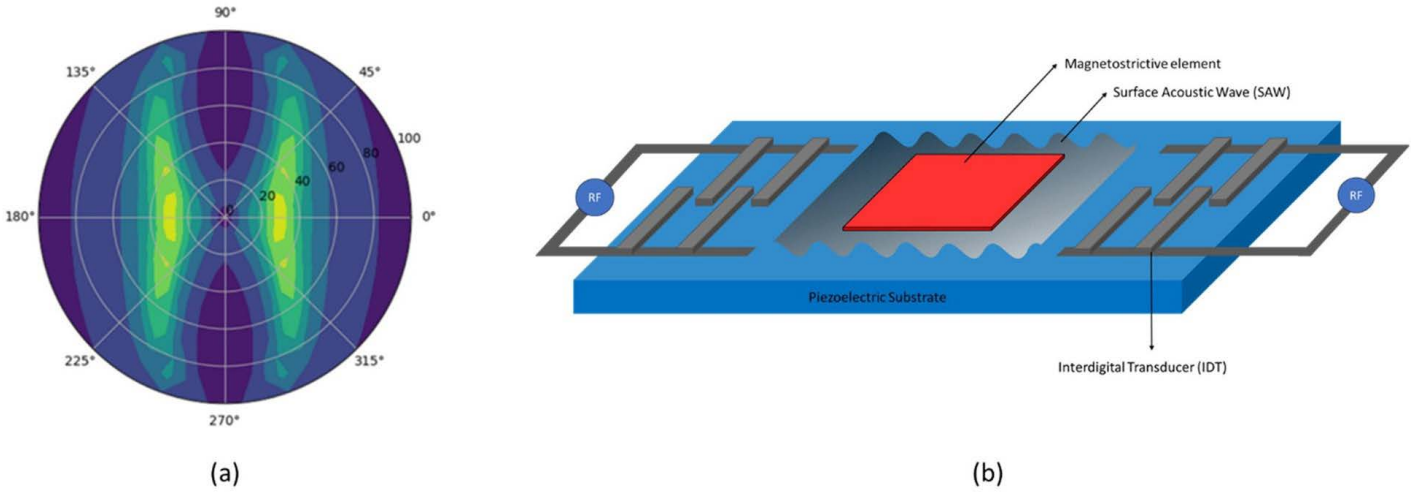


Figure 1: (a) FMR absorption for thin film having uniaxial anisotropy (Ku1) =1400 J/m. (b) Schematics of proposed AD-FMR device for magnetic sensors.

given resonance frequency and at zero external magnetic fields which will result in a system that is extremely sensitive to the variation in the external magnetic field, which can be used in the development of sensors. Further, we aim to design and model an Acoustically driven FMR (AD-FMR) sensor [10] (Figure 1b), the working principle is the same as that of the normal FMR but instead of a tickle field that has a frequency in microwave range, AD-FMR will have a frequency in radio wave range which is provided through SAW [11]devices. Such sensors will be cheaper and more efficient compared to the standard FMR sensors.

Another step towards power efficient storage systems is evolved by study of various configurations inside of our conventional STT-MRAM and SOT-MRAM. While STT-MRAM provides us with deterministic fast switching, SOT-MRAM requires quite less current density for switching. We try to utilize best of both worlds and study a hybrid switching method. One such switching case is illustrated in figure 3. Here, the system is initially applied with an SOT current to bring the magnetization of out tunnel junction to in-plane, and then a small STT current is applied to provide a deterministic switch to the required out of plane configuration [7]. The STT current required for switching in our hybrid MRAM device was considerably lower, than conventional STT-MRAM as much of the activation energy of switching (caused due to perpendicular anisotropy of the system) is overcome in aid with SOT current.

