

## School of Engineering

### Five - Year Strategic Plan Document (2023-2028)

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Submitted by:

Dr. Sasangan Ramanathan

Chairman, Leadership Council of School of Engineering

Submitted to:

1. The Vice Chancellor
2. The Provost

#### **Vision:**

To be a global leader in the delivery of engineering education, transforming individuals into creative, innovative, and socially responsible contributors in their professions.

#### **Mission:**

- To provide best-in-class infrastructure and resources to achieve excellence in technical education,
- To promote knowledge development in thematic research areas that have a positive impact on society, both nationally and globally,
- To design and maintain the highest quality education through active engagement with all stakeholders - students, faculty, industry, alumni and reputed academic institutions,
- To contribute to the quality enhancement of the local and global education ecosystem,

- To promote a culture of collaboration that allows creativity, innovation, and entrepreneurship to flourish, and
- To practice and promote high standards of professional ethics, transparency, and accountability.

Amrita Vishwa Vidyapeetham, School of Engineering is a multi-disciplinary, research-intensive school comprising diverse student population, well-qualified faculty, innovative group of researchers and guided by a dedicated, far-sighted administration. The campus has a long-drawn-out plan in many spheres of academia & research.

Leading the academic and administrative governance is world renowned humanitarian leader Shri Mata Amritanandamayi Devi (Amma). Amma has been relentlessly supporting education, innovation and research towards upliftment of society.

Amma's profound mission of providing education for life, and emphasis on compassion driven research, has shaped Amrita as a unique institution:

### **Education for Life**

There are two types of education: education for living and education for life. Studying to become a professional is education for a living, while, education for life requires an understanding of the essential human values. At Amrita, we believe that education should also impart a culture of the heart, based on enduring values and inner strength. Amrita's culture of education helps to inculcate in our students the right ethos to be rooted in the values of Dharma (righteousness), Karuna (compassion), and Shraddha (mindfulness). Endowed with qualities of acceptance, patience, self-confidence, perseverance, and enthusiasm, the benefit of humanity will become the uppermost in the students' thoughts, words and actions. They will then pioneer innovative solutions for the benefit of all humankind, leading to sustainable health and prosperity for all. This resonates with the ancient Sanskrit prayer 'Lokah Samastah Sukhino Bhavantu'. It is a reminder of our deeper connection to the entire world around us, "May our work contribute to the happiness of all beings."

### **Compassion Driven Research**

Our motivation to pursue research is focused on alleviating major global problems related to poverty, starvation, sickness, environmental pollution, and sanitation. We believe that if we could transform compassion from a mere word into a path of action, we would be able to address most of the world's problems. If we take this step courageously, then our

research and its outcomes will have a special impact, spontaneity, and power. This has translated into many latest advancements and innovations that have culminated in greater societal benefit.

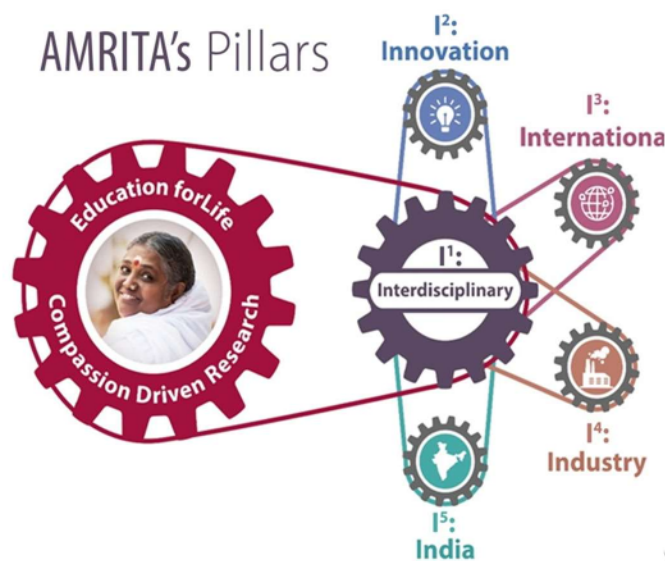
## Global Impact

At Amrita, we stand united in our mission towards solving globally recognized scientific and societal challenges, including environment, development, and health. Amrita stands at the strategic juncture of two streams of cultures: East and West. It is our vision to bring the two together to bridge the divide through meaningful collaborations with world-class universities and innovative approaches that will benefit the entire planet.

## Five Strategic Pillars

Quality and commitment have been the cornerstones for the success of Amrita. Being a multi-campus, multi-disciplinary university, decentralized administration was essential to maintain agility and quality. Amrita's strategic plan for academic and research excellence is driven by the following five priorities, the key five strategic pillars:

- Inter-disciplinary
- Innovation
- International
- Industry
- India



## Institutional Strategic Plan

Building on these strategic pillars is critical for Amrita to be recognized as a world class university.

### **a. Inter-disciplinary:**

Holistically addresses national and global challenges. To bring together multiple related disciplines to tackle complex problems faced in societal applications.

Offers degree programs that are inter-disciplinary/intra-disciplinary in nature. The degree programs are designed to fit with the thematic research areas of the school. Initiate and secure funds for inter-disciplinary projects from Govt. agencies and industry

More programs involving automation & rural technology, e-mobility in electrical vehicles, sensors for health applications, cyber physical systems, security and forensics, data analytics and medical systems, vision-based systems for smart transportation and bioinformatics, data analytics and machine learning, Robotics, AI, are being introduced. A new school of AI & DS has been established. Two new centers on smart vehicles and flexible electronics and advanced materials have also been recently started.

The Automotive Research and Technology Center has been a success story in building industry-academia partnership. Automotive Test Systems (ATS) the partnering industry has brought many projects for mechanical, electrical and automation students (both UG and PG students).