Next, we worked on development on skyrmionic tunnel junctions[12], where memory bits are simulated by creation and annihilation of skyrmion, inside

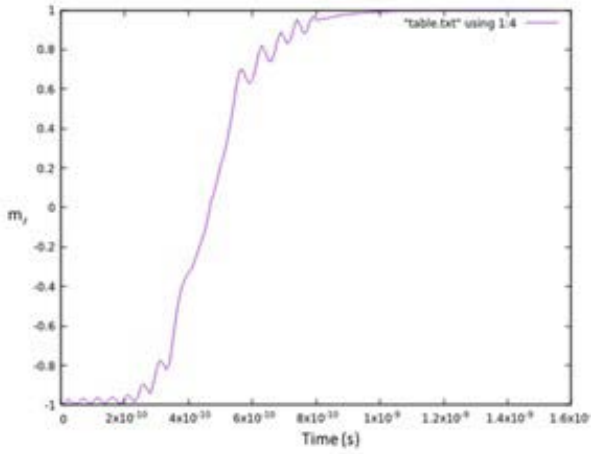


Figure 2: (a) Magnetization switching in a hybrid MRAM stack.

an antiferromagnetically coupled tunnel junction device. The system was simulated in Mumax3 by creating individual layers of the stack and setting up interlayer coupling[13]. One important aspect of the simulation was finding the correct values of hyperparameters, which can provide us the desired stability of the system as well as the flexibility of switching when required. Once the system has been created, we observe the magnetic properties of the system by applying external field. Next, we studied the system by varying the various layer's thickness and various material properties, providing us crucial insights about how various properties affect the switching efficiency in the magnetic memory system. Utilizing skyrmions for our tunnel junction provides us with 3 bits in our storage and hence increasing the storage density. As illustrated in figure 1(b), we can observe three states of magnetizations, where each magnetization state

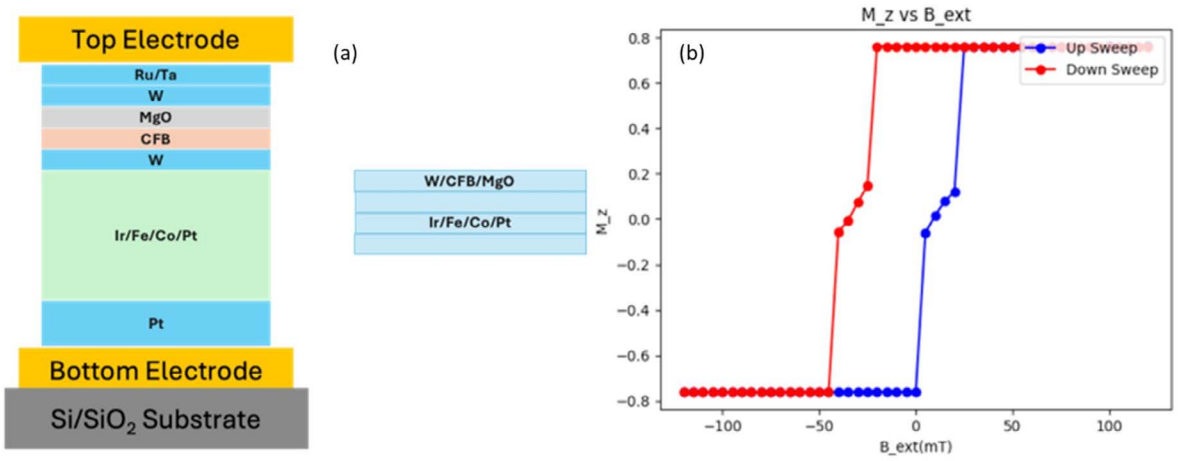


Figure 3: (a) Experimental model for the stack and the simulation simplification of the stack. (b) 3-state switching behaviour for skyrmionic tunnel junction

will have a separate resistance state associated with it. These resistance states can be recognized with reading current. Having 3 bits instead of 2 bits of out conventional systems will boost our storage density by over 150%. Further, the creation, manipulation, and annihilation of skyrmions require considerably lesser current densities, about 1000 times lesser than state of art methods, making it a much more power efficient method.