### **b. Innovation:**

Innovative teaching-learning process: Strengthening the curriculum and introducing pedagogical changes that would trigger better knowledge gain. Introduction of modular mathematics courses was implemented in 2015. Presently a Spiral learning Methodology for Teaching Mathematics has been introduced wherein the approach is based on revisiting and building upon previously learned material in a spiral fashion. This approach contrasts with linear learning, where new concepts are introduced and learned in a strict sequential order.

Introduced flexible curriculum with open electives across all engineering departments. We have introduced minors & specializations in departments. For e.g. minor in AI and data science, specialization in robotics and automation, etc., in the 2023 curriculum.

Carry out innovative research that can result in patents and entrepreneurship.

**c. International:**

Currently, more than 180 MoU's have been signed with foreign universities, which allow student exchange programs, dual degree programs, internships and projects. The strategic plan calls for an additional 100 MoU's with universities ranked in the top 500 of the world ranking. We are also planning international joint centres of excellence in thematic areas like water, sustainability, advanced materials etc. Work with World Organizations such as UN, EU, and UNDP etc. to translate and scale research outcomes to achieve UN SDG goals.

**d. Industry:**

Amrita's engagement with industry is critical to ensure that

- i. the curriculum and pedagogy match with the needs of the industry.
- ii. to ensure that the research problems chosen are industry relevant problems
- iii. industry gets a chance to assess the caliber and quality of Amrita. Goal is to increase industry consultancy.

**e. India:**

The founding trust of Amrita has adopted 103 villages across India. Experiential learning (named as Live-in-Labs), introduced in 2015, is part of the curriculum. Primary goal is to ensure that society benefits from all the research work done at Amrita. Some of the goals envisaged are:

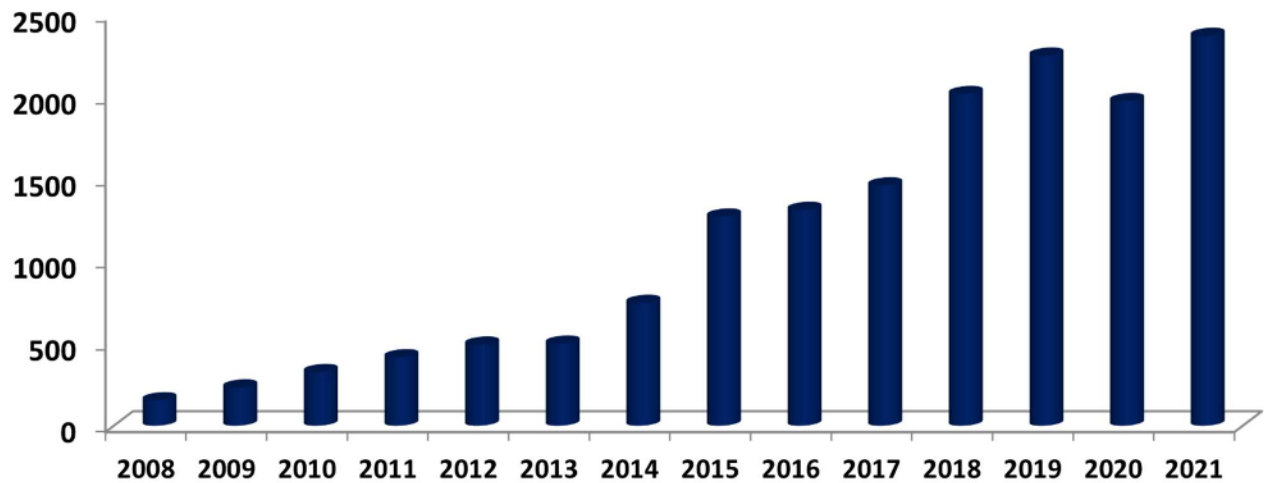
- Become role models in promoting green, clean and sustainable practices.
- Focus on National Missions such as Education, Literacy, Empowerment, Water, Disaster management and develop implementable and adaptable solutions.
- Orient research objectives and work with communities for societal impact through Amrita's adopted villages program across India and other initiatives
- Develop university-wide initiatives that embrace, appreciate and incentivize societal impact. This can be in the form of extension activities as well.

Monitoring the implementation of the strategic plan is handled by the Board of Management, which is the Apex body of Amrita.

## Existing significant strengths and accomplishments of national & international stature

- a. Amrita's fundamental strength lies in the culture. The culture of nurturing openness, creativity, mutual respect and participatory decision making have been the key elements to the success and growth of Amrita.
- b. Amrita was able to contribute in a very significant and positive way to the higher education sector in India because of the healthy mix of highly qualified faculty and administrators with rich international experience. Amrita enjoys the luxury of having 5-10% of their faculty and administrators with a broad spectrum of work experience from abroad, one of the cornerstones for Amrita's success.
- c. The fundamental building blocks (mentioned above) have resulted in Amrita being ranked among the top 10 Universities in India, in addition to gaining significant international recognition within a short span of time (evidenced from the 2018 - 2023).
- d. School of Engineering is well recognized by both higher education institutes and industry.
- e. With a placement record of >95% and approximately 15% of the students going abroad every year, ASE enjoys wide recognition both nationally and internationally. Amrita students have been able gain admissions to graduate programs in top tier universities in the US, EU, Australia, Singapore and Japan - UNM, UCSD, UCLA, MIT, CMU, Penn State, UB, Colombia Univ, TU Delft, EPFL, NTU, Deakin, Univ. of Tokyo, to name a few.
- f. Research productivity has been on the rise since the University was recognized as a Deemed to be University in 2003. A total of Rs. 350+ Crores in research funding from various Govt agencies and industry has propelled Amrita as a pioneering contributor in research areas such as advanced materials development, medical devices, sensor technology development, computational science and engineering, cybersecurity, wireless communication, internet of things, water and waste management, engineering for allied health science, computational drug discovery, artificial intelligence, renewable energy, automotive engineering, etc. Amrita has been very successful in disseminating the research work through high quality publications in reputed international journals and conferences. In fact, the publications have doubled almost every 4-5 years as seen in Figure 1.

Figure 1: Publication count progress over the past 10+ years



### Academic Plan (2023-28)

- Personalized Academic Pathways to provide a flexible academic program that is personalized to the needs of the students.
- Integrate choice-based credit system and increase flexibility in the curriculum.
- Recruit expert faculty in strategic areas to enable teaching and research.
- Introduce new interdisciplinary electives across the board.
- Introduce minor programs in Data Science, AI/ML to core engineering students for an additional 18 credits. This will allow core engineering students to have a better portfolio.
- Introduce AI, ML and Data Science in core engineering curriculum and integrate core engineering learning using AI/ML & Data Science tools.
- New B. Tech programs like B. Tech in Quantum Computing, Artificial Intelligence & Data Science with emerging specializations.
- New M. Tech programs in AI in Power systems (EEE), System dynamics and control (EEE), M. Tech in Digital signal processing and RF (ECE).
- Curricular development should include courses on High-Performance Computing and GPU Technology
- Upskilling and certificate courses on Semiconductor Manufacturing
- Transform learning experiences to be participative, activity and project-based. More emphasis should be on the formative learning and summative component must be significantly reduced or eliminated.

- Amrita Values program, cultural education and exposure to societal needs should be integral to every student's education. Periodic exposure and training for holistic well-being such as Amrita Yoga, IAM Meditation and their integration.
- Introduce novel programs to align to national and industry requirements having focus on employability/ entrepreneurship/ skill development.
- Aspire beyond program objectives. Enhance training and mentorship to create demonstrable talent at regional, national and global forums.
- Accommodate students with a wide range of proficiencies from all strata of society and mould them into extraordinary human beings who are motivated to serve society. Towards this end, the university will be structured with a graded learning environment which will provide adaptive learning for slow learners, average students, and exceptional performers. In addition, the university plans to inspire students from disadvantaged backgrounds to dream higher, provide the essential bridge training, and compensatory exposure to build self-confidence and communication skills.
- Experiential Learning to provide students with real world environments beyond the classroom and the labs.

## **Research Plan**

The campus envisions starting various Centers of Excellence in several thrust areas to inculcate, develop, and promote advanced research among faculty and students in these areas. The strategic plans for the Research Labs/centers and Thrust Area Groups (TAG) are as follows:

- **AI in healthcare**
- **Smart Manufacturing**
- **Intelligent Electric Grids and e-Mobility**
- **AI in Power System Operation and Control**
- **Embedded Control and Automation**
- **Power Electronics & Power Systems**
- **VLSI Design**
- **Communication and Signal Processing**
- **Flexible Electronics and Advanced Materials**
- **AI enabled Robotics & Automation**
- **Materials and manufacturing for Defence Technology**
- **Additive Manufacturing**

- **Green Energy and in particular "Green Hydrogen Technology"**

## **Computer Science and Engineering**

### **1.1 Research themes (AI & AI Applications)**

- **AI & Disability Studies**
  - Setup new joint centres with disability establishments for differently abled in Speech, deaf, blind
  - Enhance inter disciplinary research
- **AI & Computer Vision**
  - Joint centres with international experts and Amrita School of Agriculture
  - Joint centres and international collaborations in health care.
  - Collaborations with AIMS on more health domains
- **AI & NLP, NLU, NLG in Indian Languages**
  - Collaborations with Ayurveda School, Amrita Darshanam, CEN Ettimadai
  - Enhance inter disciplinary research
- **Formal specification and verification of mission-critical AI systems.**
  - Collaborations
- **AI & Robotics**
  - Collaboration: with international experts
  - Joint centres with international labs
- **AI in Networking**
  - Collaboration with WNA labs, San Diego labs
- **AI & quantum computing**
  - Motive: AI and quantum computing based design strategies to enhance the performance of on-chip integrated circuits
- **VR-AR Lab**
  - Setup of new VR-AR lab
  - Joint centres with international labs

### **1.2 Goals of the Research Themes**

#### **(a)AI & Computer Vision, AI & Disabilities**

Amrita School of Computing-Amritapuri aspires to be leading hub of innovation and discovery in the rapidly evolving fields of Computer Vision and Artificial Intelligence (AI) and play pivotal role in advancing interdisciplinary research that addresses complex global challenges for societal good. With a growing number of aspiring faculty members focused

on these emerging areas, our School is well-positioned to become a leading research hub, driving technological advancement and contributing to societal progress.

### Research Objectives

Ø **Advance Foundational Research:** Develop new algorithms, models, and methodologies that push the frontiers of current capabilities in Computer Vision and AI.

Ø **Translate Research into Practice:** Apply these advancements to real-world problems, particularly in areas such as healthcare, agriculture, remote sensing, surveillance and safety, autonomous systems and environmental sustainability.

Ø **Foster Interdisciplinary Collaboration:** Leverage Computer Vision and AI with other domains, such as robotics, human-computer interaction, and data science, to create holistic and sustainable solutions to complex problems.

Ø **Ethical AI Development:** Address the ethical, legal, and social implications of AI technologies, ensuring that their deployment is responsible, fair, and beneficial to society.