Magnetic devices and sensors are difficult to optimize through experiments alone, hence we are doing studies of effectively optimize the various parameters that affects the performance of the system. There is an ever-growing demand in magnetic devices in the current technological era and being in the forefront and explore new device configuration through methods such as one this report shows not only will save time and resources but may help discover new parameters which can help in finely optimizing the device.

Deliverables:

Conferences Presentation:

- Bhagwati Prasad, "*Electric field control of magnetism: energy efficient spintronics for AI and IOT applications*" Invited talk at International Conference on Advanced Functional Materials and Devices (AFMD-2024), Feb 26 –29, 2024 SRMIST, Chennai, TN, India.
- Bhagwati Prasad, "*Energy-Efficient Spintronics: Enabling Next-Generation AI and IoT*", Invited talk at XXII International Workshop on Physics of Semiconductor Devices (IWPSD), Dec 13th – 17th 2023, IIT Madras Research Park, Chennai, India.
- Bhagwati Prasad, "*Voltage-Controlled Magnetism: A Promising Approach for Ultra-Low-Power Computing*" Invited talk at the 34th Annual General Meeting of MRSI and the 5th Indian Materials Conclave, Dec 12th – 15th 2023, IIT (BHU), Varanasi, India
- Astha Khandelwal, Vinod Kumar, Yu-Hui Tang, Mark Blamire, and Bhagwati Prasad, "*Current-induced switching in spin-filter tunnel devices*", Oral talk at MRS Fall Meeting, Nov 27 – December 2, 2023, Boston, MA, USA
- Bhagwati Prasad, Akash Surampall, Rajesh Chopdekar, Alan Kalitsov, Lei Wan, Jordan Katine, Derek Stewart, and Tiffany Santos, "*Voltage Control of Exchange Coupling: A Novel Way to Switch MRAM Devices*", Oral talk at MRS Fall Meeting, Nov 27 – December 2, 2023, Boston, MA, USA

Research Articles Under Progress:

- Akash Surampalli, Anup Kumar Bera, Rajesh Chopdekar, Alan Kalitsov, Lei Wan, Jordan Katine, Derek Stewart, Tiffany Santos, and Bhagwati Prasad*, "*Voltage Controlled Interlayer Exchange Coupling and Magnetic Anisotropy Effects in Perpendicular Magnetic Heterostructures*", Under revision in Advanced Materials (2023)
- Jiamian Hu, ……, Bhagwati Prasad, *et al.* "Roadmap on Low-power Electronic", Under revision in APL Materials
- Vinod Kumar, Astha Khandelwal, Yu-Hui Tang, Mark Blamire, Alan Kalitsov, Julia Mundy, Bhagwati Prasad*, "*Current-Induced Magnetoresistance Switching in Spin-filter Tunnel Devices*", Under submission in Nature (2023)

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Report of Molecular Communication in Crowded Environments, Sumantra Sarkar

Project status

We proposed to work on two different problems with the support of this grant: (a) molecular communication with relays and (b) first passage problems in crowded media. An integrated Ph.D. student, Mr. Phanindra Dewan, leads both projects in my group. We have made considerable progress in the first project and expect to submit a manuscript this summer. We started working on the second project in January 2024 as part of Phanindra's MS thesis project (PH250).

Molecular Communication with Relays: We have developed a computational model of a 1D molecular communication channel where communication is facilitated by molecular diffusion.

However, the molecules can periodically get a kick toward the receiver's direction if they happen to be on "relay" sites. We wanted to understand how the efficacy of molecular communication changes as we increase the number of relays in the system. Fig. 1 shows that when the number of relays, N_{relay} goes above a threshold, mutual information, I_3 increases exponentially.