### Thrust research areas

#### 1. Thrust Areas (with primary partnering School within the University specified)

- **Advanced Computer Vision:** Investigate new techniques for image and video analysis, object detection, facial recognition, and 3D modeling. [**School of Computing**]
- **AI in Healthcare:** Develop AI-driven solutions primarily centered around, but not limited to Computer Vision for medical diagnostics, patient monitoring, personalized medicine, and public health interventions. [**School of Medicine**]
- **AI in Agriculture:** Develop AI-driven solutions for precision agriculture, disease detection, and promotion of sustainable agriculture practices. [**School of Agriculture**]
- **AI in Autonomous Systems:** Integrate AI in robotics, autonomous vehicles, drones, and smart infrastructure. [**School of Engineering**]
- **AI for Social Good:** Leverage AI technologies to address societal challenges such as disaster response, environmental monitoring, and poverty alleviation. [**School of Sustainable Futures**]
- **Ethics, Fairness, and Accountability in AI:** Explore the ethical, economic, and financial implications of AI, focusing on issues such as bias, transparency, privacy, and accountability in AI systems [**School of Business**]

## The Plan (5 years)

- Propose the establishment of a Centre for Computer Vision and Artificial Intelligence (CCVAI). This research centre will serve as a dedicated space for innovation, collaboration, and knowledge sharing among faculty, researchers, and industry partners
- Develop competence of students and faculty in the respective areas.
- Apply for grants in these areas from DST, DRDO and other reputed funding agencies.
- Establish strong national collaborations.
- Produce graduates with Master's and PhD degrees in these areas.
- Organize workshops to train students and faculties across the country.
- Host reputed national conferences in these areas.
- Procure state-of-the-art equipment for performing research.
- Hire high calibre research faculty of national repute.

### **(b) AR-VR Metaverse initiatives**

Creating a robust and forward-looking AR-VR lab at a university requires research strategies that can leverage emerging technologies while also focusing on real-world applications. Some key future research strategies for an AR-VR lab are the following

#### **1. Human-Centric AR-VR Experiences**

Personalization of AR/VR Experiences to enhance fields like education, healthcare, and entertainment:

2. **Emotion-Aware VR Systems:** Investigate how to integrate emotion detection (through facial expressions, voice tone, and physiological sensors) into AR/VR experiences, making systems more empathetic and responsive.
3. **User-Centric Interaction Models:** Focus on understanding how different users interact with AR/VR systems based on age, background, disabilities, or cognitive ability
4. **Immersive Education and Training**  
AR/VR in Education: Research how immersive environments can revolutionize learning experiences in various domains, such as medicine, engineering, and history
5. **VR for Mental Health Therapy:** Research how VR can be applied to mental health treatment, including exposure therapy, anxiety management, and post-traumatic stress disorder (PTSD)

rehabilitation.

### **The Plan (5 years)**

- Develop AR/VR Research and Development Capabilities
- Expand infrastructure for AR/VR development, including high-end headsets, motion capture devices, haptic feedback systems, and immersive environments.
- Security in the Metaverse
- Build a research team to focus on AR/VR applications in education, healthcare, manufacturing, and training simulations.
- Partner with industry leaders for access to AR/VR development platforms (e.g., Unity, Unreal Engine).
- Focus on AR/VR in Healthcare, AR/VR Content for healthcare, Education and Training
- Collaborate on AI-Driven AR/VR Systems
- Partner with industries like manufacturing, automotive, and real estate to develop AR/VR applications for product design, prototyping, virtual tours, and customer experiences.
- Organize hackathons, innovation challenges, and competitions to encourage students and researchers to create novel AR/VR applications.
- Offer AR/VR workshops and certification programs for students, faculty, and industry professionals to enhance skills in immersive technologies.

### **(c) AI and Data Science (NLP, Big Data Analytics, Data Science)**

#### **Thrust Areas**

To remain at the forefront of research and innovation, the center will focus on the following forward-looking thrust areas in the area of AI

#### **1. Explainable AI (XAI) and Responsible AI**

- a. Develop interpretable models for decision-making in high-stakes domains like healthcare, finance, and law.
- b. Ensure AI systems are ethical, fair, transparent, and explainable to end-users.

#### **2. AI for Precision Medicine**

- a. Use AI/ML for genomics, high-throughput sequencing, and medical imaging to create personalized treatment plans.
- b. Leverage predictive analytics for early detection of diseases like cancer

and neurodegenerative disorders.

### **3. Federated Learning and Edge AI**

- a. Explore decentralized AI that enables collaborative learning from distributed data sources while preserving privacy.

### **4. Quantum Machine Learning (QML)**

- a. Investigate how quantum computing can accelerate data science by solving optimization, classification, and clustering problems faster than classical methods.
- b. Apply quantum algorithms to large-scale data analytics and AI problems.

### **5. Generative AI: Synthetic Data and Data Augmentation for AI**

- a. Generate high-quality synthetic datasets to overcome limitations of real-world data, especially in sensitive fields like healthcare.

### **6. Multi-Modal Data Fusion and Cross-Disciplinary AI**

- a. Integrate AI models that can process and analyze multiple data modalities (text, speech, video, sensor data) simultaneously to gain deeper insights.
- b. Focus on AI applications across fields such as healthcare (combining medical records, imaging, and genomics) and smart cities (combining IoT, video, and geospatial data).

### **7. AI for Security and Privacy**

- a. Research secure AI systems that can defend against adversarial attacks and ensure the privacy of sensitive data, such as medical records.
- b. Investigate privacy-preserving AI techniques like homomorphic encryption and differential privacy.

### **8. AI for Digital Twins and Simulation**

- a. Develop digital twin models for simulating real-world systems in industries such as manufacturing, healthcare, and urban planning.
- b. Use simulations and AI-driven optimization for predictive maintenance and operational efficiency.

### **Short Term Goals**

- **Research in Frontier AI Domains:** Conduct research in advanced AI fields like federated learning, quantum AI, autonomous systems, and synthetic data generation. Publish findings in top-tier journals and conferences like NeurIPS, ICML, and CVPR.
- **Interdisciplinary Collaboration:** Foster collaborations across disciplines (healthcare, energy, urban planning) to apply AI/ML to real-world problems such as disease prediction, renewable energy management, and smart city development.
- **Focus on AI for Social Good:** Lead projects that apply AI for solving

societal issues, such as healthcare in underserved populations, disaster management, and climate change mitigation.

- **AI Ethics and Responsible Innovation:** Establish a dedicated team working on AI ethics, focusing on building fair, transparent, and inclusive AI systems. Apply for grants that support AI governance and responsible innovation.
- **Global Industry Collaborations:** Form strategic partnerships with leading technology companies (e.g., Google, NVIDIA, Microsoft) for joint research, funding, and access to advanced computing resources. Create a research ecosystem that bridges academia and industry for impactful innovations.
- **AI for Precision Medicine in Healthcare:** Partner with AIMS hospitals to deploy AI-driven personalized healthcare solutions and collaborate on medical data research to create models for disease prediction, treatment optimization, and remote health monitoring.
- **Global AI Conferences and Workshops:** Organize international AI conferences and workshops in emerging fields like federated learning, quantum AI, and autonomous systems. Create a hub for researchers and practitioners to share advancements and solve key challenges.

#### **(d) Computational Life Sciences (Data Science)**

Computational life sciences comprise a deep collaboration across scientists from biological sciences, chemistry and advanced research in computer science to address critical healthcare issues of disease diagnostics, management and treatment. These areas are moving at trailblazing speeds due to the compounded synergies between governments, industry, private philanthropic foundations and large venture funds in the western world. These frameworks are implemented in very large, advanced, and organically interdisciplinary facilities. Most of these centres have many things in common like access to patient-data and respective physicians, advanced data management and data analytic capabilities, collaboration with many life scientists - all of whom are working within strong collaborative groups.

Further, it is getting to be fairly obvious that efficacy of drugs and diagnostics are poorer in India since the science that created these tools and products originated to serve European populations (based on European data and trials). Hence, it is critical that we set up multiple interdisciplinary ecosystems to start developing India-centric diagnostic and drug discovery capabilities. The proposed

centre will start with taking minimum viable steps. To begin with, aim to set up back end computational storage and processing capabilities to genomic centers, build high performance machines that focus strongly on life sciences (examples below) and build intelligent data analytic frameworks for healthcare predictions. In this center, we will focus on having one group leader to each vertical mentioned above. Further, there will be a common core chemistry and biology labs to develop synergies with life scientists, as well as do basic experiments in-house. While the life science labs are not explicitly mentioned below, they must be assumed to form a core part of the centre.

### Thrust Areas:

1. Prototypes of context focused **High Performance Machines**, supported by targeted algorithm development and development of API access for the same. Bioinformatics areas:
  - a. Sequence assembly
  - b. Sequence alignment
  - c. Molecular dynamics
  - d. Massive throughput docking (~)
2. Scientific computing software pipeline development for multiple TYPES of **sequencing projects (multi-omics)**, including Big Data tech development for the following main areas. Omic Areas (prominent examples)
  - a. RNA-seq, DNA-seq, WGS, Exome-seq, and others.
  - b. SNP detection, evaluation and prediction
  - c. Annotation using big data based database integration
  - d. Pharmacogenomics
  - e. Gene panel development (towards prototyping and validation)
  - f. India-centric personalized medicine based AI applications for currently available cloud platforms like IBM Watson
3. **Computational drug discovery** using deep learning and AI with a strong focus on search and optimization techniques.  
Drug discovery areas:
  - a. Hybrid sequence-structure search for druggable protein binding sites
  - b. Peptide-based drug discovery with simulation and modeling workflows enabled by deep precision
  - c. Massive semantic integration of drug, bioinformatics and bio-

medical databases with an aim to create an extensible drug repurposing hyper-layer

### **Short term goals (1-5 years, for each thrust area)**

- **High performance machines:** Build high performance prototype machines in each of these sub-thrust areas through custom optimization of both hardware and software: sequence alignment, assembly and annotation pipelines AND 3D molecular dynamics simulations using HPC tech (Example ANTON)
- **Sequencing technology software development:** Software and pipeline development for massively parallel sequencing technologies
- **Computational drug discovery:** Customized development of deep learning and AI tools to support drug discovery pipelines
- Apply for new grants in the area of computational Biosciences

### **(e) Formal specification and verification of mission-critical AI systems.**

Obtaining high assurance on safety and security of computing systems is critical in today's world that is increasingly becoming dependent on such systems for critical functions. Some systems like satellites in aviation, and drug delivery and surgical systems in medicine are safety/mission critical. Robust engineering with sound scientific basis is required to develop fail-proof systems. Moreover, as protection of information becomes critical in today's increasingly networked world, we need high assurance on the safety and security of the systems and protocol software underlying today's computing systems. This center aims to work on theoretical and engineering aspects of designing, building and verifying such safety critical systems. The work done in this center will immensely help key sectors of importance to our university and our nation, such as the aerospace program, defence systems, high security/safety systems, and medical institutes of Amrita.

### **Thrust Areas**

1. Engineering hardware/firmware/systems software/toolchains/protocols for embedded high assurance applications;
2. Engineering safety certified high assurance systems including protocol stacks and system software.
3. Formal methods for specification, construction, and verification of high assurance systems.