We studied I_3's Variation with the average inter-relay distance to understand where this dependence comes from. The more the inter-relay distance, the more prominent the effect of diffusion. In fact, we found that if the inter-relay distance was more than five diffusion lengths, then diffusion dominated the mutual information. However, below this threshold, the effect of the relay was prominent, and I_3 increased exponentially.

These two figures demonstrate the key results of this project. Currently, efforts are underway to obtain mathematical expressions for the Variation of mutual information as a function of the inter-relay distance. Specifically, we want to understand why the decay of mutual information happens in steps. We have a mathematical understanding of the decay of I_3 between inter-relay distances of 1 and 2. However, the generalization of this understanding to longer inter-relay distance has not matched the numerical results. Therefore, we have decided to numerically understand how the interplay of diffusion and relay sites determines the mutual information.

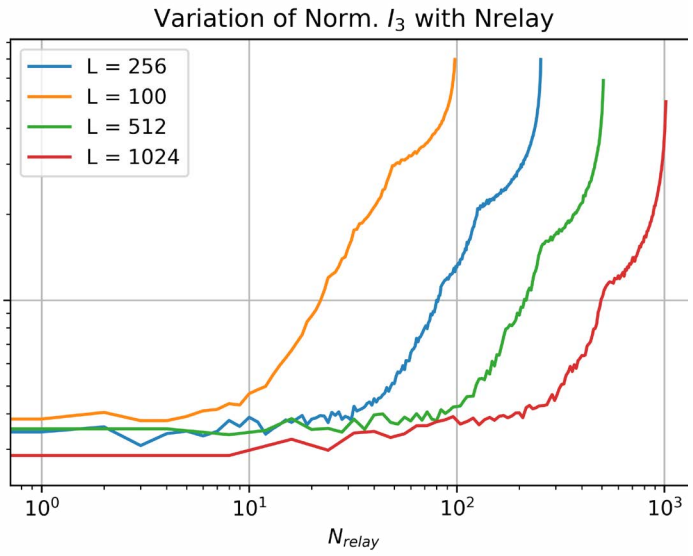


Figure 1: Variation of mutual information with the number of relays, N_{relay}. Mutual information increases exponentially with N_{relay}.

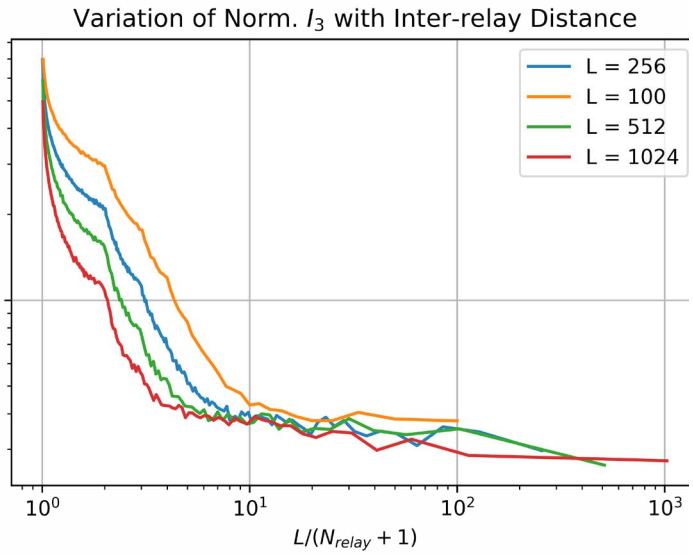


Figure 2: Variation of mutual information with inter-relay distance..

First passage in crowded environments: We are using molecular simulation to study the first passage distribution of target search in crowded environments. We assume that crowders are static entities that are arranged in predetermined patterns, such as random, regular, and hyperuniform, and will measure the effect of the crowder arrangements on the first-passage time distribution.