### **Short term goals (1-5 years).**

- Perform cutting edge research areas in verifiably safe high assurance systems, including embedded and robotic systems.
- Application areas include finance, healthcare, manufacturing industries, smart cities, and robotic systems.
- Develop competence of students and faculty in the respective areas.
- Apply for grants in these areas from DST, DRDO, ISRO, BARC, NAL and other reputed funding agencies.
- Work with leading manufacturing industries.
- Establish strong national/international collaborations.
- Host reputed national conferences in these areas.
- Procure state of the art equipment for performing research.
- Hire high calibre research faculty of national repute.
- Subscribe to relevant magazine and journals.

## **2. New research labs / New Equipment to existing labs**

### **(2.1) New Research Labs proposed**

- **AI and quantum computing Lab**
  - For designing strategies to enhance the performance of on-chip integrated circuits".
  - CAD Simulation Lab. for AI/Quantum-Computing supported VLSI Design.
  - Estimated budget: ~40-50 Lakhs (Including manpower viz., Research Faculty/Research Scholar)
  - Infrastructure: (a) Laboratory Room (1000 sq. ft.)
  - (b) 5 Server PCs (configuration to be shared later). (c) 20 Client PCs (configuration to be shared later)
- **Systems Analysis Lab**
  - This research lab will help the faculty and students who are doing work in combination of formal methods and programming languages
- **Next Generation Networks Research Lab**
  - Specialised research lab for IoT, 5 G, Software Design Networks research and projects for students
- **Development Hub**
  - This is for the student community to get training and hands on in modern application development tools, frameworks and databases and cloud application. This can be in collaboration with TBI too in later stages

- **Hardware requirements**
  - High Performance Computing machines
  - Iot sensors required for robots, Raspberry Pi model and accessories
  - Long range spectro-radiometers; plant canopy analyser; differential GPS:
  - Deep Learning Workstations / Workstations for Data Analytic applications
  - Surveillance cameras: Bosch LTC0495/51
  - Video Camera : SRG-X1201080p PTZ Camera with HDMI, IP & 3G-SDI Output
  - Thermal camera
- **Software Requirements:**
  - AWS scalable cloud infrastructure to run our HPC applications
  - GIS Software
- **Data Requirement**

Access to data from such ISRO satellites as:

  - Resourcesat : Resourcesat-2A satellite provides continuity of data with higher temporal resolution for various operational applications namely crop production estimation, forest cover mapping, mapping and monitoring land & water resources, environmental applications, rural& urban development plans. Etc.
  - Cartosat, Oceansat - OCM, IRS-1A , IRS-1C : It is a high resolution imaging satellite for address urban planning, rural resource and infrastructure development etc.,
  - Envisat - ASAR (Microwave): Envisat gathered information about the Earth (land, water, Ice and atmosphere).

## **Intelligent Electric Grids and e-Mobility**

### **I. Amrita Center for Intelligent Electric Grid and e-mobility (Amrita i-GEM)**

- To promote collaborations with industry, reputed academic institutions and other establishments for resource sharing and to promote creativity, innovation and entrepreneurship culture.
- To enhance the teaching learning process by adopting the best and innovative practices through active engagement with all stakeholders in Research, Industry and Business with social and common concern.
- To produce world standards deliverables in publications, patents, PhDs etc.

**Near future Goals (5 years)**

- To obtain funded research projects from government (DST, DRDO, MeitY, MNRE etc) and industries (TATA Power, Nissan Leaf etc.)
- To set up state-of-the-art Advanced Research facilities for Smart grid and e-Mobility research
- To recruit experts (national and international) to enrich us with high-quality research and exposure
- To improve collaboration with industry and academia.
- To publish papers in reputed tier-1 international conferences and journals (SCOPUS indexed)
- Organize workshops and seminars to be conducted by people from industry and academia at all Engineering campuses for stronger industry-academia partnership
- To organize an international conference in the next two years that brings together leading experts from industry and academia at Amrita, with the objective of enriching research, fostering knowledge exchange, and enhancing learning opportunities for undergraduate and graduate students as well as faculty in the domain.

## **AI in Power System Operation and Control**

### **Near future Goals (5 years)**

- A. Demonstration of Energy Management System for EV charging station in Microgrid.
- B. Demonstration of sustainable and rural community friendly Energy Management of Decentralized and Adaptive Hydrogen Energy Systems through use of smart contracts and blockchains.
- C. Demonstration of cooperative control algorithm benefits in path planning of unmanned surface vehicles (USV).
- D. Demonstration of effective scheduling in Net Zero Energy Buildings.

### **Intermediate Goals (for the next 5-10 years)**

- A. Development of Decentralized Intelligent Control and Automation algorithms for Hybrid Micro Grid energy management and autonomous systems.
- B. Development and usage of modern tools and methods for design, techno-economic analysis for high penetration of Electric vehicles to provide viable energy in low carbon microgrids.

- C. Development of AI algorithms for Navigation of Unmanned surface vehicles (USV) for Flood Relief and Water Body Management.
- D. Prototype development for cooperative control of USVs

### **Future Goals (for the next 10-15 years)**

- A. Development of Scalable and inter-operable Microgrid architecture with renewable energy.
- B. Development of re-configurable smart controller for Navigation of Unmanned surface vehicles (USV).
- C. Implementation of improved fault tolerant control strategies for autonomous vehicles which work in cooperation
- D. Deployment of USVs to assist in offshore operations such as pipeline inspection, and oil spill response
- E. Test USVs in locating and rescuing individuals in distress at water bodies by deploying sensors, cameras, and communication equipment
- F. Conduct a feasibility study on the deployment of USVs in tourism for autonomous sightseeing tours, underwater exploration experiences, and recreational activities

## **Embedded Control and Automation**

### **Near future Goals (5 years)**

- Establish a track record as a tag leading towards innovative technologies for industrial and national needs.
- To give more emphasis for Participative Learning in teaching that have to be practiced for enhancing the learning capability across the departments through co-curricular, extra curricular activities, Open electives etc.

### **Intermediate Goals (for the next 5-10 years)**

- Incubate successful start-ups under the tag creating innovative products and business models using the knowledge and technologies developed by tag members.
- Become known globally for transformational technologies that impact lives of people.

### **Future Goals (for the next 10-15 years)**

- Provide an invigorating work environment for tag members where merit and hard work are recognized.

## **Power Electronics & Power Systems**

- **Near future Goals (5 years)**

To be a center of excellence of global standing for developing professionally competent research talent and contributing to socio-economic benefits on nation building focusing on:

- Priorities for research and innovation, accelerating interdisciplinary research.
- Open and responsible research environment: Build and invest in state-of the-art research infrastructure.
- To strive for clean, practical and affordable energy solutions through research & development as well as demonstration & commercialization.
- To provide research platform for young, talented, innovative, restless minds for proving and actualizing worthy ideas.
- Committed to act with sense of urgency for suitable energy technologies to fulfil energy needs.

## **1. Intermediate Goals (for the next 5-10 years)**

- Developing research leadership, stimulating teaching-learning with research-intensive environment: Engagement, involvement and inspiration.
- Focusing on Reliable and self-Sustainable customer centric smart electric distribution system.
- To become an internationally recognized integrated energy research center and not just restrict itself to energy distribution.
- International collaboration and partnerships, sharing facilities and knowledge with select international partners
- Research funding from international sources, engaging geographic and socioeconomic diversity

## **2. Future Goals (for the next 10-15 years)**

- Energy for ALL in a clean and sustainable way, Ahead of the change, Ahead of the challenge.
- Social responsibility as a core goal: Translating and implementing research discoveries for societal impact.
- Make a difference on grass root social issues at local, national and global scale, embedding responsible research processes for environmental sustainability.

## **Center of Excellence in VLSI Design and semiconductor chip manufacturing**

- A dedicated center for design and layout of ICs for signal processing and communication applications
- The center will focus on funded research activities in high-speed data interfaces, verification and hardware security, low power ICs for biomedical applications and GHz range data interfaces for RF applications
- Skilling of students in semiconductor chip fabrication

### **Specific Vision**

- To improve the expertise of VLSI graduate students and faculty in the VLSI domain.

- To make the resources available for undergraduate and graduate students to enhance their learning and impart knowledge on research and to make them industry ready.
- To facilitate collaboration with VLSI industry and to provide consultancy services.
- Establish collaboration with semiconductor capital equipment manufacturers in India and abroad. Establish collaborative projects and semiconductor fab operations skills among students.

### **Near future Goals (5 years)**

- To obtain funded research projects in the area for VLSI design from government (DST, DRDO etc) and industry (e.g. Analog Devices, Austria Microsystems, etc)
- To set up state-of-the-art Advanced Research VLSI Lab with high end design tools and board design.
- To recruit experts (national and international) in VLSI domain to enrich us with high quality research and exposure
- To set up a state-of-the art analog VLSI Testing facility up to 1GHZ sampling rate.
- To improve collaboration with industry and academia.
- To publish papers in reputed tier-1 international conferences and journals (SCOPUS indexed) that mainly focus on VLSI Design.
- Organize workshops and seminars to be conducted by people from industry and academia here at all Engineering campuses
- To organize an international conference exclusively on VLSI Design in the next two years so as to bring the people from industry and academia together here at Amrita so as to help improve the research and knowledge of both undergraduate and graduate students along with faculty in the VLSI domain.
- To ensure most of the faculty in department are PhD degree holders

### **Intermediate Goals (for the next 5-10 years)**

- To continue obtaining funded research projects in the area for VLSI design from government (DST, DRDO etc) and industry (e.g. Analog Devices, Austria Microsystems, etc)
- To set up state-of-the-art fabrication facility for fabricating advanced microelectronic devices such as MOS capacitors and transistors, FinFETs, and Memory devices.
- To set up state of the art device testing facility which will support the fabrication facility by helping in performing all electrical measurements of capacitors, transistors etc.
- To set up a state-of-the-art materials characterization facility for characterization of ultra-thin films used in semiconductor devices.
- To enhance the analog VLSI Testing facility up to 60GHZ sampling rate.
- To publish high quality papers in high impact factor journals and in highly reputed international conferences.
- To improve collaboration with industry and academia.
- To host reputed VLSI Design conferences such as VDAT, VLSI Design in our campus.
- To develop knowledge and expertise in the upcoming new areas of research in VLSI.

### **Future Goals (for the next 10-15 years)**

- To focus research and development in the new and upcoming areas of VLSI and to focus on the latest technology prevalent in the industry at that time.
- To extend and upgrade existing design, characterization, and fabrication facilities to newer technologies.
- To have a pool of experts in VLSI who can initiate, develop and take research to greater heights.
- To continue collaboration with industry and academia for a healthy symbiosis.
- To host reputed International VLSI Design conferences such as ISCAS, IEDM, NEWCAS, and MWCAS in our campus.

## **Center of Excellence in Communication and Signal Processing**

A dedicated center for communications systems and biomedical signal processing design, development and implementation.

### **Specific Vision**

- Develop extensive curriculum on analog, digital, wireless communications and signal processing focusing both theory and practice.
- Develop a research laboratory which seeds innovation in communication systems design and biomedical signal processing.
- Build a platform where academics and industry come together and reap mutual benefits.