Utilization of the funds

We have used the funds from this project money to purchase the following:

1. Computers: I purchased a workstation for my group using this fund.
2. iPad: I purchased an iPad for research and teaching using this fund. This tablet was used extensively to create and distribute lecture notes for my classes.
3. Computer accessories: Several computer accessories, such as GPU cards and storage, were purchased from this fund.
4. Books: Several books were purchased using this fund. The list of books are as follows:

- Differential Geometry by Kuhnel, AMS
- Vectors, Tensors, and the basic equations of fluid mechanics by Aris, Dover.
- Ordinary Differential Equations by Ince, Dover.
- Complex Variable Methods in Elasticity by England, Dover.
- Invitation to Geometry by Melzak, Dover.
- Critical Dynamics by Tauber, CUP
- Dynamics of Self-Organized and Self-Assembled Structures by Desai & Kapral, CUP
- Nonequilibrium Statistical Mechanics by Bagchi, CRC

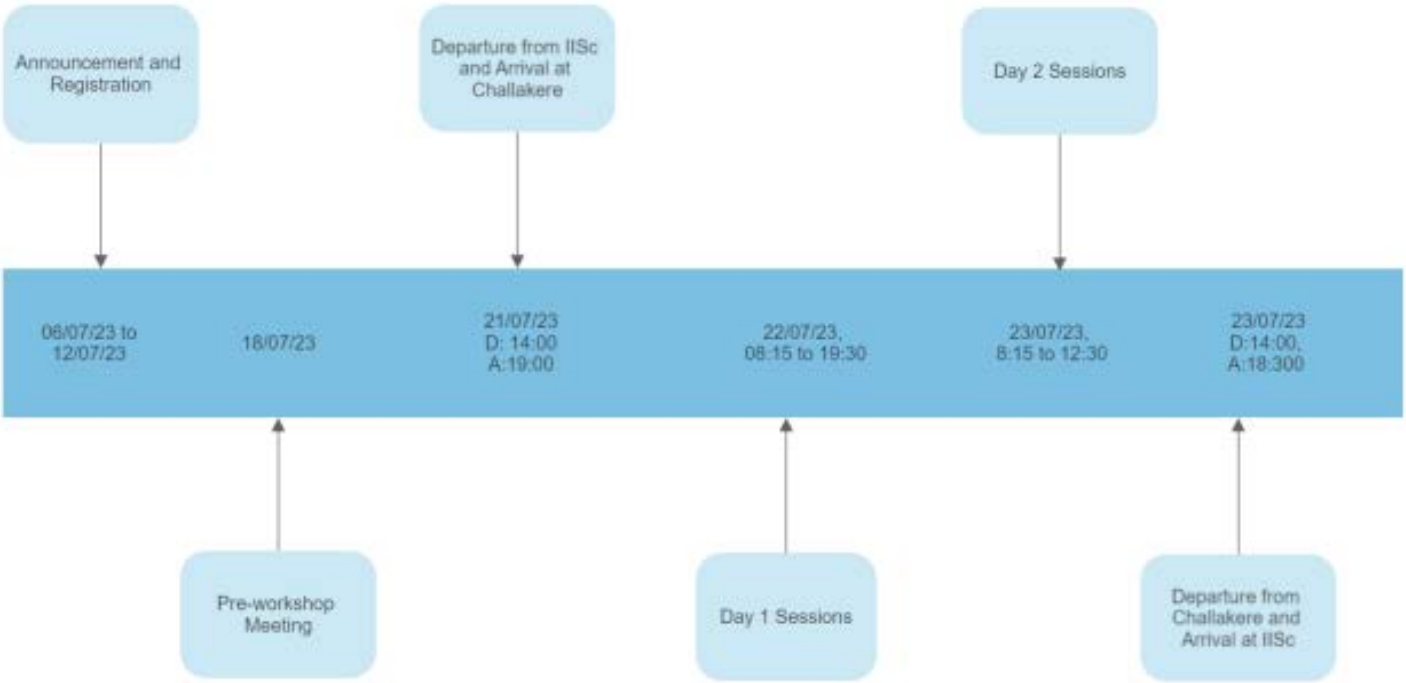
5. Travel: A large portion of this fund will support the PI's travel to a conference in the USA in February-March 2024. The PI will spend two weeks in Boston for research collaboration and one week in Minneapolis to attend the APS March meeting. The PI will be giving several talks in both places.

List of publications

- Coarsening of topological defects in 2D polar active matter, Soumyadeep Mondal, Pankaj Popli, and Sumantra Sarkar, arxiv:2401.00203
- Transport of molecules is temperature independent on active membranes, Saurav G. Varma, Argha Mitra, and Sumantra Sarkar, Manuscript under preparation
- Efficacy of information transmission in the presence of relays, Phanindra Dewan and Sumantra Sarkar, Manuscript under preparation.

Outreach workshop on let us C++

Timeline



Pre-workshop activities: The workshop was announced via the Campus Bulletin, inviting students pursuing M Tech (Res) and Ph.D. degrees in the Mechanical Sciences division to participate.

Online registration was conducted, and participants had to provide their emergency contact information.

An in-person meeting was held with registered participants to discuss logistics and computer requirements for the workshop.

Participants:

The List of participants and their respective departments are mentioned below.

Participants	Department	Program
Himanshu Gupta	AE	Ph.D.
Pramay Bhatpahri	AE	Ph.D.
Chandra Prakash Sharma	AE	Ph.D.
Ajeet Kumar Yadav	AE	Ph.D.
Kain Dipendrasingh	AE	Ph.D.
Kush Tusharbhai Pandya	AE	M.Tech
Panchal Anand Jayeshbhai	AE	M.Tech
Kratika Raje	AE	M.Tech
Govardhan K	AE	M.Tech
Adhithya Ravichandran	AE	M.Tech
Krishna Avatar G R	AE	Ph.D.
Harshit Kumar Sandhu	AE	Ph.D.
Anusree Ray	AE	Ph.D.
Suprakas Saren	AE	Ph.D.
Pranjal Vishnukumar	CE	Ph.D.
Anupama S	CE	Ph.D.
Sanyogita	ChE	Ph.D.
Subin Raj P	CPDM	Ph.D.
Mubarak T N	CPDM	Ph.D.
Shivakumar V	CPDM	Ph.D.
Arunkumar S	CPDM	Ph.D.
Maharudra Rajendra	CPDM	Ph.D.
Naveen Talawar R	CPDM	Ph.D.
Prabeen Kumar Pattnayak	ME	Ph.D.
Nemai Mondal	ME	Ph.D.
Poornakanta Handral	ME	Ph.D.
Chiraprabha Bhattacharyya	ME	Ph.D.
SUMAN DUTTA	ME	Ph.D.
Sonu Dhiman	ME	Ph.D.
Ragula Shyam Sundar Rao	ME	Ph.D.
Ashish Paman	ME	Ph.D.

Teaching Assistants:

1) Jay Prajapati ME Ph.D

2) Jayant Raj CPDM Ph.D.

Instructor: Ramsharan Rangarajan, Associate Professor Mechanical Engineering

Workshop sessions: The workshop comprised two-day sessions spanning a total of 12 hours and 30 minutes.

Day 1: The workshop commenced with sessions 1, 2 and 3. (10 hours).

Session 1 covered an overview of compiling, linking, and execution, the basics of C/C++, data types, variables, pointers, arrays, loops, functions, and file I/O.

Day 2: The workshop continued with sessions 4 and 5 (2 hours 30 minutes), and a TA session of 30 minutes followed by departure from the Challakere campus.

Link to example codes from the workshop: bitbucket.org/rram/demos/src

All participants have access to the examples to help them try and test.

Session-wise activities

Session 1 consisted of an Introduction to C++ program, a Hello World program, Usage of function, numeric data types, and CLI11 for command line interfacing. Laying the foundation for everyone to comprehend the fundamental structure of a C++ program, syntax, compile-link-execute procedures.