### **Near future Goals (5 years)**

- To obtain funded research projects in the area for wireless communications, biomedical processing from government agency (DST, DRDO etc) and industry (e.g. Qualcomm, Intel, MediaTek, etc.,)
- To setup a research laboratory which focuses on 5G wireless technology design and development. This lab will also bring out innovations in biomedical signal processing and application and Internet of Things.

### **Intermediate Goals (for the next 5-10 years)**

- To have a pool of experts in communications and signal processing who can initiate, develop and take research to greater heights.
- To publish high quality research papers in high impact factor journals and in highly reputed international conferences.
- To improve collaboration with industry and academia.

### **Future Goals (for the next 10-15 years)**

- To be a leader in Communication Systems transceiver design, development and implementation
- To innovate Wireless products focusing both on societal needs and technological growth.
- To host and be part of international conferences like ICC, ISIT, PIMRC etc

# Center for Excellence in Advanced Manufacturing and Robotics

## **Specific Vision:**

- To become a hub for cutting-edge research and innovation in advanced manufacturing processes and robotics
- To equip students and faculty with expertise in areas such as additive manufacturing, smart manufacturing, automation, and robotics
- foster collaboration between academia and industry for the development and implementation of advanced manufacturing technologies.

## **Near Future Goals (5 Years):**

- Obtain funding for research projects in advanced manufacturing and robotics from government agencies (e.g., DST, DRDO) and industry partners
- Establish a state-of-the-art Advanced Manufacturing and Robotics Lab equipped with advanced machinery, robotics platforms, and simulation tools.
- Recruit experts in advanced manufacturing and robotics to enhance research capabilities and mentor students.
- Organise workshops, seminars, and industry visits to provide hands-on experience and exposure to the latest technologies.
- Publish research papers in reputable international conferences and journals focusing on advanced manufacturing and robotics.

## **Intermediate Plans (5-10 Years)**

- Expand research activities to encompass emerging areas such as cyber-physical systems, digital twin technology, and human-robot collaboration.
- Develop partnerships with international universities and research institutions for collaborative research projects and knowledge exchange.
- Enhance the curriculum to include courses on advanced manufacturing techniques, robotics, mechatronics, and automation.
- Establish a Technology Transfer Office to facilitate the commercialization of research outcomes and industry adoption of innovative technologies.
- Host international conferences and symposiums on advanced manufacturing and robotics to showcase research findings and facilitate networking.

## **Future Goals (10-15 Years)**

- Pioneer breakthroughs in the field of advanced manufacturing, leading to the development of next-generation manufacturing processes and systems.
- Contribute to the development of sustainable manufacturing practices and technologies to address environmental challenges
- Establish joint research centers with industry partners to address specific challenges and foster collaborative innovation.
- Expand the scope of research to include interdisciplinary areas such as artificial intelligence, materials science, and renewable energy.
- Strengthen ties with government agencies and policymakers to influence policies related to manufacturing technology and robotics.

## **Centre for Flexible Electronics & Advanced Materials**

This upcoming multidisciplinary research Centre offers state-of-the-art facilities to design, develop, fabricate, and characterize non- enzymatic, flexible wearable sensors for health care and engineering applications, materials for hydrogen storage, artificially engineered materials with a variety of applications like bone/dental implants, micro/nano fluidics, materials for electromagnetic shielding in food packaging, high entropy alloys, energy harvesting and materials with high load bearing capacities.

Another important venture in this center is that it will host Kerala's hydrogen valley center which is focused on Hydrogen as the future fuel, in collaboration with IIT's and NIT's.

Recent works done at the centre developed a low-cost solution for diagnosis of tumour using non-invasive wearable passive sensors. The flexible electrodes developed by the researchers can accurately locate of the position of the tumour using ERT (Electrical Resistive Tomography) and has developed a flexible wearable device for targeted localised radiation therapy.

The centre has developed next generation micro fluidic based lab on chip devices in combination with auxetic / meta structures for improved efficiency and modularity. These devices can be used to measure effectiveness of medicine absorption in blood, and can be used to predict diseases.

Applied mechanics group of the center has recently developed a high strength engineering load bearing auxetic members with a significantly high load to weight ratio with 65% of material reduction. These designs with light weight auxetic structures have been utilized in improving the bio-mechanical property of the newly designed bone implants. The auxetic

structures developed in the centre produce sustainable implant models with easy post operative recovery.

Biodegradable/ bioabsorbable materials represent a pertinent class of biomaterials which can eliminate the need for revision surgery and minimizes the impact of long-term foreign body response as in the case of permanent implant materials. This research team is working towards the development of novel Mg-based alloys for biodegradable implant applications.

The electromagnetics group of the centre works towards reducing electromagnetic pollution by producing flexible shielding materials using natural polymers. Polymer nanocomposites have been proven to be a significant alternative to metals for reducing the impacts of radiation pollution because they have high impact resistance, low density, and corrosion resistance.

### **Green Energy Technologies**

Focused on green energy generation, storage and waste to energy production, this team should leverage the expertise and focus on national mission projects on energy technologies.

Energy Materials, Technologies and Devices

Sustainable Resource Management

Biomimetic and Biomolecular Chemistry

Energy Storage Technologies (Alternate Battery Technologies, Fuel Cells)

5 year Plan:

1. Invest in critical characterization equipment which will accelerate the research progress.
2. Addition of manpower dedicated to research in these areas.
3. Interdisciplinary approach with a team of focussed researchers from electrical, mechanical, materials and chemistry background



Submitted by Dean - Faculty of Engineering