The sample programs included a ‘Hello world’ program, Factorial programs and various wriJng methods, and a simple arithmetic operations program.

Session 2 cantered on an introduction to arrays and pointers, simple control statements, and loops, followed by an introduction to ‘enums’ and exception handling via try-and-catch methods. After this session, the fundamentals of file streams were discussed to help attendant comprehend the ‘fstream’ functionality.

Session 3 introduced templated function and templated class. Also, how to write function declarations in a header file (.h file) and define them in .cpp file was discussed.

The templated function was introduced using an example of a function to find the maximum of two values. It started with overloading a function with different data types. Then, a templated function was introduced. Defining a class, what are private, public and protected members of the class, what are constructors, copy constructors, assignment constructors, and what is destructor was discussed.

A class that deals with the arithmetic of complex numbers was defined to show the power of templated class. It discussed how to set the private members using the setter function and access them using the getter function. Arithmetic operations on complex numbers was discussed using operator overloading and friend function to access. This session ended with an example of implementing a simple vector class using a template as a practice problem using the above stated concepts.

Session 4 began with a hands-on experience for the participants. They were tasked with writing a simple program capable of performing gradient descent on a given function. Initially, the function was hard-coded and fixed. The session continue to make the program more robust by implementing the tolerance and exception management concepts discussed in the previous session. The session gradually introduced the concepts of pass-by-value and pass-by-reference. The next step was to add complexity to the program by enabling the function parameter passing feature. The next stage was passing function pointers and using aliasing for the function name. The context was used to demonstrate the application of one of the standard templates, 'pairs'. The session then discussed the concepts of Templates creation and new features such as auto, followed by the concepts of overloaded functions and operators. Towards the conclusion, the concept of Functor was also introduced, and Templates and functors were applied to the initial gradient descent program to produce a generic program.

Sample programs consist of a program to perform matrix multiplication, another to perform matrix inversion, and a program to read mesh data from an input file.

Session 5 This session aimed to introduce inheritance and polymorphism classes and how they can help reuse existing code. It was explained with the base class "person" and how to derive the base class to create the derived class "student". In this case, polymorphism was shown using the "print_info()" function.

Another example of multi-inheritance was given with "student" and "mathematician" base class and "math_student" derived class—ambiguous behaviour of "print_info" function in math_student derived class and how to avoid this ambiguity.

TA session on OpenCV

Both TAs introduced the participants to an open-source library, "OpenCV", for image processing and computer vision. An example of linking OpenCV libraries and including header file paths was given using shell scripting. A simple image-processing example highlighted how classes, namespaces, functions, and constructors are used in the OpenCV library. Examples of copy constructors, assignment constructors and templated functions were demonstrated. This example included an introduction to the function for loading, displaying and saving an image. An example of image processing was given by modifying the RGB channels of an image.

Copilot session

The last session was about a new tool related to GitHub Copilot for coding. This tool can be used to ease the coding task was demonstrated using some examples from previous sessions.

Photographs from the workshop

A.1. Photographs from the workshop

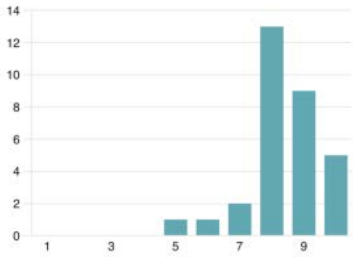

NASA

 # Responses: 31

Response ratings: On a scale of 1- 10

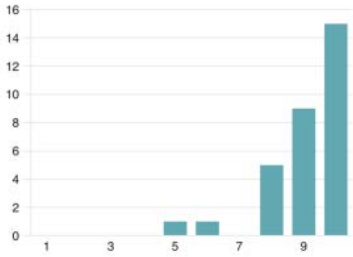
1. How would you rate the "Let us C++" workshop?

8.39
Average Rating



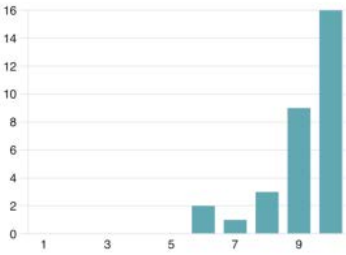
2. Was the workshop well organized (planning, logistics, communication, etc)?

9.10
Average Rating



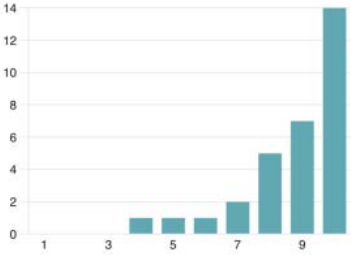
3. Did you learn something new at the workshop?

9.16
Average Rating



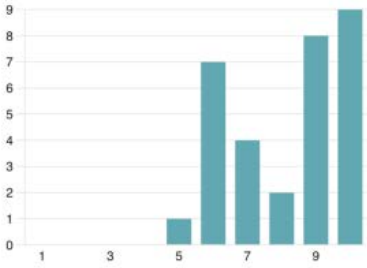
4. Was the workshop helpful in improving your overall proficiency in programming?

8.77
Average Rating



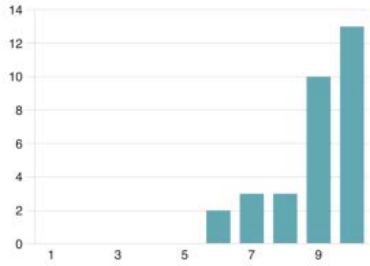
5. Will you be confident using C++ for programming assignments in the future (e.g., FEM, CFD)?

8.16
Average Rating



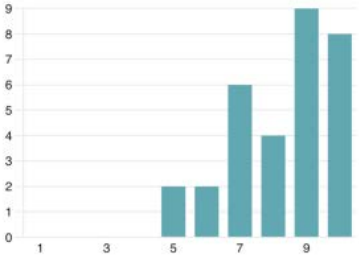
6. Were you able to complete the last task of implementing a root finding method?

8.94
Average Rating



7. How was your experience at the Challakere Campus?

8.29
Average Rating



8. Was the course content interesting

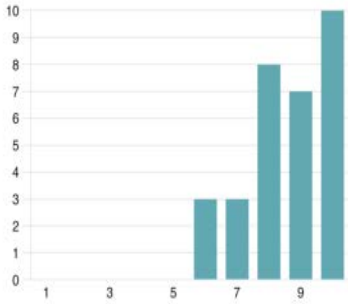
Yes	31
No	0
Maybe	0

9. Was the method of presenting concepts through a series of simple examples interesting?

Yes	29
No	0
Maybe	2

10. How do you rate this workshop compared to other programming courses/workshops you have attended in the past

8.58
Average Rating



11. Provide feedback for the instructor (anything you wish to convey- e.g., preparation, presentation, clarity, explanations, accessibility, etc)

Wonderful teaching by Prof Ramsharan
After the first 4-5 hours of session I feel like disconnected and the content seems hard to understand. Also I personally found the pace of teaching is litter faster than my grasping ability.
Excellent teaching as always. One interesting idea would be to have the full code and get a student to explain what's happening in the code.
It was appropriately designed for what I came here. It gave me a lot of hands on experience and confidence to try on things that I feared to attempt in programming
Content and presentation was nice.. could go a little slower during coding so that we could catch up with what was being taught in class.
Excellent presentation with good examples. It is really easy to learn with him.
The Content was good but the speed of the lecture was fast. It's difficult for beginners to understand the whole concept in this short period of time.
It would have been better if the workshop was more focused on basic concepts
Some workout assignments will be good to test what has been taught in class with combination of simple to complex problem

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